Bharat Broadband Network Limited
A Government of India Undertaking

Detailed Project Report

"Government User Network"

For

Service Delivery at Village Level

February, 2014

ver 5.0

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PREFACE

The Overlay network over NOFN to be named as **Government User network (GUN)** was proposed through a strategy paper by BBNL. The proposal was based on various interactions and the understanding of the network requirements to make direct impact with viable model. The proposal was to establish a framework for the delivery of high speed Broadband or Government Closed User Group connectivity from District Headquarters to Gram Panchayat (GP) and few other locations in the GP along with a community access to Broadband. The work is proposed to be carried out by BBNL as Executing agency on cost plus model. MoRD shall be the anchor Institution which shall use the connectivity provided to deliver e-services to the citizens in coordination with Deity and state Governments. Tenure of the project is envisaged as 10 years to ensure viability and sustainability.

The above proposal duly vetted by BBNL board was sent to DOT for consideration of the Telecom Commission. It was desired to have a Detailed Project report as well as third party vetting of the assumptions made in the strategy paper.

Keeping this in view a consultancy firm namely M/s Pwc was appointed by BBNL. The strategy paper prepared for the Government user network was made over to M/s Pwc, the consultancy firm appointed by BBNL. The firm was given mandate to analyze the various assumptions made in the strategy paper and review the same based on detailed study of the International practices and ground realities in India. The firm was asked to submit a Detailed Project Report (DPR).

Subsequently, this DPR has been prepared and submitted by M/s PwC.

Disclaimer

This report has been prepared by PwC staff deployed on secondment to BBNL based on the information provided to them by BBNL. The conclusions arrived at in this report are based on the completeness and accuracy of the stated facts and assumptions; which if not entirely complete or accurate, should be communicated to us immediately, as the inaccuracy or incompleteness could have a material impact on our conclusions.

Other than information provided by BBNL, the data needed for preparation of this report has been derived from secondary sources. Primary research including meetings with stakeholders and market study is advisable for further verification of conclusions drawn in this report. PwC will not be responsible for any consequences arising out of actions taken based upon the conclusions in this report.

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1. Executive Summary

1.1. Report Background

Bharat Broadband Network Ltd (BBNL) is the agency entrusted with the task of spreading Broadband connectivity in the country with an objective of enabling delivery of broadband based services from Government and other agencies to the rural population. BBNL has already launched a program to create **National Optical Fiber Network (NOFN).** NOFN aims to set up OFC connectivity from 10,000 Blocks to their respective 250,000 Gram Panchayats (GP).

While the connectivity between Blocks and their respective GPs is being set up by NOFN, The prospective users, both in Government sector and other Telecom Service Providers, perceive viability, feasibility and technology concern since mounting a service for rural sector on NOFN would require a large number of interconnects. BBNL has observed a low level of interest from the prospective service providers. The 'Government User Network (GUN)' has been envisaged as an extension over NOFN in order to address the above concern and greatly ease mounting of services for delivery to rural population. GUN envisages that the connectivity would be aggregated at district level from where it can be connected to the National Knowledge Network and the Internet as well as other State Wide / Nation Wide Networks as required.

1.2. About GUN over NOFN

As explained above, while NOFN aims to connect Blocks to Gram Panchayats (GP), BBNL is planning to extend the connectivity created by NOFN on both ends as below:

i. **Backward Aggregation**: Establish connectivity between Block and District Headquarters and aggregate the network at District level.

ii. **Forward Extension**: Extend the connectivity from GP PoP to 2 selected Government institutions and provide low cost Wi-Fi internet services within the vicinity of GP

The above extensions would enable end to end connectivity till the GP level and would be used to provide Government services at village level and is labeled as "**Government User Network (GUN) over NOFN"**. In addition, the District PoP of GUN would have the option to be connected to the National Knowledge Network (NKN) PoP at each district, this would allow for end to end closed user group connectivity upto the State Data Center and

National Data Centers. Others networks can interconnect with this network at the District, State or National level. The GUN would also be connected to Internet at district level.

The project aims at making available the required connectivity and bandwidth for rural service delivery across the nation. Accordingly, consultations and discussions have been done with DeitY, MoHRD, USOF and DoT. Going forward and prior to implementation it may be necessary to interact with a larger set of users and that an inter-ministerial/departmental committee may be formed for better coordination of inputs.

This DPR focuses on GUN over NOFN with the objective to assess the feasibility of its implementation from following perspectives –

- As-is, gap and stakeholders analysis
- Technical Solution
- Project Implementation Strategy
- Operations and Management of Infrastructure
- Legal and Regulatory environment
- Risk Analysis
- Budgetary Estimation

1.3. Source of Funds

Capital Expenditure: The capital investment for the project is envisaged from USOF

Operating Expenditure: BBNL is planning to engage **Ministry of Rural Development (MoRD)**, as "**Anchor Customer**[1]", to support the operating cost for a period of 10 years. In lieu GUN over NOFN will provide MoRD with 50 Mbps of broadband connectivity across all GPs in the country with an assured Quality of Service (QoS).

MoRD will utilize the 50 Mbps connectivity as below:

i. 10 Mbps for delivery of community Wi-Fi internet services at GP
ii. 10 Mbps for delivery of services at GP
iii. 20 Mbps for 2 government institutes at GP (10 Mbps each). The institutes could be School and health center or any other government institute such as Police Station, Post office etc
iv. 10 Mbps reserved for future use

[1] MoRD is being referred to as the Anchor Customer since this network primarily is being envisaged to cater to MoRD requirements.

In order to provide above mentioned capabilities to MoRD, GUN scope includes the following:

i. Backward aggregation of NOFN so that CUG service provider can interconnect at District level
ii. Setting up infrastructure at GP level and providing community Wi-Fi internet services to rural population within a vicinity of approx 300 to 500 meters
iii. Extending network from GP to minimum two government institutes – one School, one PHC/ Police Station/ or any other Government institution

1.4. Beyond the "Anchor Customer"

The NOFN would provide a capacity of 100 MBPS from GP to Block Level. Further, GUN extension would have a capacity of 1 GBPS from Block to District level. The District aggregation point of Gun would have 4 X 10 GBPS ports for upward connectivity. Therefore, it can be seen that GUN over NOFN would actually create much higher bandwidth capacity than the 50 Mbps assured to the MoRD. This additional capacity is envisaged to be offered to other service providers, on a non-discriminatory basis, to enable them to deliver their services to rural population. This additional capacity can be offered at economical rates to other service providers, since the project would already be completely funded. Low cost bandwidth can potentially enable service providers to create a viable business model for delivery of services at rural level. Refer to *section* *12:Bandwidth Demand Analysis* for estimates on potential bandwidth demand.

The guiding principle for arriving at tariffs, for providing bandwidth to service providers, would be to encourage them to provide their services to rural population at affordable cost. Exact methodology to determine the tariffs will be decided by the BBNL board from time to time.

The incremental revenue, if any, generated from customers other than the 'Anchor Customer' can be utilized for technology refresh and reducing the OPEX burden of the "Anchor Customer".

1.5. Project Implementation

GUN over NOFN aims to

i. Backward aggregate around 6000 Blocks (10,000 OLTs) of NOFN with their respective 600 Districts. Connect with NKN and Internet at District level.

ii. Forward extend around 2,50,000 GP PoPs of NOFN to

a. Connect to two Government institutes

b. Provide community Wi-Fi services at around 2,50,000 GPs

Project is envisaged to take around 3 years to implement. A high level implementation plan is provided in section *6.7:High level Implementation Plan*.

The implementation approach envisages that BBNL would need to deploy a team of around 200 staff at implementation units spread across the country. During Operations and Management phase the required staff number is expected to be around 700. Primary function of this staff would be to manage the on field vendors who will provide the implementation and O&M services to BBNL.

In order to effectively meet the implementation objectives, this DPR outlines the strategic aspects of implementation approach across the following key implementation areas -

i. Dark Fiber leasing

ii. District, GP and Institute level implementation

Below are the key highlights of the suggested implementation approach -

1.5.1. Dark Fiber Leasing

- For leasing of Dark Fiber, tendering process needs to be followed for discovering the availability of dark fiber and its price.
- Based upon received responses, categories for dark fiber leasing and rate card for each category shall be created.
- Dark fiber providers to sign contract against the published rate card. This rate card to be used on an on-going basis to enhance the reach in areas where dark fiber may not be available as yet.

1.5.2. District, GP and Institute level implementation

- Detailed design with Bill of Material with item specifications to be created for the entire solution.
- Through an open RFQ process, centralized empanelment of OEMs to be done for all key equipments. For each of the equipment, at least 4 to 5 vendors who meet the specification requirements shall be empanelled based on lowest quote.
- States to be grouped together into clusters based upon geographical proximity, size of State, number of Districts, average number of Block per District in State so that an average of around 100 Districts are grouped in cluster. This will result in formation of around 6 to 8 clusters.

- Through tendering process identify an SI for each cluster who would undertake implementation in all Districts and GPs in that selected cluster.
- SIs to bid with equipment specifications from empanelled vendors only. The equipment prices in SI bids to be less than or equal to the prices quoted by the empanelled OEMs.
- Maintenance for 5 years (with layered SLAs) to be part of post implementation tender to be extended at the discretion of BBNL.

1.6. Operations and Management Approach

As in case of project implementation, the lean structure of BBNL poses a challenge to Operations and Maintenance of the network of the scale of GUN over NOFN. Below mentioned key strategic aspects of O&M approach are designed to address this challenge.

- The implementing agency to be responsible for overall maintenance (referred as O&M agency) of the network. Maintenance contract to be integral part of the implementation contract.
- The expected SLAs to be defined in the tender itself. The Agency shall be responsible to maintain the SLA for whole network *excluding*:
  i) NOFN Network
  ii) Dark fiber between Block-District and PoP
  iii) ISP Bandwidth
- SLA of NOFN network will be managed separately by BBNL as per NOFN O&M strategy and SLA of other two components (Dark fiber and ISP link) will be negotiated back to back from respective provider.
- BBNL would establish a central performance monitoring and SLA audit team to carry out overall performance monitoring and SLA audit for each of the individual agencies viz;
  - System Integrators
  - Dark Fiber Providers
  - ISP Bandwidth provider
  - NOFN maintenance agency
  - POP providers
- As part of its services the performance monitoring and SLA audit team shall administer the SLA with above entities on behalf of BBNL. All breaches, compliances and escalations shall be compiled and reported by to BBNL. BBNL shall undertake the centralized payment based on report submitted by the team.

- BBNL will deploy State Managers (GM) and Area Managers (SDE) for administrative management of NoFN. This report factors in the additional resources that will be required to manage GUN over NOFN.
- Additional resources required for NOC and service desk have been taken into consideration. These resource may required to be increased over time as the customer base expands.
- New additional NMS has been considered to manage backward aggregated network between Block-District and Wi-Fi access points.

1.7. Budgetary Estimation

Estimated budget for implementation of GUN over NOFN is as below:

CAPEX	**INR 4942 Cr**
OPEX / Annum	**INR 2472 Cr**

Refer to *section* *10:Project Budget* for details on project budget and related assumptions.

Key aspects of project budgeting are as below:

- Total project period has been considered as 10 years
- Project will be funded as:
  - CAPEX to be funded by USOF
  - OPEX to be funded by MoRD
- Cost of NOFN bandwidth included in GUN OPEX would be considered as revenue for NOFN Project
- It is considered that that the District-Block and Block-Block incremental fiber pair shall be available on lease from other service providers. An average distance of 33 K.M per Block is considered for the same (Refer to section *A.1:GIS based survey)*
- The average distance between Institution and GP PoP of BBNL is considered to be 1 K.M.
- Existing PoP of BSNL at Blocks and GP are used for over all GUN Project as BBNL collocated PoP. Cost of power for the same is considered.
- At District the BBNL will create its own PoP that shall be linked to the relevant CUG service provider's PoP

1.8. Technology at a glance

The Technical solution proposed for GUN's backward aggregation at District level and forward extension in GP comprises of following key features:

1.8.1. Features of GUN network designed for Backward aggregation at District

- The NOFN network designed to work on Layer-2, the new Block to District network is also planned to be deployed to provide L2 services. This will enable end to end GUN over NOFN to deliver services as Packet switched Layer-2 (Transparent IP) Network.
- Underlying architecture of GUN over NOFN is highly secure and completely segregated from the Internet.
- The proposed backward aggregation connectivity between Block and District will have capability to carry 1-2 Gbps traffic from each Block to District. It will further have Minimum 4*10Gbps uplink ports to integrate with Government/OSP network at District. The interconnect link between BBNL DHQ PoP and NKN/SWAN/NII PoP has been considered.
- A Separate NMS/EMS has been proposed to manage this network centrally. This new NMS/EMS shall be integrated with existing CDOT NMS for end to end management.

1.8.2. Features of GUN network designed for forward extension at GP

As a part of GUN project four different connectivity of 10 Mbps each need to be provided, The extension network in GP has been designed to cater the requirement of extension network for individual 10 Mbps connectivity as briefed below:

- It is assumed that GP e-Service delivery center and BBNL GP PoP will be collocated in same premises. A L3 CPE device (Router/Switch) has been considered additionally to terminate the link in GP e-service delivery center. This device will also have inbuilt Wi-fi capability providing Wi-fi access in the center for e-GP services.
- 10 Mbps connectivity to two Institutions at Gram Panchayat (GP): The last mile connectivity will require various options based on geographical situation at GP. Various options for different scenario are detailed in the report. A L3 CPE device (Router/Switch) has been considered additionally to terminate the link in Institution. This device will also have inbuilt Wi-fi capability providing Wi-fi access in the institution.
- LAN accessories i.e. Switch, Computer, LAN cabling, UPS etc. are not part of this project and need to be factored by respective institution/line-ministry.
- Community Wi-Fi service will enable villagers to access broadband internet using their Wi-Fi appliances (i.e. Laptop, Teblet, Mobile Phones, computers using Wi-Fi access point). One access point will be installed at every GP to provide the Wi-Fi internet hot-

spot around the installation location at GP. Contention ratio of 1:50 has been considered for aggregated B/W at District Level for Internet from ISP.

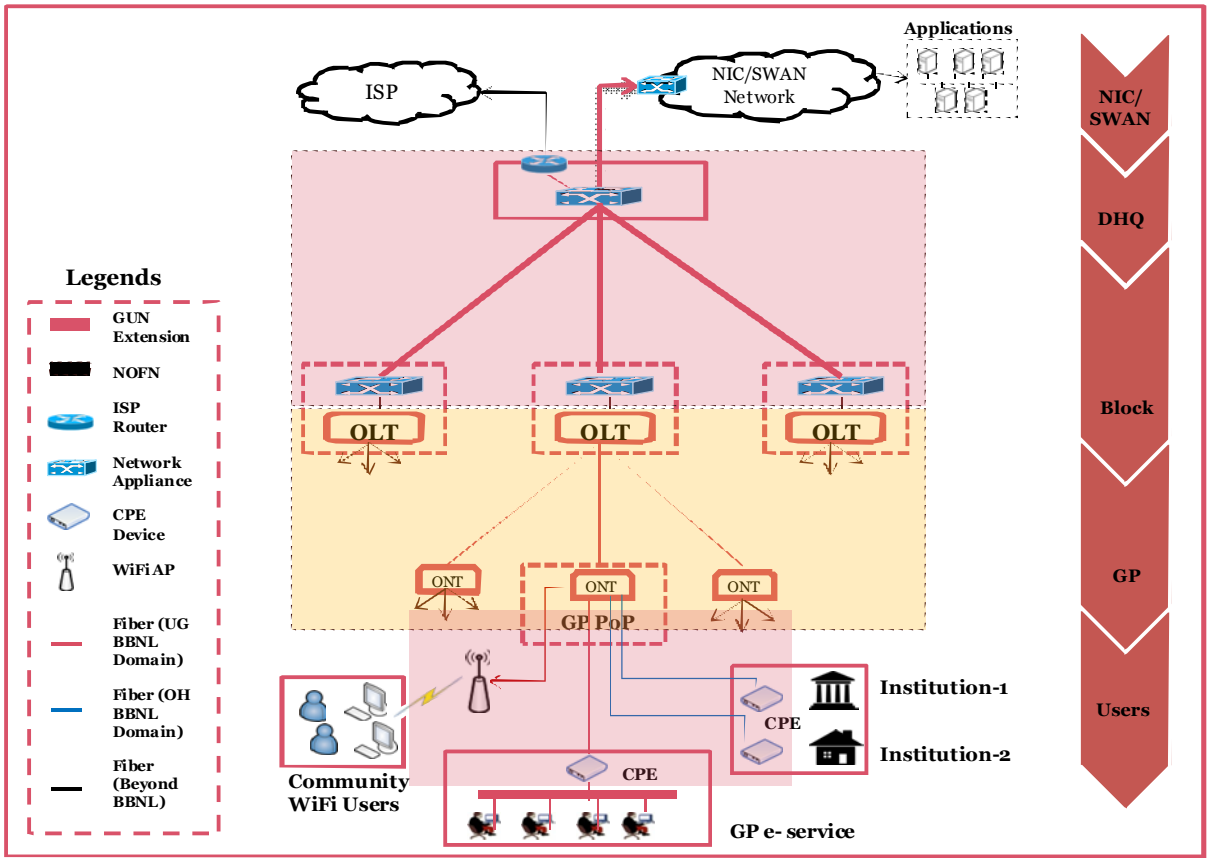


Figure 1: Solution Architecture – GUN overlay on NOFN

1.9. Legal and Regulatory Assessment

In order to provide additional services as envisioned under GUN over NOFN project, BBNL will need to make changes to its current legal status. In order to identify the required changes, study of the Memorandum of Association as well as the National Long Distance (NLD) license currently held by BBNL was done.

Key outcomes of the assessment are provided in section 9*:Legal and Regulatory Assessment* of this document. Key changes are:

- Current NLD license held by BBNL will suffice the purpose of providing bandwidth services under GUN over NOFN project
- Additionally, BBNL will need to acquire ISP license in order to provide community Wi-Fi services at GP
- Memorandum of Association of company will need to be updated. Suggested changes are detailed in section *9.4:Impact on Memorandum of Association*.

2. Project Context and Background

The National Telecom Policy – 2012 (NTP-2012), recognizes that overall public good can be maximized by making available affordable, reliable and secure telecommunication and broadband services across the country[2].

NTP-2012 has the vision "Broadband on Demand" and envisages leveraging telecom infrastructure to enable all citizens and businesses, both in rural and urban areas, to participate in the Internet and web economy thereby ensuring equitable and inclusive development across the nation[3].

In line with the objectives of NTP-2012, Government of India approved setting up of the **National Optical Fiber Network (NOFN)** to provide 100 Mbps broadband connectivity in each of the 2,50,000 GPs of the country. Ultimate aim of NOFN is to enable and encourage various service providers, Government as well Private, to deliver various services to remotest rural areas of the country through the use of communication infrastructure setup by NOFN. Service providers envisaged to use NOFN include various Government departments and ministries such as Ministry of Rural Development (MoRD), Ministry of Health and Family Welfare (MoHFW) etc; private players such as Telecom Service Providers (TSPs), Internet Service Providers (ISPs), cable operators, banks etc.

Bharat Broadband Network Ltd (BBNL), setup as a Special Purpose Vehicle (SPV) under Department of Telecommunications (DoT), has been entrusted with execution of NOFN project. Objective of BBNL is to create NOFN as the communication infrastructure and offer it to various service providers on a non-discriminatory basis in order to ensure faster proliferation of services at rural level.

Scope of NOFN is to create the Optical Fiber Cable (OFC) network between Blocks and GPs all across the country. NOFN is conceptualized to act as a telecom layer built by leveraging existing optical fiber network that is available between Blocks and GPs while creating incremental fiber network in areas where current OFC network is not present.

Pilot phase of NOFN was completed on 15th Oct 2012. The pilot was conducted in 3 Blocks covering roughly 58 GPs. Three Blocks included in pilot phase were - Arain in Rajasthan, Parvada in Andhra Pradesh and Panisagar in Tripura. Department of Electronics and Information Technology (DeitY), through a counter funding program, enabled delivery of a

[2] Telecom Annual Report 2012-13
[3] National Telecom Policy – 2012

selected government services at GP as well as to the government institutions connected to GP.

The Pilot phase brought to fore a few important issues across various domains including technology, project implementation, market demand etc. The Primary issue was pertaining to demand off take of bandwidth from service providers to offer their services to rural citizen. Key reasons[4] cited for low interest in demand were -

i. Most players had their presence till District level. In order to provide their services at GP level, they would have to deal with multiple service providers across various segments of the network.

ii. High cost of bandwidth from District to Block

iii. NOFN will provide around 10,000 Point of Interconnects (PoIs) at the Block level. In order to deliver their services all across the rural India, service providers will have to connect to 10,000 PoIs. This poses viability and manageability challenges to service providers.

iv. Absence of an entity that could take lead in delivery of services using NOFN

v. Lack of availability of some initial service across all GPs to trigger retail demand at rural level

In order to address the above mentioned issues identified during the pilot phase of NOFN, BBNL is planning to extend the scope of NOFN to include creation of an IT layer overlaid on top of NOFN that would be called **Government User Network (GUN) over NOFN**.

About GUN over NOFN

GUN overlay on NOFN aims to address the issues pertaining to creation and development of the services ecosystem at rural level. Below table provides a high level snapshot of what GUN project's response to the identified issues.

Issue	GUN over NOFN response	How the issues are addressed
Issue number (iv) above	Engage an "anchor customer" would provide initial service delivery	Anchor customer would pay for the bandwidth by way of partial funding of the project. They would be one of the key

[4] NOFN Pilot report

Issue	GUN over NOFN response	How the issues are addressed
		stakeholders in the project and therefore will have incentive to deliver services.
Issue number (i) above	Extend the NOFN network from District to Block	By extending network from District to Block, BBNL would provide end to end service from District to GP level
Issue number (ii) above		Idle capacity, after serving the anchor customer, can be offered by BBNL at very attractive commercial rates to other service providers.
Issue number (iii) above		By creating another network entry at District level, BBNL will be able to offer additional option of network entry with much less interconnect points. In order to offer a pan India service at rural level, Service Providers will have an option to interconnect at approx. 600 PoIs
Issue number (v) above	Offer low price community Wi-Fi services within 300 to 500 meters area of GP	Low price Wi-Fi service can act as the catalyst for proliferation of broadband usage in rural India

Table 1: Responses to issues

GUN overlay on NOFN is an attempt to address the issues pertaining to delivery of services in rural India by involving multiple stakeholders. It aims to do so by aligning their requirements towards the fulfillment of NTP-2012 objectives.

3. Stakeholder Analysis

In order to appreciate the potential benefits of the GUN over NOFN project, it is important to identify all key stakeholders, their requirements & expectations, and role that they play in the project.

3.1. Project Stakeholders and Benefits

Stakeholder	Role in GUN over NOFN	Requirements / Expectations	Potential Benefits
Rural Population	▪ Consumer of services being offered by various service providers using the communication network	▪ Delivery of relevant services in close proximity ▪ Be included in the overall growth of the economy	▪ High-speed reliable bandwidth availability at GP which ensures easy access to information and lowering of digital divide. ▪ Increased participation in government services due to availability at panchayat level. ▪ Employment opportunities on account of new business services from government and private players at panchayat level. ▪ Higher chances of earning livelihood at village level due to increase in economic activities at panchayat level.

Stakeholder	Role in GUN over NOFN	Requirements / Expectations	Potential Benefits
BBNL	▪ Act as GUN Implementation and Operation agency and implementation of PMO teams at different levels ▪ Appoint body to facilitate and manage mounting of services at center as well as State/local level ▪ Implement excess bandwidth utilization models that can support delivery of services on a non-discriminatory basis ▪ Appoint commercial body to manage usage of spare bandwidth	▪ Realize the ultimate objective of enabling and supporting delivery of services to rural population on a high speed communication network	▪ Efficient utilization of NOFN by using it for both government and private entities. ▪ Triggering the G2C and B2C services demand at rural level resulting in citizen empowerment and inclusive governance. ▪ Developing network platform as a product for other government players to offer services in rural India. ▪ Act as demand aggregator at District, Block and GP level in turn offer flexibility to the service providers for choosing the suitable entry and exit point. ▪ Creating scalable capacity to address the broadband demand in rural India.
Universal Service Obligation Fund of India(USOF)	▪ Provide funding for Capital Expenditure (CAPEX) ▪ Ensure that end objective of	▪ Wide scale broadband usage in rural areas in line with NTP-2012 within the stipulated budget	▪ Enhance broadband penetration at rural level contributing significantly towards achieving of NTP 2012

Stakeholder	Role in GUN over NOFN	Requirements / Expectations	Potential Benefits
	broadband proliferation and service delivery is fulfilled	▪ Delivery of services to rural population	▪ Increase in the bandwidth penetration in rural areas ▪ Bridging the digital divide between urban and rural India ▪ Better utilization of existing NOFN investment ▪ Making broadband based services available universally across rural India
Ministry of Rural Development (MoRD)	▪ Act as the "Anchor Customer" ▪ Provide funding for Operational Expenditure (OPEX) ▪ Effective utilization of allocated bandwidth by deliver of ePRI services to rural population	▪ Availability of communication infrastructure from District to GP ▪ Availability of low price Wi-Fi broadband services at GP level for general usage by rural population ▪ Broadband connectivity to 2 government institutes ▪ Appropriate interconnect provision at District and GP ▪ Provisioning of required QoS across all the above mentioned components for effective delivery of their services	▪ Delivery of ePRI services through high-bandwidth network ▪ Availability of a single agency for communication network service from District to GP ▪ Access to communication infrastructure till GP level without having to incur CAPEX
Other Central & State	▪ Utilize the communication	▪ Availability of communication	▪ Reliable channel with assured QoS

Stakeholder	Role in GUN over NOFN	Requirements / Expectations	Potential Benefits
Government Ministries and Departments	infrastructure setup for service delivery	infrastructure from District to GP at the required QoS for effective delivery of their services	to provide Government Services up to GP level. ▪ Ability to make government service available at last mile at low infrastructure investment ▪ Faster rolling out of services due to readily available network with higher bandwidth penetration. ▪ Improved Capacity building via remote centralized training sessions
Bharat Sanchar Nigam Ltd (BSNL)	▪ As the infrastructure provider, share/lease existing infrastructure that can be reused in the GUN project. This includes dark fiber between Block and District, District PoP Infrastructure and facilities etc ▪ As the service provider, Utilize District to GP communication network to offer B2B, B2C and G2C services to rural	<< Yet to be consulted >>	▪ Revenue from the existing capacity between District and Block by leasing dark fiber to BBNL ▪ Opportunity to offer broadband services to rural population

Stakeholder	Role in GUN over NOFN	Requirements / Expectations	Potential Benefits
	population		
Department of Electronics and Information Technology (DeitY)	▪ Identify and enable delivery of relevant services for rural population from various departments and ministries	▪ Availability of communication infrastructure from District to GP at the required QoS for effective delivery of the services ▪ Utilize District to GP network as a last leg for NII 2.0	▪ Availability of high-speed reliable connectivity for delivery of existing NeGP services ▪ Increase in people participation in availing services at rural level due to broadband at doorstep ▪ A variety of services can be delivered including information, interaction and transaction services such as rich multimedia based content delivery. ▪ Higher sustainability of programs on account of better access on higher bandwidth for managing infrastructure and undertaking the capacity building. ▪ Optimal utilization of service delivery assets.
Private Entities and Service Providers	▪ Provide lease on dark fiber available between District and Block ▪ Utilize District to GP	▪ Availability of broadband communication infrastructure at the required QoS and cost that can create a business case for them to tap into	▪ More viable access to rural market through interconnect points provided at District level ▪ End to end single window for

Stakeholder	Role in GUN over NOFN	Requirements / Expectations	Potential Benefits
	communication network to offer B2B, B2C and G2C services to rural population	the rural market	communication network service from District to GP ▪ Overall reduction in bandwidth cost that will make the delivery of service more viable ▪ Higher ROI for products and services due to higher consumption spread for services ▪ Contribution in community development by creating job opportunities for the locals at GP level

Table 2: Stakeholders Analysis

In order for the above mentioned benefits to be realized, GUN project should fill in the gaps that are currently present in the infrastructure and bandwidth supply ecosystem.

4. Gaps in current ecosystem

This section aims to highlight the key gaps that exist in the current ecosystem and the ecosystem that will be created after commissioning of NOFN vis-à-vis the stakeholder's expectations as listed down earlier. It also highlights the strategic options available to fill these gaps in order to realize the stakeholder benefits.

Gaps that need to be addressed to meet stakeholder needs

1. **Ability to offer a single window service for providing high speed communication network from District to GP level**

Based on preliminary discussions with service providers, most of them have their presence till District level in the country. In order for them to deliver services at the rural level, they have to deal with multiple service providers along different segments of the network i.e. one service provider from District to Block and another from Block to GP. On a pan India basis service delivery in this scenario becomes even more complex. A single service provider who can guarantee end to end connectivity and QoS to them would make service delivery at GP level viable.

Following options were considered as responses to address this gap.

S. No.	Options	Evaluation	
1.	For Service delivery user departments could engage a 3rd party service provider for providing bandwidth between District and Block. This service provider will lease bandwidth from BBNL for providing connectivity between Block and GP, thus offering a single window service to end customers.	Each user department will have to engage with a service provider which would lead to disaggregation of demand and inefficiencies in service delivery roll out.	
2.	BBNL to extend its network from Block to District so that it can offer end to end network to other service providers	BBNL will be able to offer end to connectivity with centralized non discriminatory terms applicable to all user departments. This would lead to demand aggregation and efficient use of capacity.	

Table 3: Options for Gap 1

2. Ability to aggregate communication assets owned by various players and consolidate their dispersed capabilities to offer pan country network reaching up to the rural areas

As per data collected from key TSP (Refer section *A.2:Dark fiber availability between District and Block*), there is substantial investment done by them on creation of OFC network between District and Block. A large part of that capacity is lying unutilized. There is a need to consolidate this capacity and offer it as a pan India bandwidth service.

S. No.	Options	Evaluation	
1.	Consolidate the available capacity under a neutral player who can play the role of an aggregator, convert it into bandwidth capacity and offer the same to service providers on a non-discriminatory basis	BBNL being one of the non-interested players in the retail services market, fits the bill for playing the role of such an aggregator. Moreover, since the Block to GP network is also being built by BBNL, it will be able to offer end to end service under a single umbrella	✔

Table 4: Options for Gap 2

3. Ability to aggregate demand emanating from various service providers so that an optimal solution for supply against the same can be designed and implemented

S. No.	Options	Evaluation	
1.	Consolidate potential demand from Government Ministries & Department and Private Players and create a communication platform that can be used by various service providers	Network to be built from District to GP should be technology agnostic from the point of view of interconnecting different networks.	✔

Table 5: Options for Gap 3

4. Availability of low cost broadband communication network that can enable service providers to create a viable business case for delivery of service to rural population

S. No.	Options	Evaluation	
1.	Create the network and subsidize bandwidth cost from District to GP for enabling service providers to create viable business case for delivery of services to rural population.		
2.	Rope in an "anchor customer" who will at least partly fund the network.	Since an OFC network has the capability to augment the capacity at low incremental cost, the additional capacity beyond what is required by anchor customer, can be created quickly and offered to other service providers at very low cost	

Table 6: Options for Gap 4

5. Low cost last mile access to broadband network for rural population

Usage of broadband in rural India can only be triggered by actually providing the population with easy last mile access. Since NOFN is envisaged to terminate at GP, the last mile access issue is not addressed.

S. No.	Options	Evaluation	
1.	Encourage ISPs to build last mile connectivity for providing broadband access to rural population	Due to lack of enough demand of bandwidth in rural areas to start with, private ISPs have refrained from making the initial investment in building the last mile for villagers to access broadband. This has become amply clear from the response received from service providers during pilot.	
2.	Create infrastructure to provide broadband access at a community level rather than at individual level	Community Wi-Fi service can be provided as part of GUN project. This will remove the reliance on ISPs to try and build the business	

S. No.	Options	Evaluation	
		case. Initial access to broadband may, over a period of time, trigger enough demand for private players to create business case for building last mile individual level connectivity.	

Table 7: Options for Gap 5

6. Last mile connectivity to key Government institutions from the GP to enable relevant Government Ministries/Departments to immediately start delivery of service

NOFN network is envisaged to terminate at GP. However for government departments such as MoHRD, MoHFW etc to deliver their services, connectivity would be required to their relevant government institutes such as School, Primary Health Center, Police station etc. Absence of last mile network acts as a barrier to usage of network for delivery of services.

S. No.	Options	Evaluation	
1.	Provide last mile connectivity option such as wireless RF in the design so that as and when required the government institutes can be connected to the network fairly quickly	Wireless RF may not be a feasible and reliable option in all scenarios. This may be taken up on a case to case basis	
2.	Connect at least the key institutes as part of the network setup while keeping the option open to connect to more institutes at a later time	Identify the key institutes and connect them to GP as part of initial setup while leaving options in design to connect more institutes if required	
3.	Connect government institutes to GP using the broadband Wi-Fi evaluated above	This option may work in some of the cases where the services can be accessed over the internet and where the government institute is within the vicinity of GP	

Table 8: Options for Gap 6

5. Technical Solution

5.1. NOFN Architecture

The NOFN is being built as a GPON based network between Blocks and GPs to connect 2.5 lakh GP locations across the country with Blocks. Objective of NOFN is to enable multiple service providers to integrate with NOFN at Block level and deliver their services at GPs. A diagrammatic representation of the NOFN architecture is as shown in figure below.

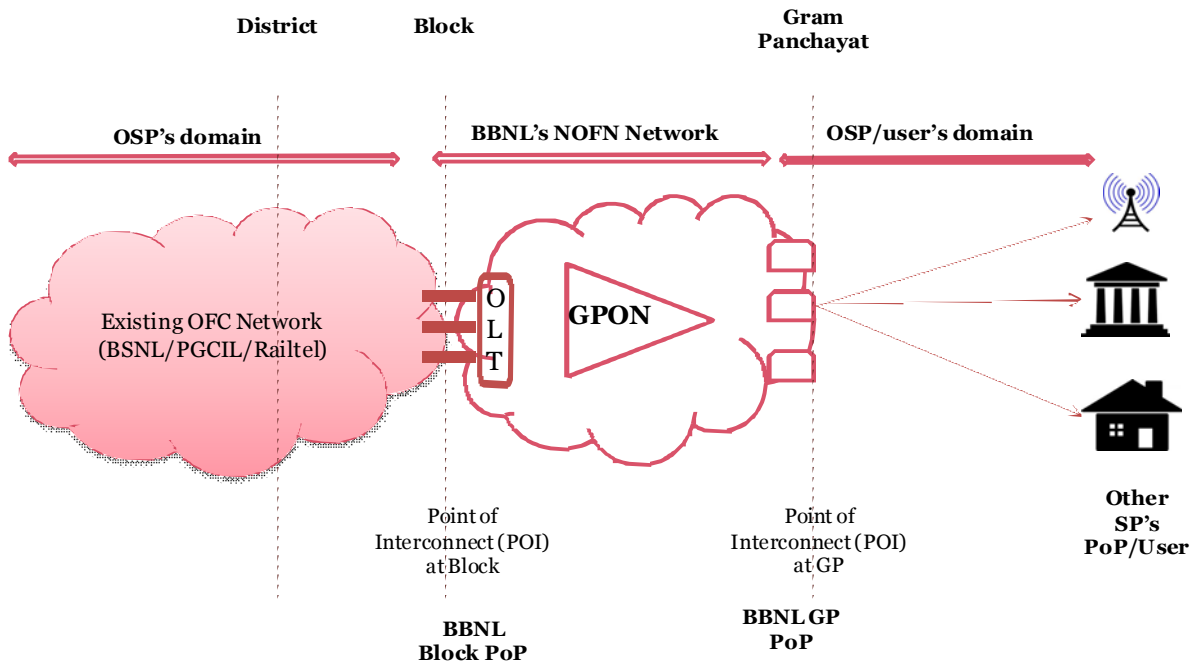


Figure 2: AS-IS: Network Architecture (NOFN)

BBNL has planned to create necessary infrastructure to manage and operate this GPON Network spanning across the country. Various infrastructure components under development with BBNL to cater to the aforementioned requirement include:

- Data Communication Network (DCN)
- Network Operations Center
- Business and Operations applications
- Data Center (DC) to host applications and Disaster Recovery (DR) site

Based upon discussions held with various officials in BBNL, following figure illustrates the detailed solution architecture of NOFN project along with integration of various internal and external components as of now:

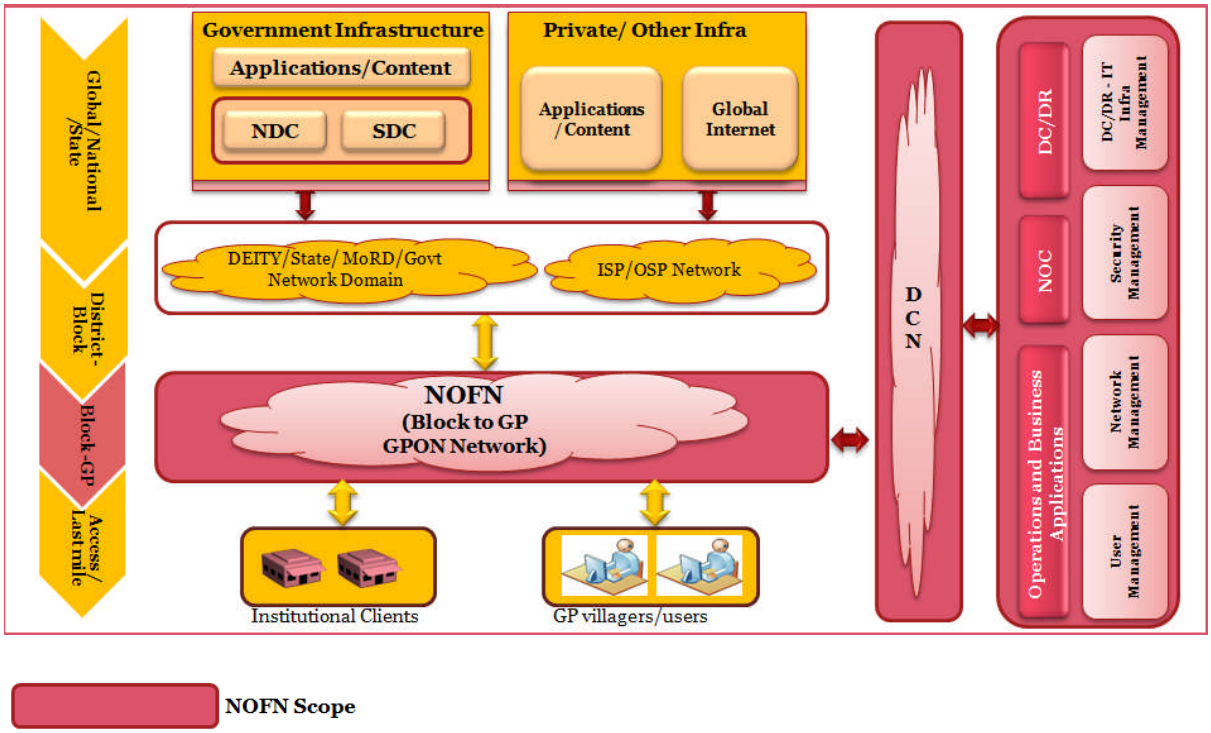


Figure 3: NOFN Architecture

5.2. Proposed GUN over NOFN Architecture

From a technology standpoint, GUN Over NOFN aims at achieving following two functionalities:

1. Extend the NOFN connectivity from Block to District level
2. Extended connectivity at GP level to connect minimum two institutes and provide community Wi-Fi services at GP level

Diagram below identifies the extensions proposed part of creation of GUN over NOFN architecture

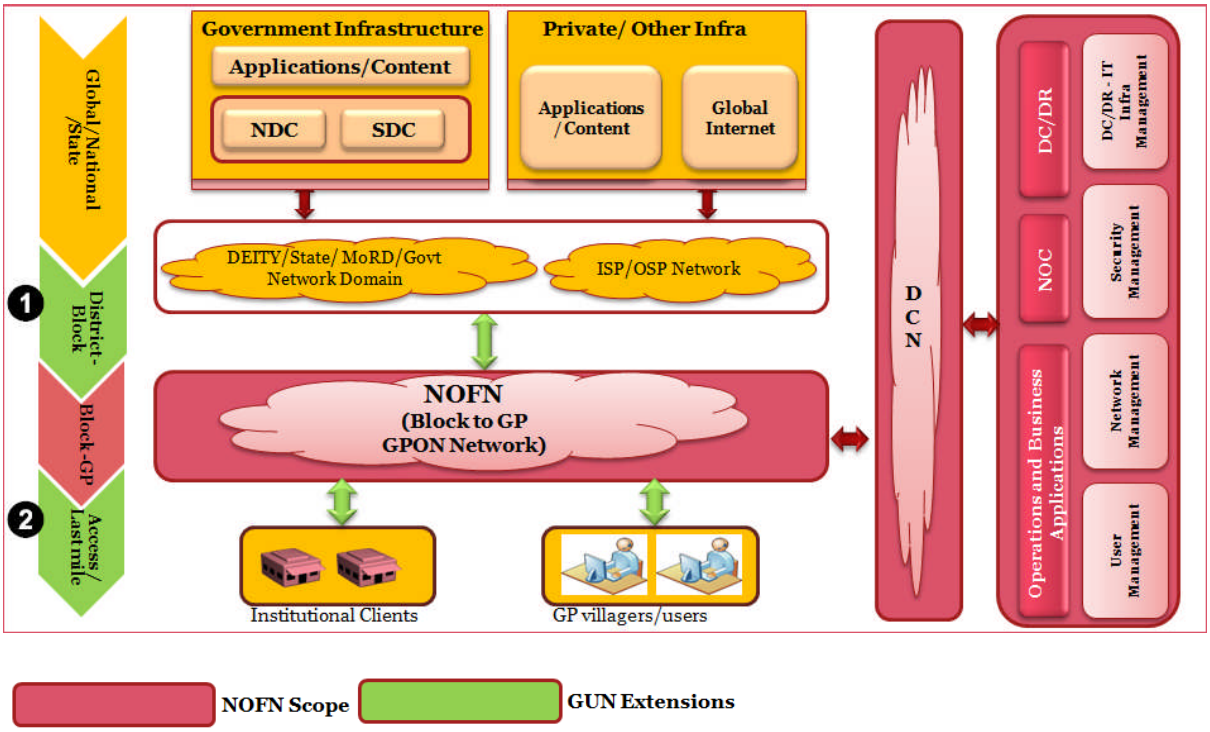


Figure 4: GUN over NOFN Architecture

Based on above the proposed Network Architecture will have additional connectivity between:

- Blocks and District: There are 6000 Blocks, however some large Blocks has been divided into two NOFN segments. Thereby the total number of OLTs stands at 10000. These 10000 OLT would be connected to their respective DHQ.
- BBNL GP PoP to the identified institutions and GP users

This will provide a point of interconnect with other network at District level. It will also reduce the POIs required for launch of a nationwide service from 10000 to 600. The existing 10000 OLT locations would still be available for POI if required by some users.

The detailed To-BE network architecture to meet the objective of GUN over NOFN is given below.

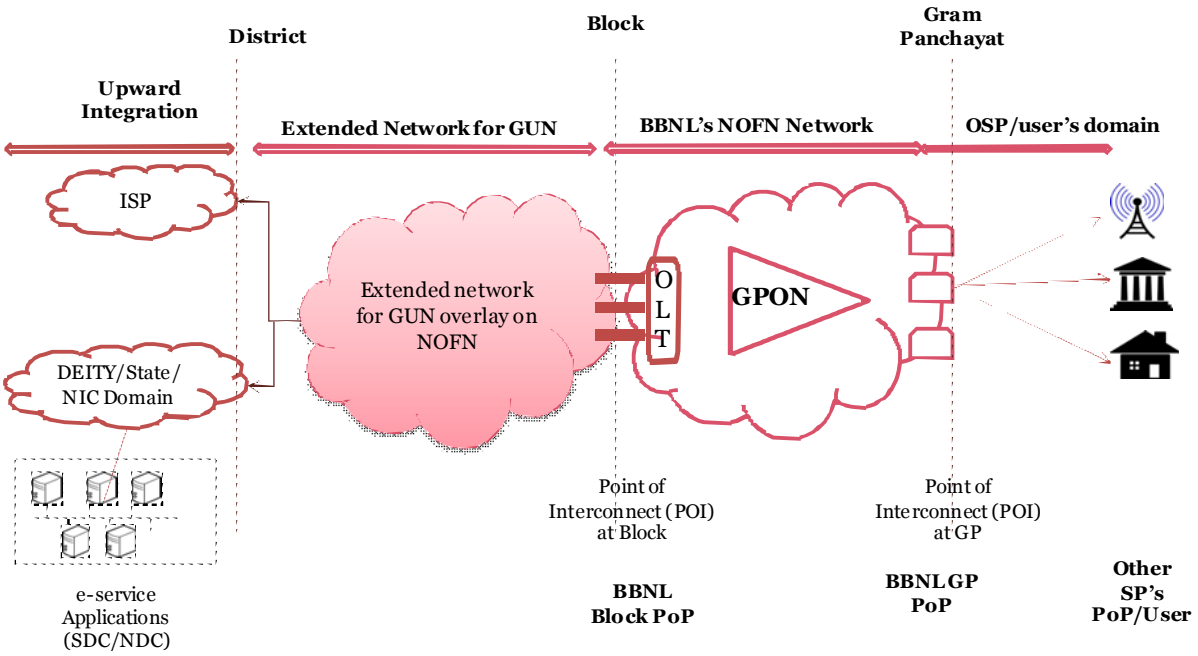


Figure 5: To-BE: Network Architecture – GUN overlay on NOFN

In addition, required components would need to be added to the network management infrastructure planed for NOFN to enable management of GUN over NOFN components. These additional components required to manage the GUN over NOFN network infrastructure are described in section *5.4:Network Management Infrastructure*

5.2.1. Backward Aggregation at District Level:

Backward integration of connectivity from Block to District is one of the key elements of the project. Proposed solution is required to integrate with Government and private infrastructure at District. The Network to be deployed between Block and District will

1. Connect with NOFN network at Block level
2. Integrate with upstream network (Government/Private/ISP) at District level

This section of the network will carry traffic of many Blocks and hundreds of GPs, hence the proposed network should be able to meet high bandwidth and scalability requirements.

Key features that this network should support are:

- **Type of Network**: The Network between Block to District will be integrating with IP-MPLS based Core network of Government i.e. NKN/SWAN/NII and private players. Accordingly the network technology between Blocks and District will function as **Aggregation Network.**

- **Seamless Connectivity:** The extension created from Block to District should be able to connect seamlessly with the NOFN network.

- **Topology:** As discussed in section *5.2.1.4:Topology Architecture* the Block to District network will have different network topology based on geography and availability of fiber. Various applicable topology options based on different scenarios are details in a separate section.

- **Bandwidth Capacity/Scalability:** The Block-District section should be able to cater the B/W of 1-2 Gbps per Block and should be able to aggregate it at District. The aggregated B/W at District will depend on number of Blocks in a District, However in most of the cases it would be in range of **10 Gbps to 40 Gbps/District.**

- **Bandwidth Granularity**: BBNL will be provisioning B/W required from 2 Mbps to 100's of Mbps per client per GP. The same should be supported by the technology.

- **Service Features**: The Technology should support the features like QoS, Service Management, Auto-failover, Security, SLA Management etc. The Technology should support all modern services and network integration.

- **Optimized Cost:** The Technology should provide optimized Opex and Capex for the project. It should provide the optimum total cost of ownership i.e. cost of equipments, cost of Maintenance, Cost of power consumed and life of equipments etc.

5.2.1.1. Network Components

The extension network, to be created between Blocks and District, comprises of multiple components. This section provides details of these components.

5.2.1.2. BBNL PoP

As part of NOFN implementation, BBNL is creating the network between Districts to GP and will have their equipments at District, Blocks (OLT Locations) and GPs. BBNL is presently planning to collocate NOFN equipments, OLT at Blocks in BSNL exchanges and ONT at GP in its premises.

The GUN infrastructure will require additional PoP at District level. It is proposed that BBNL shall create their own PoP at District either by collocating with the NKN PoP[5] or renting a new space. Creating a new PoP at District will enable easy access to their service providers to BBNL network and hence providing end to end connectivity. However BBNL will require deploying the PoP infrastructure in both

[5] As per initial discussion, NII 2.0 has currently been deployed at around 200 Districts. It is expected to complete deployment in remaining of the 400 Districts by the year 2015

the cases. The PoP at District will require Power, cooling and facility management services from vendor to manage the PoP. Various components included in creating the PoP at District are:

- Part new fiber to be laid to connect BBNL PoP with exiting PoP/chamber of TSP)
- Part new fiber to be taken on lease from TSP to connect with NKN/SWAN/NII PoP with BBNL DHQ PoP
- Diesel Generating Set - N+1 Mode, with AMF Control Panel, 15 KVA
- Comfort AC - 1 Ton (N+1)
- On-Line UPS with isolation transformer suitable for single phase AC input & single phase AC output, Rating of UPS: 5.0 KVA, Indicative Back-up time: 120 Minutes
- Civil, electrical and furniture
- Power consumption at DHQ-PoP: - 3 KVA
    - Power consumption by AC = Ton Capacity * What conversion/ Efficiency (W/W) of 5 star * Watt to VA conversion= 1*4.4/3.1*1.2 =1.7 KVA
    - Power Consumption for PoP lighting etc :0.3 KVA
    - Power Consumption by DHQ Network equipments : 1 KVA
- DHQ PoP Facility Management

5.2.1.3. Connectivity Media

In order to cater to the high bandwidth requirement, OFC connectivity will be needed between Block and District. The fiber already laid by different service providers between Blocks and Districts will be reused by taking it on lease and mounting appropriate equipments on it for providing the required bandwidth. It is estimated that 94.3% fiber is already available between Block and Districts across the country from existing telecom Service providers (TSP), additional fiber would need to be laid in some areas as described below -

- Locations where Block to District fiber is not available/partly available
- To extend the fiber from Fiber owners PoP/nearest location to BBNL PoP. (In case BBNL PoP is not collocated in fiber providers premises)

The total quantity of fiber media to be leased from fiber providers will depend on distance, fiber route between Blocks to District and selected network topology. Based on empirical estimation from study of geography and fiber availability (refer section *A.1:GIS based survey*) across the country following is discovered:

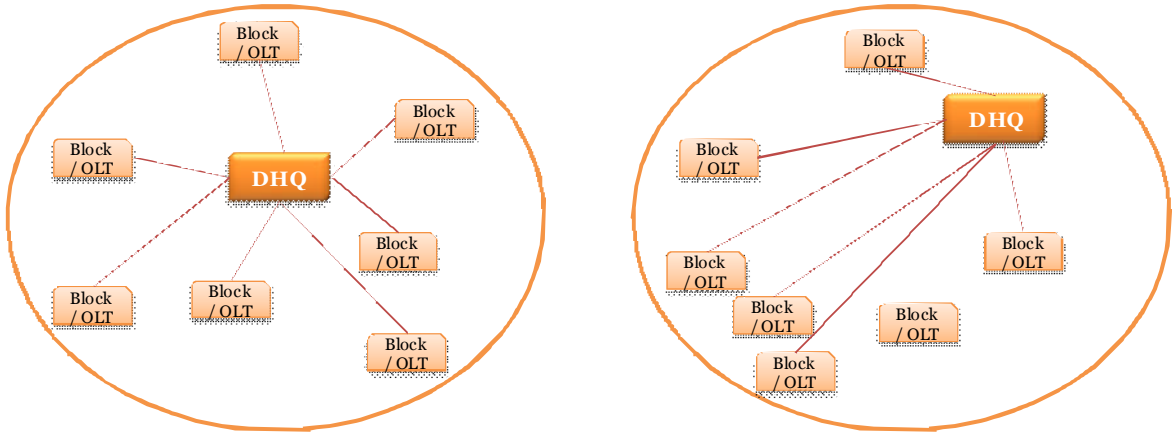
- Average fiber rote distance between District – Block: 33 KM

5.2.1.4. Topology Architecture

The Block to District Network topology will have dependency on topology of fiber already laid between Block-District and geographical presence of DHQ in District. Multiple scenarios of topology that caters for the actual fiber availability would be required. Different scenarios that may be encountered are enumerated bellow:

a. Scenario-1: Fiber is available in star topology between Block and District

This is the scenario where fiber media is connecting all Blocks directly with DHQ in Star Topology. Based on geographical situation of DHQ in the District, two representations governing this scenario are illustrated below:



DHQ Geographically situated in centre of district **DHQ Geographically situated at district periphery**

Figure 6: Network Topology: Block- District: Scenario-1

Pros and Cons of the topology:

S. No.	Pros	Cons
1	Fiber cut in one link does not affect multiple Blocks	No Redundancy in the solution, This will result in lower uptime SLA of service
2	Comparatively lower Equipment Capex at Blocks. Link shall directly be terminated on OLT at Blcoks	Higher length of fiber (in KM) required to be taken on lease.
3		Higher Opex required
4		Scenario will not be feasible for locations with fiber distance more than 70 KM

Table 9: Topology Evaluation Scenario 1

b. Scenario-2: Fiber is available in linear Star + Tree topology between Block and District

This will be the scenario where fiber will be available in star topology from DHQ to nearest Blocks and thereafter will be distributed in tree topology to connect other Blocks as illustrated below:

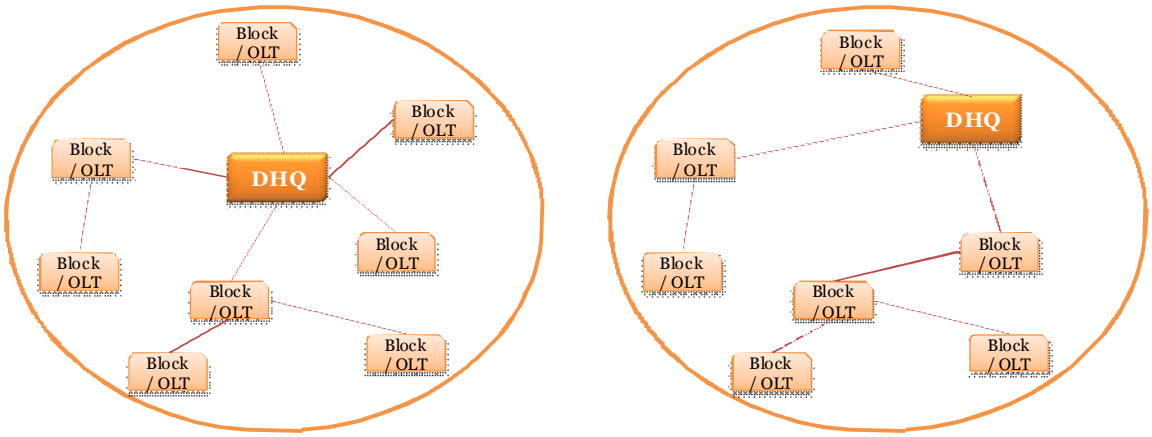


Figure 7: Network Topology: Block- District: Scenario-2

Pros and Cons of the topology:

S. No.	Pros	Cons
1	Less incremental fiber is required.	No Redundancy in the solution, This will result in lower uptime SLA of service
2	Lower Opex as overall fiber lease cost goes down	Fiber cut in one link may affect multiple Blocks.

3		Additional Capex will be required at Blocks for equipments to interconnect multiple Blocks

Table 10: Topology Evaluation Scenario 2

c. Scenario-3: Fiber is available to form a ring/multiple rings to connect Blocks with DHQ

This will be the scenario where fiber will be available between some Blocks to interconnect all Blocks together to form a ring or multiple rings to connect with DHQ as illustrated below:

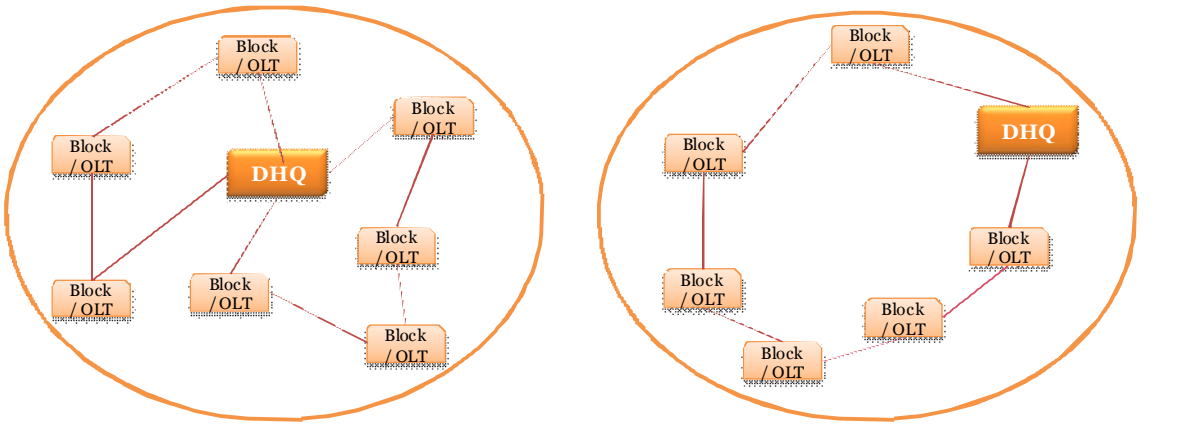


Figure 8: Network Topology: Block- District: Scenario-3

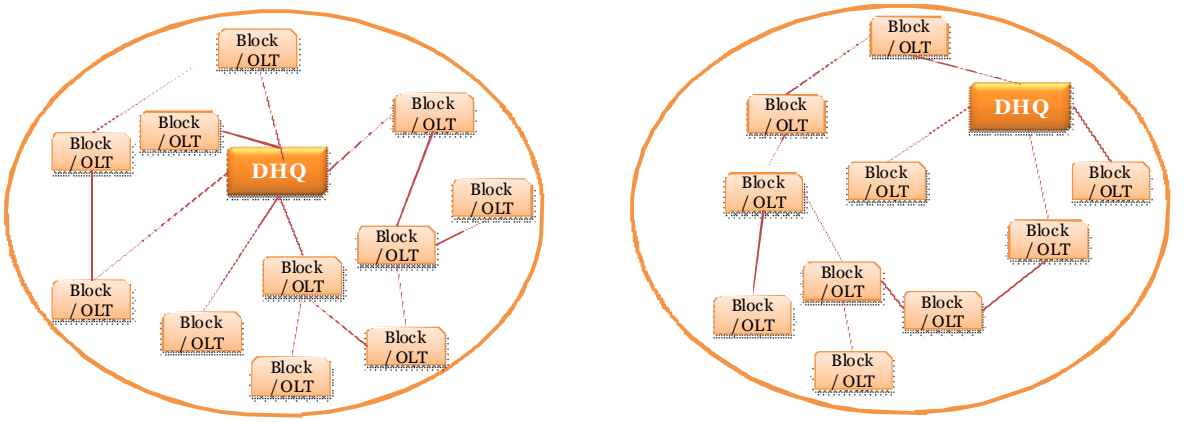
Pros and Cons of the topology:

S. No.	Pros	Cons
1	Moderate incremental fiber is required for Block to Block connectivity	Block to Block direct fiber media will be required. This may not be feasible in most of the cases
2	Moderate Opex as overall fiber lease length will be moderate	Additional Capex for equipments required at Block to form a ring
3	In built redundancy in solution topology to provide higher uptime and service SLA	

Table 11: Topology Evaluation Scenario 3

d. Scenario-4: Hybrid Topology- Fiber rings will be formed wherever possible and other Blocks shall be connected in liner connectivity with ring or directly with DHQ.

This will be the scenario where fiber will be available between some Blocks to interconnect Blocks together to form a ring or multiple rings to connect with DHQ. The rest of the Blocks would be connected using star/tree topology as dictated by the geography and availability of fiber as illustrated below:



DHQ Geographically situated in centre of district **DHQ Geographically situated at district periphery**

Figure 9: Network Topology: Block- District: Scenario-4

Pros and Cons of the topology:

S. No.	Pros	Cons
1	Moderate incremental fiber is required for Block to Block connectivity	Those connected on ring would enjoy redundancy. Those connected directly through star/tree topology would not enjoy redundancy.
2	Moderate Opex as overall fiber lease length will be moderate	Additional Capex for equipments required at Blocks to form a ring
3	In built redundancy in solution topology to provide higher uptime and service SLA for Blocks connected in ring	District to District detail planning is required
4	Most feasible scenario considering the availability of fiber media.	

Table 12: Topology Evaluation Scenario 4

Based on empirical estimation from study of geography and fiber availability (refer section *A.1:GIS based survey*) across the country following is discovered:

- Percentage of Blocks that shall be connected in ring (including the Blocks connected in ring in hybrid topology): **51.67%**

- Percentage of Blocks that shall be connected in linear connectivity (including the Blocks connected in linear/tree in hybrid topology): **48.33%**

5.2.1.5. Bandwidth Requirement

BBNL is planning to create a 100 Mbps bandwidth capability per Gram Panchyat with NOFN project. Out of this 50 Mbps will be further reserved from GUN project out of this bandwidth. This overall bandwidth will be further aggregated at Block level by GPON network. The planned connectivity between Block and District should be capable to carry this traffic from Block to District. Hence it is important to estimate the number of GP in a Block and Number of Blocks/District for bandwidth (BW) estimation.

The planned network to be laid down across the country and number of GP in a Block or Number of Blocks/District differ state to state. Considering these factors bandwidth estimation is projected in table below for average number of GP per OLT and Number of OLT locations per District:

S. No	BW/GP	GP/Block (OLT)	Block (OLT) /District	Aggregated BW/ Block	Aggregated BW/ District	Remarks
1	50 Mbps	25	17	1.25 Gbps	21.25 Gbps	Average GP and Blocks considered
2	50 Mbps	10	3	0.5 Gbps	1.5 Gbps	Minimum Blocks/GP in a District considered
3	50 Mbps	40	40	2.0 Gbps	80 Gbps	Maximum Blocks/GP in a District considered

Table 13: Topology Evaluation Scenario 5

The Actual number B/W requirement at Block and District for GUN will differ in different Districts. Considering this an aggregated B/W of minimum 1 Gbps will be required per Block to be aggregated at District. In General the aggregated B/W at Block will be in range of 1-2 Gbps from the traffic generated from GPs. The actual B/W capability of the Block equipment

will depend on the topology used and traffic of other Blocks passing thorough a Block. Aggregated B/W at District will further depends on number of Blocks and GP in a District estimated to range from 1.5 Gbps to 80 Gbps.

5.2.1.6. Choice of Technology

In order to meet the key features required from the technical solution as listed earlier, following suitable technology options are considered:

a) IP- MPLS Network

b) Carrier Ethernet Network

c) MPLS-TP based Packet Transport Network

Technologies	**IP- MPLS Network**	**Carrier Ethernet**	**MPLS-TP Packet Transport**
Service features	Support all type of service @ L2/L3 with QoS, Auto-failover	Support L2 service with QoS, Auto-failover	Support L2 service with QoS, Auto-failover
Reliability	Good	Good	Better
Best Suited for	Core Network	Aggregation/Access	Aggregation
Cost	Higher Capex and Opex (Comparatively 30-40% higher than other two options)	Moderate	Moderate
Limitation	Consume higher appliance resources i.e. processing and power consumption. Hence higher Capex and Opex	L3 Services not available. Designed for only Ethernet based services	L3 Services not available. New technology, not much existing implementations in India

Table 14: Technology Comparison

Conclusion and recommendations:

Based on above comparison it is clarified that MPLS-TP based Carrier packet transport network fits best for Aggregation network requirement of BBNL. The technology provides

better OAM as compared to Carrier Ethernet network and Cost effective solution as compared to IP-MPLS. The existing GPON network of NOFN operated on layer-2, hence there may not be much effect of not having Layer-3 functionality in proposed technology. Being a new technology and its capability to integrate with IP-MPLS network it is envisaged that this technology will sustain for longer run in Telecom industry. There are enough OEMs available in Indian market to provide the services for MPLS-TP based network.

5.2.1.7. MPLS-TP Network – Deployment Options

5.2.1.7.1. MPLS-TP Functionalities

The Multiprotocol Label Switching – Transport Profile (MPLS-TP) is a packet transport technology based on a subset of MPLS features with additional transport functionalities such as comprehensive Operations, Administration and Maintenance (OAM) capabilities, restoration and survivability, data-plane/control-plane separation, and static provisioning of bidirectional services, these functionalities makes MPLS-TP a carrier class solution. Various Functionalities of MPLS-TP are briefed below:

1. **Data Plane**
    1. MPLS Forwarding
    2. Connection-oriented Unidirectional and Bidirectional P2P and P2MP LSPs
    3. Pseudo-wires to carry L2/L1 services (Ethernet, ATM, FR, SDH etc.)
2. **Control Plane**
    1. NMS provisioning option
    2. GMPLS control plane option
    3. PW control plane option

3. **Security**
    1. The issues and areas addressed with respect to MPLS-TP security are:
    2. Attacks against G-Ach integrity, availability, or confidentiality
    3. Misuse of G-Ach to attack data plane resources
    4. ID spoofing attacks
    5. Attacks against the loopback mechanism and Authentication TLV
    6. Attacks against the network management system (NMS)
    7. NMS and CP interaction vulnerabilities
    8. MIP and MEP assignment and attacks on these mechanisms
    9. Topology discovery vulnerabilities
    10. Data plane authentication (using G-Ach or by other means)

11. Label authentication
12. DoS attacks on the data plane
13. Performance monitoring vulnerabilities
14. In-band OAM channel (GACH)
15. Connectivity Check (CC): proactive (ext. BFD)
16. Connectivity Verification (CV): reactive (ext. LSP Ping)
17.

4. OAM

1. In-band OAM channel (GACH)
2. Connectivity Check (CC): proactive (ext. BFD)
3. Connectivity Verification (CV): reactive (ext. LSP Ping)
4. Alarm Suppression and Fault Indication with AIS,
5. RDI, and Client Fault Indication (CFI)
6. Performance monitoring, proactive and reactive

5. Resiliency

1. Sub-50ms protection switch over without c/p
2. 1:1, 1+1, 1:N path protection
3. Linear protection
4. Ring protection
5. Shared Mesh protection

6. References:

1. A Framework for MPLS in Transport Networks - RFC 5921: https://ietf.org/doc/rfc5921/
2. MPLS Transport Profile User-to-Network and Network-to-Network Interfaces: RFC 6215
   https://ietf.org/doc/rfc6215/
3. Requirements of an MPLS Transport Profile- RFC5654
   http://tools.ietf.org/search/rfc5654
4. Requirements for Operations, Administration, and Maintenance (OAM) in MPLS Transport Networks – RFC5860
   http://tools.ietf.org/search/rfc5860
5. MPLS Transport Profile (MPLS-TP) Security Framework - RFC 6941
   http://datatracker.ietf.org/doc/rfc6941/
   http://tools.ietf.org/html/draft-ietf-mpls-tp-security-framework-04

5.2.1.7.2. MPLS-TP Standardization

The Telecommunication Standardization Bureau (ITU-T) and the Internet Engineering Task Force (IETF) have agreed to organize a joint project on the use of Multiprotocol Label Switching (MPLS) to meet the needs of the transport network in 2008. Standards for MPLS were to be developed by the IETF, and standards for transport networks were to be developed by the ITU-T. This joint project would result in a transport profile for MPLS technology, commonly called MPLS-TP. IETF and ITU-T has defined/drafted the requirement for MPLS-TP Architecture, Framework and OAM.

TEC has also published the specifications of MPLS-TP network, at the time of writing of this report the revised TEC-GR was in publication.

5.2.1.7.3. MPLS-TP Deployment Architecture (Block-District Network)

As MPLS-TP supports various topologies the required architecture shall be mapped to the actual topology applicable to a respective District as discussed earlier in this document. District and Blocks will require appliances with different capacity, which would need to be identified and used as per actual requirement on site. A few categories of appliances have been identified for this purpose and are given below. Illustrative deployment architecture in a hybrid network topology is also provided below.

Appliance Category	**Appliance Components**	**Features**	**Block***	**DHQ**
Type-1	10 Gbps Bidirectional Throughput. with 2*10G and 2*1G SFP Scalable to 8*1 G Ports	MPLS-TP, QoS, IPv4/IPv6, Security, management, OAM, Redundant Power Supply, Non Blocking switch fabric, 2@10 G SFP+ (Lx/Ex/Zx), 2@1 G SFP (Sx)	20%	0%
Type-2	20 Gbps Bidirectional Throughput. with 2*10G and 2*1G SFP	MPLS-TP, QoS, IPv4/IPv6, Security, management, OAM, Redundant Power Supply, Non Blocking swicth fabric, 2@10 G	70%	10%

		SFP+ (Lx/Ex/Zx), 2@1 G SFP (Sx)		
Type-3	40 Gbps Bidirectional Throughput. with 8*10G SFP	MPLS-TP, QoS, IPv4/IPv6, Security, management, OAM, Redundant Power Supply, Non Blocking switch fabric, 8@10 G SFP+ (Lx/Ex/Zx) ,	0%	50%
Type- 4	80 Gbps Bidirectional Throughput. with 16*10G SFP	MPLS-TP, QoS, IPv4/IPv6, Security, management, OAM, Redundant Power Supply, Non Blocking switch fabric, 16@10 G SFP+ (Lx/Ex/Zx) ,	0%	35%
Type- 5	160 Gbps Bidirectional Throughput. with 16*10G SFP	MPLS-TP, QoS, IPv4/IPv6, Security, management, OAM, Redundant Power Supply, Non Blocking switch fabric, 16@10 G SFP+ (Lx/Ex/Zx) ,	0%	5%

Table 15: MPLS-TP Appliance Categories

* 10% Block locations are envisaged not have new devices, these Block locations shall be connected to District by connecting OLT of these location directly with MPLS-TP device of nearest Block/District.

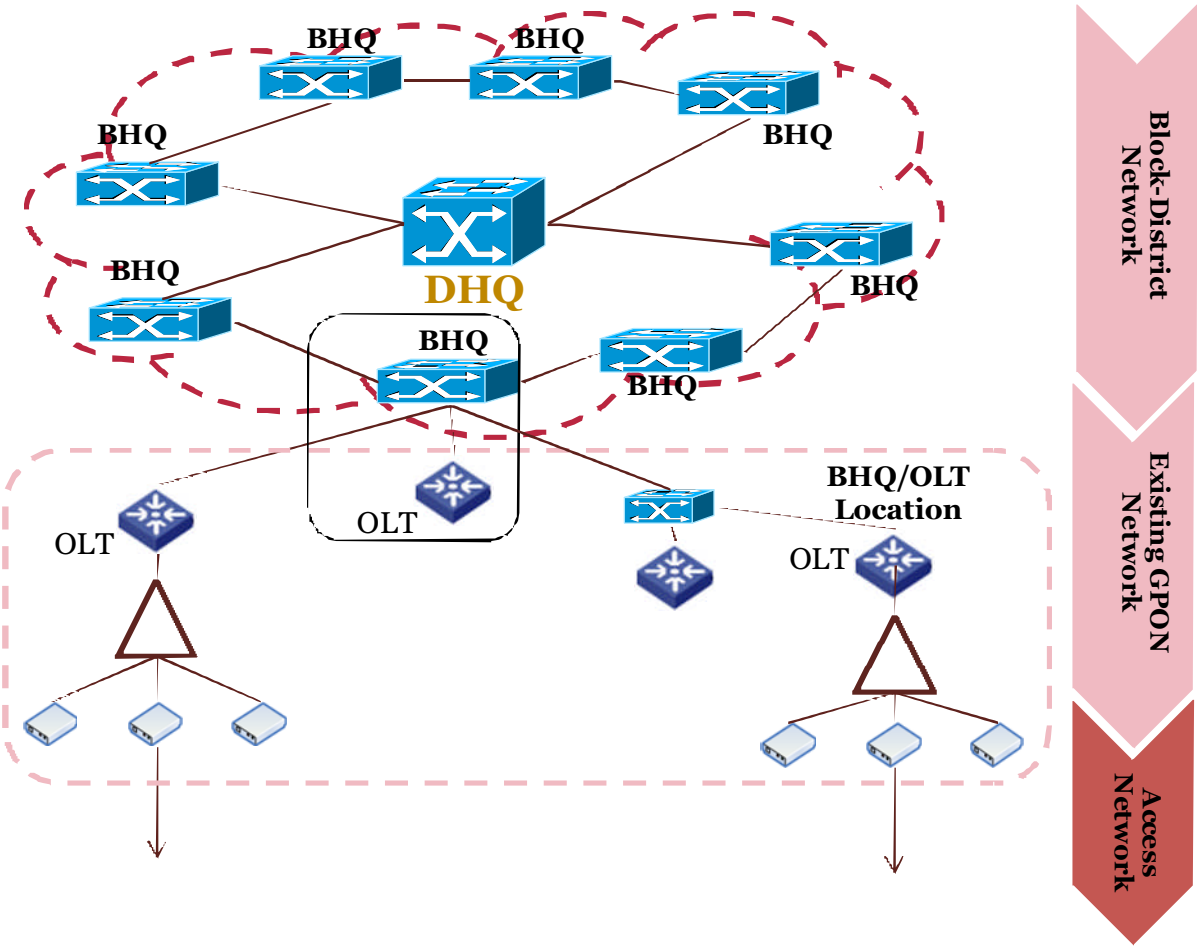


Figure 10: Deployment architecture: District to Block network

5.2.2. Access Network

The access network is required to connect BBNL GP PoP with prime GUN users at GP. As a part of GUN MoRD has identified following institutions to be connected with BBNL Network:

1. Gram Panchayt E-service delivery center
2. Two Government institutions at GP i.e. Health and educational

Various possible options and scenarios are described below for access connectivity network at GP.

5.2.2.1. Connectivity to GP E-service delivery platform:

It is assumed that GP E-service delivery centre would be located in the same building where BBNL will collocate their GP PoP, hence it shall be connected using one of the following two methodology:

Scenario-1: Using Integrated WiFi of BBNL GP ONT:

The Proposed ONT for GP as a part of NOFN has inbuilt Wi-Fi access point. This shall be one of the options to extend the connectivity to GP e-service delivery users.

Pros:

- No Physical cabling required
- No additional ONT port required

Cons and Dependencies:

- Wi-Fi signal
- Wi-Fi access point required in GP e-service delivery platform
- B/W or throughput over the Wi-Fi link

Scenario-2: Copper Wire connection to GP E-service delivery center

A connectivity using the UTP cable shall be extended from GP ONT to CPE device (L3 Switch/Router) at GP e-service delivery centre. This will not required any additional equipment at BBNL GP PoP.

Pros of the Scenario:

- No Dependency on Wi-Fi signal strength
- Additional Wi-Fi access point at GP e-service delivery centre not required.
- The link shall be terminated on E-Service delivery centre switch.

Cons and Dependency of the Scenario:

- It will consume one additional port of the ONT at BBNL GP-PoP.

5.2.2.2. Connectivity to GP Government Institutions:

One of the important deliverables of GUN project is to connect two identified Government institutions at GP. These institutions may physically lie at different location in GP hence last mile connectivity to these institutions needs to be planned. Few possible scenarios and possible way of last mile connectivity are detailed below:

5.2.2.2.1. Deployment Scenarios:

Scenario-1: Last mile connectivity to institutions by extending connectivity on UTM Cable

A few institute/s may be using the same building used by GP. Hence these institutes shall be connected directly using UTP cable. In all other cases last mile connectivity will be required as detailed in other scenarios below.

Scenario-2: Last mile connectivity to institutions by extending connectivity from existing passive splitter.

This scenario would exist when the fiber laid for NOFN passes near to the institutions where connectivity is to be provided for GUN Project. In this case fiber connectivity shall be provided to institution from GPON splitter by extending the cable from a nearest junction manhole.

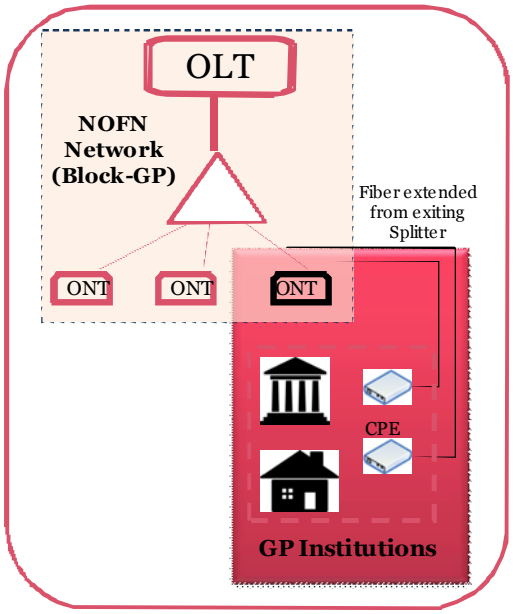


Figure 11: Government Institute Deployment Scenario 2

Pros of the option are:

- ONT to be installed at institutions shall be managed from existing EMS and NMS planned for NOFN project.
- Will not consume ports of BBNL GP-PoP ONT.

- Cons and dependencies of the option are:
  - One institution will consume one additional splitter port and there should be free ports on GPON Splitter to connect these institutions.
  - ONT will require to be installed at Institutions.

- In current tender for GPON equipments procurement all procured ONT are L2 only. This may require additional L3 device at institution.

- **Scenario-3: Last mile connectivity to institution using fiber connectivity from GP PoP:**

In this scenario the fiber will be laid down from BBNL GP PoP to Institution location. Laying the underground fiber would although provide higher uptime but will result in costlier solution and will have longer implementation time. Considering the fact that distance from BBNL GP PoP to Institutions will not be much, overhead laying of fiber shall be considered.

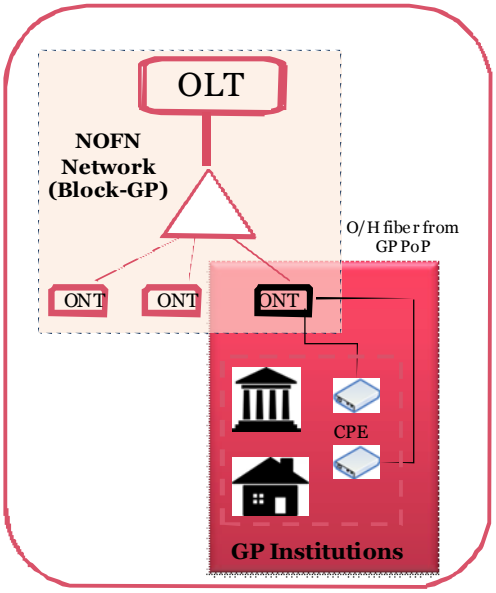


Figure 12: Government Institute Deployment Scenario 3

- Pros of the scenario:
  - No dependency on Splitter ports
  - CPE device shall be installed as per requirement without depandnacy on exsiting GPON setup.
- Cons and Dependencies scenario:
  - The solution will consume one additional port per institute of the ONT at BBNL GP-PoP
  - Will require Fiber optical convertor or SFP modules.

Scenario-4: Last mile connectivity to institution using Wireless last mile connectivity:

BBNL is planning to connect two institutions presently at GP. The number may increase in future for the requirement of connectivity for additional institutes. Wireless last mile could be an option where BBNL could deploy a wireless base station at BBNL GP PoP and wireless access radio at institutions. The same base station radio shall be utilized in future to connect other users as well.

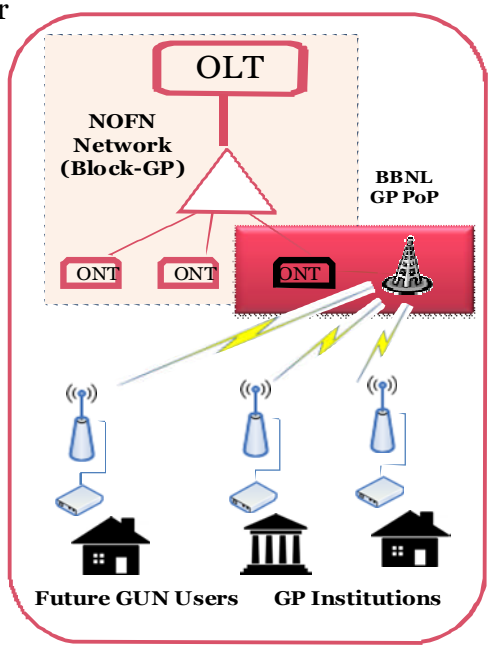


Figure 13: Government Institute Deployment Scenario 4

- Pros of the options:

- Solution provides reusability of the solution for future access connectivity requirements for other clients.
- Better central manageability of last mile as compared to overhead fiber.
- Deployment of last mile for other future locations would be easy/cost effective and faster.
- If feasibility of GP PoP and Institution comes on pole, the solution costs similar to two last miles on Overhead fiber.
- This may be automatic choice in some situations ex: Hilly/River-coastal terrains having institutes at two other ends having clear LOS.

- Cons of the options:
  - Solution requires clear line of site between GP PoP and institutions which may necessities installation of a pole/mast.
  - Locations which are in line of site may change to non-LOS due to new construction in future.
  - License band operations of wireless link will be costlier proposition. Therefore ISM band would have to be used, which is susceptible to interference. Although interference may not be an issue in GP in current scenario but may cause an issue in some locations in future in case other similar installation come up.

5.2.2.2.2. Recommendations for last mile connectivity for Institutions:

The institutions shall be connected with GP PoP of BBNL using an appropriate mode of last mile connectivity as discussed in various possible scenarios. Various possible last mile connectivity media options are compared below:

Media Options	**Underground Fiber**	**Over head fiber**	**Wireless (RF)**
Pros	▪ Higher Reliability ▪ Lower cost of maintenance ▪ Longer life of laid fiber ▪ Good Quality of Services	▪ Cost effective ▪ Faster Rollout ▪ Good Quality of Services	▪ Point to Multipoint solution ▪ Fast rollout of services, Lower Operational cost, Low cost of addition of new customer ▪ Provide higher uptime comparative

Media Options	Underground Fiber	Over head fiber	Wireless (RF)
			to over head fiber
Cons	▪ Higher cost of laying (5-10 Times than overhead) ▪ Longer Rollout time ▪ Permissions related issues to lay the fiber	▪ Low Reliability: Frequent cuts may cause higher downtime ▪ Higher cost of maintenance ▪ Short life of laid fiber ▪ Overall throughput may reduce as distance increases ▪	▪ Non Line of Site (LoS) and interference shall cause issues ▪ Requirement of mast/tower will increase the cost ▪ Low Reliability : Packet drops and jitters are comparatively higher than fiber ▪

Table 16: Last mile connectivity options comparison

a. <u>Recommendation for Last mile connectivity media:</u>

- Locations with Less than 70 Mtrs shall be connected directly using UTP cable.
- Fiber provide better services and B/W scalability in future hence fiber shall be the preferred mode of last mile connectivity
- Considering the higher cost and complexity of implementation, underground lying of fiber shall be ruled out and overhead laying of fiber shall be considered for last mile connectivity to institutes.
- Wireless as last mile shall be used for locations where Line of Site (LoS) may be obtained on pole and distance between BBNL GP PoP and Institutions is higher. This option is a must in hilly or river coastal areas where laying of fiber may not be viable option.

b. <u>Recommendation for Choice of Fiber:</u>

The Overhead Fiber to be used for last mile connectivity at GPs should be able to interoperate with GPON network as it may be extended from existing splitter at GP. The Overhead fiber should have required tensile strengths and other required functionalities to function properly in Overhead laying scenario. Usually bands are also unavoidable in the case of overhead fiber hence using the G.652D may not be viable. Various required features of the fiber are listed below:

- **Interoperability:** Interoperable with Existing Fiber between GP-Blocks
- **Type of Fiber**: Single mode fiber
- **Number of Fiber cores:** 4 core fiber
- **ITU-T standards:**
  - ITU-T G.652D (Bend Sensitive) : x
  - ITU-T G.657 (Bend Insensitive) : √
- **Cable Strengthening and Tensile Strength**:
  - FRP Strengthening and Aramid yarn
  - High Tensile strength required for aerial deployment mode

c. <u>Recommendation for CPE device:</u>

Existing GPON ONT, Fiber modem or Wireless modem will provide the L2 Ethernet handoff at customer premises. It is recommended that additional L3 router for both the institutions and GP e service center. This will provide following additional functionalities:

- Better management and troubleshooting of issues
- Preventing customer broadcast to hit GPON/GUN network.
- End to end service provider of MoRD service shall remotely manage the CPE directly for services.

5.2.2.3. GP Community WiFi services:

MoRD is planning to provide community WiFi services at GPs. Using these service GP users/Villagers will be able to access Internet broadband connectivity. Although Basic Service providers (Telecom companies) may also provide internet connectivity to users using GPRS (2G), 3G, ADSL etc, but community WiFi will provide internet services at very nominal cost.

Advantages of Community Wi-Fi services:

- This will be the cost effective way to provide internet services, as license spectrum band is not required.
- WiFi shall be easily accessible using a WiFi enabled user devices (i.e. Laptop, Tablet, Smart phone etc.), hence user will not require procuring additional infrastructure equipment.
- WiFi can be accessed by non WiFi enables devices (Personal Computer etc.) also by using a cost effective Wi-Fi access point.
- The cost effective Wi-fi services will help in capacity building at GP level.
- The Scenario can later be upgraded by installing multiple access points in Mesh to provide better coverage within a GP if required. This can also be done by a local initiative of the GP using the local funds.

5.2.2.3.1. Deployment Scenarios

Scenario-1 : Single Access Point at GP

- Single Access point at Garm Panchayat
- One Wi-Fi access point on Pole at GP to Make a Wi-Fi hot spot around GP location

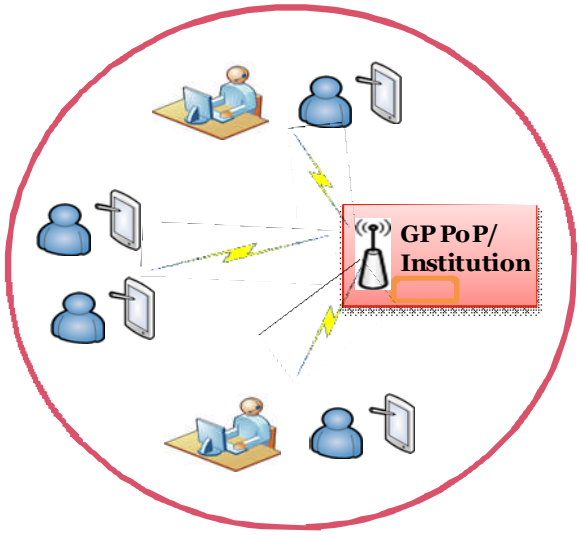


Figure 14: Wi-Fi access point deployment scenario

Scenario-2 : Single Access Point at Institution

- Access point shall be installed at one of the two Government institutions to be connected under GUN project
- One Wi-Fi access point on Pole to Make a Wi-Fi hot spot around the respective institution

Access Point feature-set:

- Outdoor/Pole mount

- Operational Band: 2.4 and 5 GHz, 802.11 a/b/g/n
- Antenna: High gain antenna (Omni directional/Sector, depending on presence of GP PoP) to cover 300-400 Mtrs area around GP (LoS)
- 2 *10/100 Base-Tx Ports
- 802.3af Power over Ethernet (PoE)
- Concurrent Wi-Fi users Connection : Min -10

5.2.2.3.2. GP Community WiFi services: Solution Architecture

Typical deployment architecture of community Wi-Fi services is given in figure below:

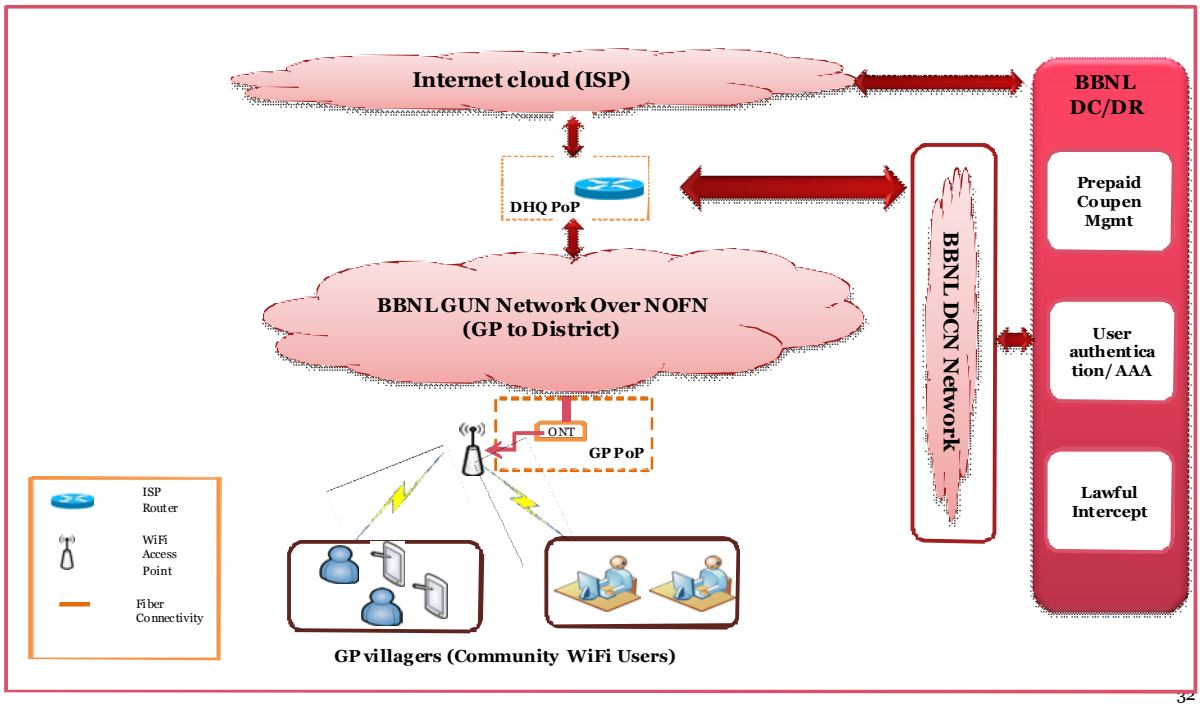


Figure 15: Community Wi-Fi Services – Solution architecture

As detailed in the architecture GP users will be able to access the Internet using Wi-Fi access point installed at BBNL GP-PoP. BBNL NoFN will further pass the traffic to Block Level and newly created extended BBNL network will forward the traffic to DHQ. The ISP router at DHQ will be responsible for NATing and user authentication from BBNL DC using DCN Network. On user authentication the traffic will be forwarded to Internet cloud.

5.3. Integrated Deployment Architecture:

The Infrastructure components detailed above from section above are required to be integrated in seamless manner for the GUN. Detailed deployment architecture for Integrated Deployment architecture for GUN is provided below. The integrated GUN Network will have following salient features:

1. GUN overlay on NOFN refers to the integrated network between GP and District.
2. The existing NOFN network is a Layer-2 network. The network between District-Block is also designed to be Lyer-2 only.
3. There are 10K aggregation points (OLT) of NOFN at Blocks to be integrated with new network to be designed between Block and District.
4. The new Block-District Network will have capability to carry minimum 1 Gbps traffic from each NOFN Aggregation Point to District.
5. The GUN Network will be integrated with Existing Government network (NKN/SWAN/NII) at DHQ and should have capability to integrate with other service provider's (OSP's - Telecom, ISP etc.) network at District. The interconnect fiber required between BBNL DHQ PoP and NKN/SWAN/NII has been considered.
6. Because of its underlying architecture the designed network is highly secure and completely segregated from the Internet.
7. The GUN Network will have Minimum 4*10Gbps uplink ports to integrate with Government/OSP network at District. Ports of integration shall be increased at DHQ at later stage by adding additional switch at District.
8. The GUN Network will be a Packet switched Layer-2 (Transparent IP) Network. Hence BBNL will not require managing customer IP addresses.
9. CPE router is planned to be installed at each institute, this shall be remotely managed by end to end service provider for customer. Hence end to end IP schema shall be maintained by customer itself.
10. The new Block to District network and NOFN will work on two different technologies hence customer services shall be provisioned separately between District-Block and Block-GP.
11. As a part of GUN project 4*10Mbps connectivity need to be provided. This will consume a few ports of ONT. In future BBNL shall add an additional switch at BBNL GP PoP in case of non-availability of ONT Port.
12. 10 Mbps connectivity to GP e-service delivery center:
    1. It is assumed that GP e-Service delivery center and BBNL GP PoP will be collocated in same premises. A 10 Mbps connectivity will be provided for the center from BBNL GP equipment (ONT)

2. A CPE equipment (Router/L-3Swicth/ONT) would be provided at institution as termination equipment. UPS Power for the same need to be provided by Institution without any charge.
3. BBNL GP PoP equipment (ONT) and GP e-service delivery center's CPE equipments shall be connected directly using UTP cable.

13. 10 Mbps connectivity to two Institutions at GP:
    1. The required last mile connectivity would be capable to carry minimum 10 Mbps traffic. Overhead Fiber and Wireless RF connectivity shall be used for the same.
    2. Power to the last mile connectivity equipments (if any) need to be provided by GP. Solar backup for the same has been considered as a part of this project.
    3. A CPE equipment (Router/L-3Swicth/ONT) would be provided at institution as termination equipment. UPS Power for the same need to be provided by Institution without any charge.
    4. LAN accessories i.e. Switch, Computer, UPS etc. are not part of this project and need to be factored by respective institution/line-ministry.
14. Community Wi-Fi Services (10 Mbps):
    1. Community Wi-Fi service will enable villagers to access broadband internet using their Wi-Fi appliances (i.e. Laptop, Teblet, Mobile Phones, computers using Wi-Fi access point).
    2. One access point will be installed at GP or one of the institutions (where fiber last mile is already provided as a part of this project) to provide the Wi-Fi hot-spot around the installation location at GP.
    3. Contention ratio of 1:50 has been considered for aggregated B/W at District Level for Internet from ISP. The same shall be increased in future as per the requirement. It will increase only the marginal Opex cost.

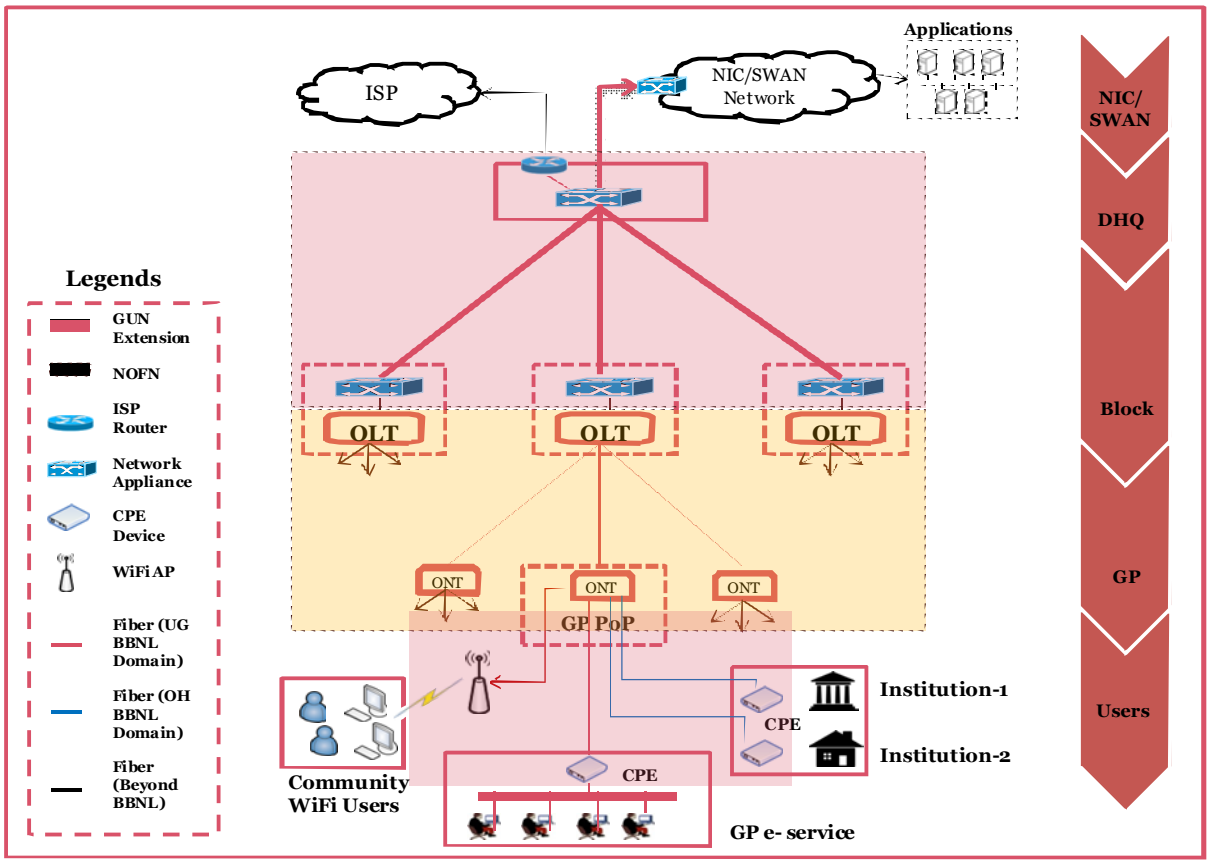


Figure 16: Integrated Deployment Architecture

5.4. Network Management Infrastructure

The Network Infrastructure created for NOFN and GUN will integrated together and will generate around 600 isolated networks. These isolated networks spanning across India need to be managed through a robust network infrastructure. Hence BBNL will require to setup and implement additional infrastructure components to convert GUN network into managed GUN network, this includes:

- Data Communication Network (DCN)
- Network Operations Center
- Business and Operations applications (BSS, OSS)
- Data Center (DC) to host applications and Disaster Recovery (DR) site
- Customer service support

The Integrated architecture of GUN with these management infrastructure components is illustrated below:

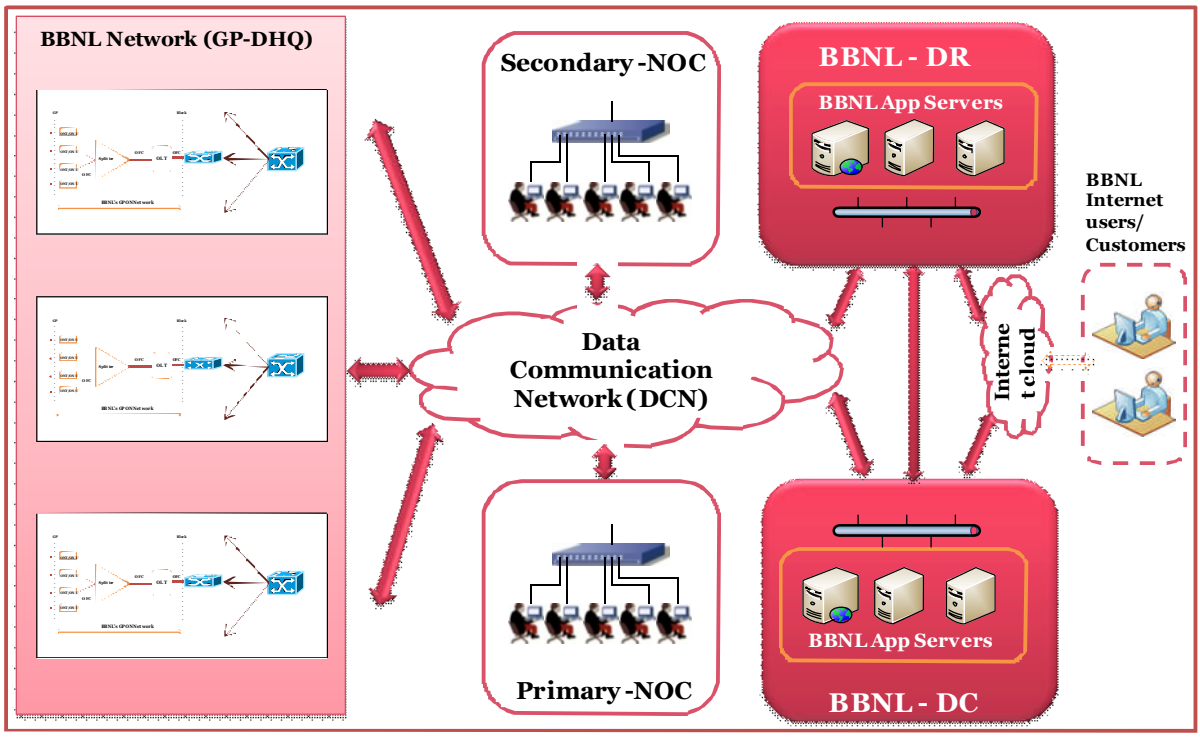


Figure 17: Managed GUN Network

5.4.1. Data Communication network (DCN):

DCN is an out-of-band network based on the configuration of telecommunication facilities for the purpose of transmitting data. DCN provides connectivity between network elements and their respective operations support systems (OSSs). Its primary function is enabling the surveillance and the status of a Telco network but it also facilitates network operations and management, such as provisioning, billing, planning, and service assurance. Therefore, it is considered to carry the network management traffic.

- Number of DCN connection required from DC/DR/NOC to network: BBNL was already planning to create a DCN network to manage NOFN network. DCN network would have been connecting 10000 OLT locations with DC/DR and NOC. Now as BBNL is planning to extend the network upto District level the overall DCN connections will dropped down to 600 only.

- DCN B/W requirement: DCN Network from District to DC/DR/NOC will carry the management traffic of NOFN, Extended BBNL network, community Wi-Fi services and CPE (customer premises equipments). The B/W requirement will be higher than the aggregated B/w required only for NOFN

Considering the above facts the overall cost of DCN will bring down as number of connection will decrease from 10000 to 600 only. Whereas the cost of DCN will increase as B/W requirement will increase. Considering both the factors it is assumed that this project will not make much difference in DCN network costing.

5.4.2. Network Operations Center

The Network Operations Center (NOC) will be the facility used for network monitoring & management. BBNL presently planning develop a 100 seat NOC in Delhi and Bangalore. The GUN project will require around 15 seats in each NOC and the same shall be collocated in the NOFN Facility to be developed by BBNL. Following resources will be required in NOC to manage the extended part of the GUN Network.

- NOC resources (Details provided in O&M section)
- Work stations
- LCD/Video wall projection
- IT support etc.

5.4.3. Business and Operations applications (BSS, OSS)

BBNL is already planning to deploy BSS/OSS suite to manage BBNL's Business and operations requirements. While the same BSS suit shall be used, few new OSS applications (NMS, LIM etc.) will require to be deployed. These additional OSS requirements are detailed below.

I. New NMS application will be required for Management, monitoring and service provisioning of District to Block Network

II. New NMS application will be required for Monitoring of Wi-Fi access point

III. Monitoring of CPE devices for institutions: It is planned that GPON network will be extended to institutions by extending the overhead fiber from passive splitter. In this case CPE ONT shall be monitored from existing CDOT NMS for NOFN. The currently planned NMS have capability of 6, 00,000 ONTs whereas 250,000 need to be installed at GP. That means 3,50,000 additional ONT to be installed at institute shall be monitored from existing NMS. Having two institutes per GP, there will be requirement of monitoring 5,00,000 CPE devices. Hence the capacity of NMS to monitor these additional 1,50,000 CPE devices need to be increased either by increasing the capacity of CDOT NMS or adding new NMS.

IV. As L2 device at customer end is being monitored so it may not be necessary to monitor the L3 CPE router by BBNL NOC. The L3 CPE router shall be remotely monitored and managed by respective customer service management team for services. However field support as and when required will be provided by BBNL OEM vendor.

V. Authentication, authorization and accounting (AAA) device will be required for Wi-Fi internet broadband services including regulatory requirement for ISP.

VI. A Billing/coupon management server will be required that will require to be integrated with AAA server.

5.4.4. Data Center (DC/DR Facility)

Data Center (DC/DR) will host all IT applications required for Network operations and support. BBNL is planning for third party data centre at two different locations in country. The same DC/DR facility will be used to host additional applications required to manage this infrastructure. There will be requirement of additional rack space to host additional application, hence cost for the same has been considered.

5.4.5. Customer Service Support:

A Customer service support center (Call center/customer helpdesk) will require to be setup to provide on-call support to customers. There will be requirement of two different helpdesks for (i) Wholesale customers (Enterprise/Telecos/ISP/Government etc.) (ii) Retails customers (community Wifi services users).

i. Support desk for Wholesale customers: The BBNL is already planning to setup a call center to cater this requirement, but there will requirement of additional resources to be deployed to support GUN customers.

ii. Support desk for retail customers: As the GUN project also include the scope to provide services to end customer in the form of community wifi services it will require a separate call center. This call center will be a multi-lingual support desk to provide on–call support to user in their local regional language.

The call center operations shall be outsourced a call center service provider on per sheet basis. The requirements of call center sheets are detailed below:

S. No.	Details	Call Centre Operational hours	No. of sheet required as per operational hours
1	Service helpdesk - Wholesale Business	4 (24*7)	4
2	Service helpdesk - Wholesale Business	8 (8*7, Business hours)	8
3	Multi-Lingual Service helpdesk - Wi-Fi Broadband services	10 (24*7)	10
4	Multi-Lingual Service helpdesk - Wi-Fi Broadband services	50 (8*7, Business hours)	50

Table 17: Call Center Requirements

6. Implementation Strategy

A comprehensive implementation strategy is required for implementation of project of this magnitude. An overall implementation strategy shall provide a reasonable framework for various stakeholders for effective implementation and coordination. This section describes various aspects of implementation strategy in detail. The Implementation Strategy for GUN over NOFN has been devised keeping in view the following considerations:

- Need for implementation framework for the overall program implementation, fiber leasing, equipment procurement and commissioning the infrastructure; at the same time maintaining uniformity of system in order to facilitate any point entry and any point service access to various users of the network.
- Need to undertake the implementation of this large-scale project in a coordinated manner through experienced implementation agencies by entrusting them with the responsibility of end-to-end implementation with a clear set of deliverables.
- Need to synchronize the roll-out of the hardware and network components with the roll-out of other equally important components such as leasing of dark fiber, connecting GPs to identified institutions via overhead fiber etc.
- Need to maintain the continuity and evolutionary path of the network for leveraging broadband as economic stimulator in rural areas.
- Need to realize the benefits envisaged by the anchor customer
- Need to do all of the above within planned time and cost budget

In order to have a holistic approach for the Implementation Strategy, following aspects have been considered:

1. Framework for GUN rollout in various regions/clusters/circles
2. Framework for Entry and Exit of System Integrators
3. Governance/Program Management Structure
4. BBNL's Strategic Control over the Program
5. Monitoring and Assessment of the Program

6.1. Framework for GUN rollout in clusters

It is envisaged that the GUN project will be implemented on a turnkey basis in an integrated manner with a clear set of deliverables and outcomes linked to delivery of broadband services to citizens. An integrated model is intended to ensure tighter coupling among roll-out of hardware, commissioning of POPs and delivery of broadband services to the citizens in line with the industry best practices. Appropriate

Implementation Service Levels will be put in place and will need to be adhered to by the implementation vendor. The implementation strategy will involve "bundling of responsibilities", to the extent feasible, of the project components such as hardware procurement, commissioning of POPs at District, Block and GP, terminating connectivity at ISP/Government cloud for upward connectivity and provisioning of connectivity at institution level

In order to carry out an effective and successful rollout, it is envisaged that States should be grouped into clusters based upon geographical proximity, size of state, number of Districts, average number of Block per Districts etc. One of the ways of creating the clusters could be to group States together so that a total of approximately 100 Districts fall in each cluster. This will result in formation of around 6 to 8 clusters. BBNL shall appoint a system integrator in each of these clusters for implementation of GUN and subsequent management and SLA delivery.

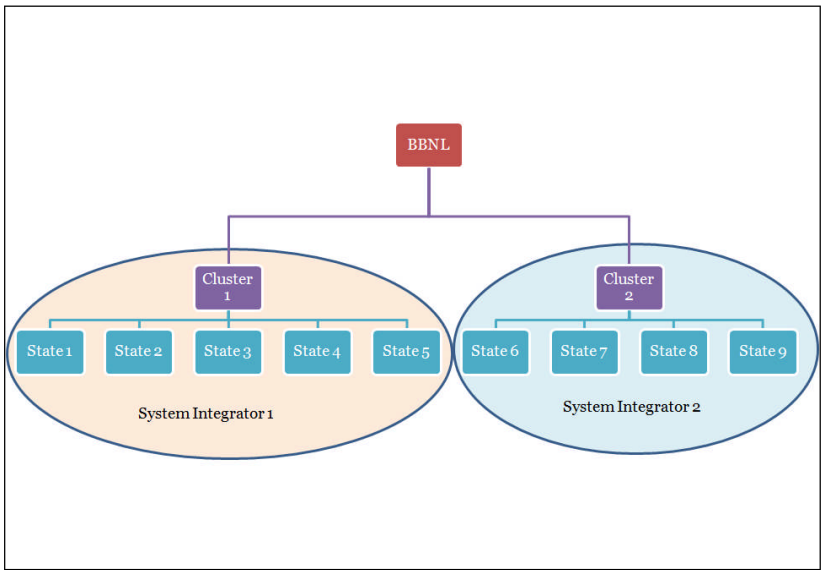


Figure 18: Implementation Clusters

Dark fiber leasing approach

For leasing of Dark Fiber between Districts to Block, BBNL shall undertake a centralized tendering process for discovering the availability and market price from various providers. A rate card along with associated SLA's shall be prepared for various categories of dark fiber. BBNL shall enter into a centralized contract with each of the dark fiber providers and shall make this fiber available for rollout of GUN to system integrators at cluster level.

System Integration approach

It is recommended that a detailed pre-requisite field survey be conducted to ascertain the implementation peculiarities of each region while also validating some of the key assumptions such as distance between GP and Government Institutes that are to be

connected with GPs. Based on this survey some of finer design elements should be tweaked and final Bill of Material (BoM) should be prepared.

It may be pertinent to mention here that a program of this size cannot and should not wait for total data clarity. The program design should allow for controlled fuzziness of data and concurrent activities for ascertaining last mile BOM and last mile implementation. The above could take about three to four months of time with the right team in place.

Based upon the final designed solution and related BoM, BBNL shall undertake the centralized empanelment of OEM's for key components of bill of material. Through an RFQ, a minimum of 6-8 vendors who will meet the minimum technical specification shall be empanelled. SI's at each cluster will be required to prepare their proposal by choosing either of these centrally empanelled OEM's. However the price of equipment in SI proposal will be required to be less than or equal to the prices quoted by the empanelled OEMs. A concurrent EOI process would shortlist and empanels prospective SI's. The above two tier procurement strategy is highly desirable for best results. However this could take around seven to eight months of time. In case this needs to be expedited, a single tier approach can be devised with technology standardization as part of preparatory work. The procurement process in this way may be reduced to four to five months.

System Integrators at each cluster shall be in-charge of managing the implementation of GUN with necessary customizations depending upon the topography requirements. Details of the qualification and selection are covered in section *6.3Framework for entry and exit of system integrators* of this document.

6.2. Bundling of Services

One of the core concepts of GUN implementation strategy is the proposed bundling of services in defining the mandate of system integrators at the cluster level. In this model, the chosen system integrator at the cluster will assume responsibility for all aspects of implementation at the cluster level with the exception of those components for which the BBNL assumes responsibility (such as the provision of the dark fiber).

Appointed SIs shall be responsible for implementation of following components in their respective clusters:

1. Implementation of PoP at District level
    i. Procurement and implementation of active and passive PoP infrastructure

ii. Connectivity between District PoP and CUG PoP

2. Upgrade of PoP at Block level
   i. Procurement and implementation of required infrastructure at Block PoP
3. Upgrade of PoP at GP
   i. Procurement and implementation of required infrastructure at GP PoP
4. Implementation of access network from GP
   i. Procurement and implementation of Wi-Fi access points
   ii. Laying of overhead optical fiber from GP to required institutes
   iii. Procurement and implementation of required CPE at the institutes

This model has been conceived in order to ensure a holistic approach to implementation at the cluster level. It is proposed that the following key activities for each of the above mentioned components be bundled together for which the System Integrator (SI) will be entrusted responsibility:

1. **Implementation:** SI shall implement and manage the GUN solution in accordance with the service level metrics defined for the project.
2. **Testing and certification:** SI shall coordinate and provide complete support to BBNL or the nominated agency in conducting the acceptance testing and certification (if required).
3. **Support and maintenance:** The SI shall provide operational support and maintenance services for a number of Years specified in the contract from the 'Go-Live' date for overall system stabilization and IT infrastructure solution maintenance, system administration, security administration, network administration and end-user problem resolution. The operational support will have to ensure that the GUN solution is functioning as intended and attending to all problems associated in operation of the system. ('Go -live' is the date on which the GUN solution is completely operational at a minimum of 25% of units of implementation in a designed cluster as per the requirements provided in the RFP and all the acceptance tests are successfully concluded as per the satisfaction BBNL. The additional unit would be added as and when the acceptance process is completed for them.)
4. **Consumables**: Supply the consumables and any other goods or articles required from time to time for continued functional operations of GUN system
5. **Help desk**: The SI shall setup the Call center with IVR facilities and Toll Free number to provide the support services, information services and status tracking services.

6. **Performance monitoring**: SI shall ensure the performance against SLAs to BBNL. The performance of the system shall be monitored and audited by BBNL and approved third party auditor and shall be part of remuneration.

The following benefits are expected out of this model:

i. Ensure that an integrated and holistic approach is taken in implementing the GUN project. Hiving off the constituent parts as separate services, will create major planning and coordination challenges that could adversely impact the quality of implementation and outcomes of the project.
ii. Hiving off separate parts of the project to different service providers is likely to result in each services provider focusing on optimizing their own component at the expense of program level optimization.
iii. This model will enable better monitoring of the performance of service providers and ensuring accountability
iv. This model is convenient from the perspective of linking system performance to the payments to be made to the service provider.

6.3. Framework for entry and exit of system integrators

In large and complex projects such as GUN it is very important to plan the entry and exit criteria for external implementation partners. This section contains frameworks that guide the entry (through an Empanelment Framework) and exit of the system integrators at the cluster level.

6.3.1. Empanelment of System Integrators

The core GUN components such as leasing of dark fiber and laying of incremental fiber, empanelment of OEM's and POP leasing is expected to be undertaken centrally by BBNL. The network will be implemented at each cluster through a System Integrator. The scope of work is to roll out GUN suitably customizing and providing for necessary infrastructure such as the hardware / any software / network connectivity / etc as required and certified for functionality, security, scalability and usability to ensure a critical minimum value to the end-users by an agency identified by BBNL.

The implementation strategy will be such that it takes care of end-to-end implementation of the various project components by a single implementing agency at each cluster. To implement such a strategy, BBNL will empanel a limited number of system integrators (SI) preferably large, reputed and experienced companies. A Committee, consisting of representatives of DoT, BBNL, NIC and DIT with adequate representation from States,

could be constituted by BBNL for deciding the modalities of empanelment of system integrators.

An Expression of Interest (EoI) will be floated by BBNL to identify eligible vendors/system integrators for each cluster. The EoI will indicate the 'bundle of responsibilities' to be entrusted to the vendors in the clusters for GUN implementation. A limited tender for cluster specific rollout will be released by the BBNL to only shortlisted vendors based on the EoI selection process and will follow the normal Bid process of the Government that will be detailed in the RFP document.

6.3.2. Managing the Exit of System Integrators

The Implementation Model should provision for Exit Management clauses with the System Integrator, which would apply on expiration or termination of the contract with the SI. Prior to expiration or termination of contract, BBNL shall ensure a smooth transfer of all assets related to GUN, application data, application configuration and customization details, license information, security passwords and up to-date documentation related to the GUN system. The System Integrator should prepare an annual Exit Management Plan that includes details of information required for smooth transitioning, such as details of employees, contractors, sub -contractors, vendors, suppliers and related third parties. As a general guideline, BBNL should ensure that the SI shall provide all such information as may reasonably be necessary to effect as seamless a handover as practicable in the circumstances.

6.4. Governance structure

To ensure effective management and monitoring of the GUN program and its implementation, strong governance structures are needed at the Centre (BBNL) as well as at the cluster level. To this extent, the following structures are proposed at the Central and cluster levels.

6.4.1. Central Level

Governance mechanism at the Central level:

i. A Program Monitoring and Review Committee with Secretary, Department of Telecom as the Chairperson to monitor the implementation of the program and provide policy directions

ii. An Empowered Committee with CMD, BBNL as Chairperson to provide necessary approvals and provide policy and project implementation inputs. The empowered committee may co-opt certain SME's as required from time to time.

iii. A Program Mission Team, below the Empowered Committee, which shall have the operational responsibility of the project including coordination with other agencies and providing directions and guidance to system integrators.

iv. Bharat Broadband Nigam Limited (BBNL) will provide secretarial and technical assistance to the program.

v. Central Program Management Office (CMPO) will be constituted to manage and supervise the program at the central level and also to collaborate with the system integrators in monitoring the program at the cluster levels.

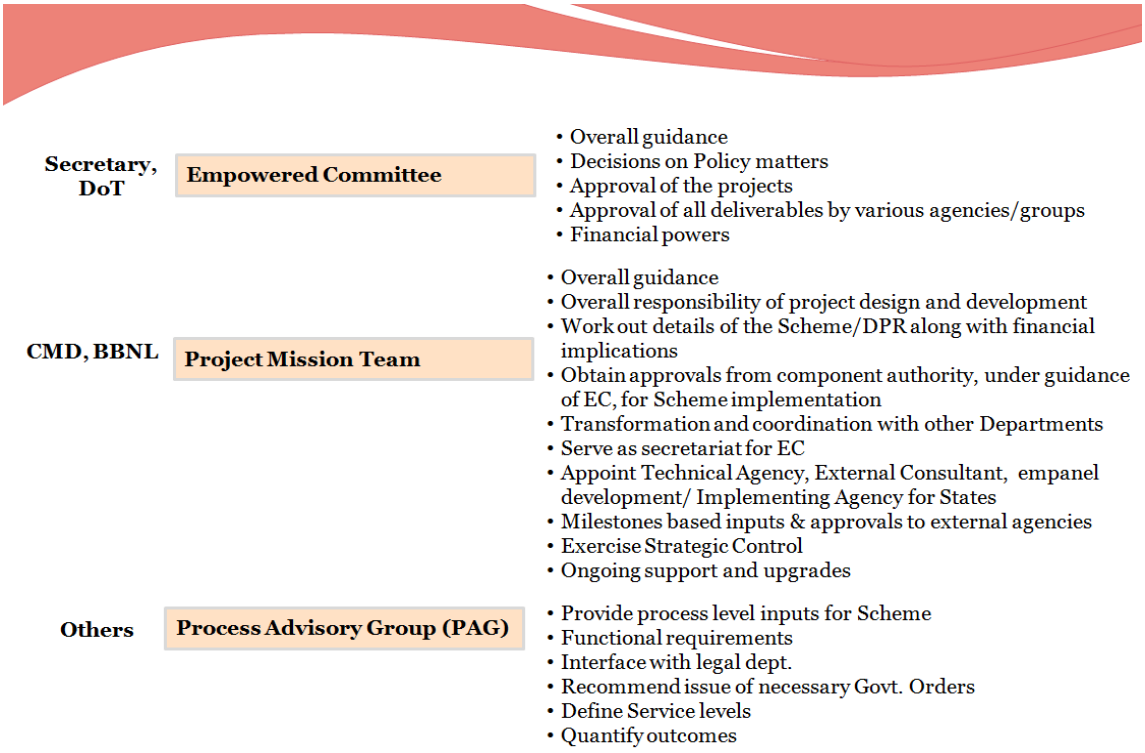


Figure 19: Overall Governance Structure at Center

6.4.2. Cluster Level

Governance mechanism at the Cluster level:

i. A Cluster Project Mission Team, reporting directly to the Central Project Mission Team, which shall have the operational responsibility of the project including coordination with other agencies in the cluster and providing directions and guidance to cluster system integrator.

ii. Cluster Management Unit (CMU) will be constituted to manage and supervise the program at the cluster level and also to collaborate with the system integrator in monitoring the program.

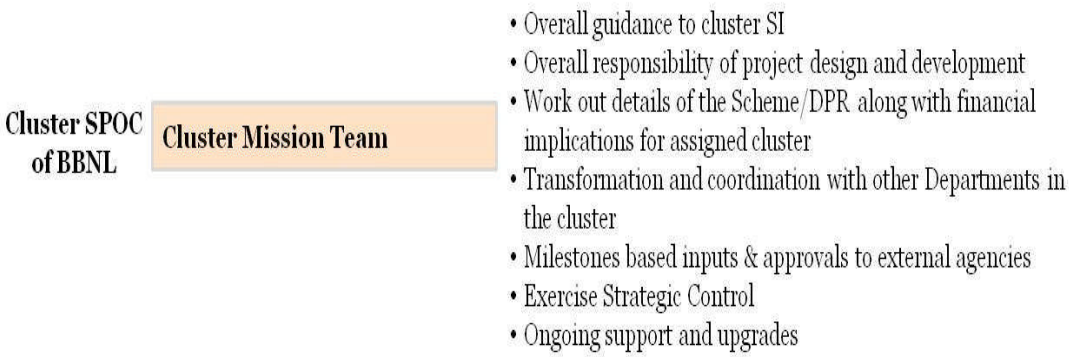


Figure 20: Overall Governance Structure at Cluster

6.5. *Ensuring BBNL's strategic control over the program delivery & performance*

The Implementation Framework has been designed keeping in view the highly sensitive nature of the GUN. BBNL should strive to retain Strategic Control over the GUN network to ensure the following:

a) That the network is installed and commissioned in a time bound and planned manner.
b) That the network is designed, developed and maintained in conformance to defined standards.
c) That any changes to the system are made under due authority of Government
d) That the GUN network is administered with utmost care and caution
e) That the security of the network is of the highest order following international standards ; and
f) That the GUN network is owned by Government

In operational terms, Strategic Control for GUN system would translate into the possession and exercise of appropriate privileges to ensure that:

i. That standards be defined clearly which govern the design principles of the core GUN design developed centrally
ii. The structure is designed to allow clusters to make any customizations and configurations without impacting the core requirements of GUN.
iii. Granting full and unlimited access to Data, applications and transactional logs to BBNL, and/or its designated agencies at any point of time.

All the above elements of Strategic Control shall be applicable to the following four areas across all units of implementation i.e. POP at District, PoP at Block, PoP at GP and Institution connectivity.

For each of these areas, guidelines are to be drawn for the three key stakeholder categories, i.e., BBNL (owner), service providers and users.

These control mechanisms can be operationalized through appropriate component(s) of the existing (proposed) governance structure.

6.5.1. Monitoring and assessment of gun

Monitoring a system and assessing the result impacts the performance of a system. Thus, continuous monitoring and assessment are key aspects of ensuring the success of a program, more so in the case of complex and long -term programs such as GUN. It is proposed that the GUN program is monitored and assessed on two key dimensions:

- Performance monitoring & SLA measurement (of system)
- Benefit realization assessment of the program

6.5.2. Performance monitoring & SLA measurement

Operational aspects refer to key parameters that cover the implementation and on-the-ground performance of the system and its components. They also cover the RASP (Reliability, Availability, Supportability, and Performance) aspects of the system. The responsibility for ensuring performance on this count lies with the system integrators working at the cluster level and is monitored primarily by the Cluster Management Unit (CMU). Monitoring of these parameters is governed by the SLAs (Service Level Agreements) agreed upon between the systems integrator and BBNL.

The activities associated with maintaining these standards fall under the following broad categories:

- Administration activities that cover system administration, network administration, security administration, IT infrastructure maintenance and storage and backup administration
- Service management activities such as Change & Configuration Management, Unscheduled Preventive Maintenance, Incident Response and Problem Resolution related tasks and activities.

Key KPIs to be measured and tracked as part of Operations and Maintenance are provided in section *8.2.2:O&M Phase KPIs*

6.5.3. Outcomes Measurement

Monitoring the business outcomes of GUN constitutes the other key component of program assessment. This assessment indicates whether and how well the core goals and objectives of the GUN program are being met. The following is a list of outcomes that

could be measured as part of the Outcomes impact assessment. The following list is indicative only, and will be developed over the course of the project:

Citizen Services

1. Ease of using various government services over broadband
2. Level of adoption of the web interface by citizens to place their requests
3. Turn-around times for receiving responses on general service petitions

Functional Department Services

1. Increase in economic level of the residents
2. Number of employment opportunities created in the given time period
3. Increase in data usage per user

Measurements by themselves may not be actionable from a performance management perspective. Measurements provide intelligence under specific context. So it is important to set the context for measurements through appropriate benchmarking. It is also crucial to continuously review these thresholds to ensure that the measurements continue to be sources of adequate intelligence.

6.6. Program Team Structure

As the central owner agency, BBNL will play a key role in the implementation of GUN to connect all 2.5 lakh GP as per agreed timelines. Some of the key focus areas are:

1. **Overall Monitoring and Control**
    a. Overall coordination, management, review, monitoring and evaluation of GUN
    b. Coordinate with other government departments, DoT, DIT, NIC and other government agencies
    c. Plan and monitor the nationwide implementation of the GUN project
    d. Assist in Formulation of the key operational aspects of Project Design
    e. Define Measurable Outcomes and Performance Assessment
    f. Facilitate policy decisions required for successful implementation of the project
    g. Provide secretarial and technical assistance to the project and coordinate with the State agencies for rollout of GUN
    h. Provide overall implementation guidelines to SI's and assist in planning and implementing GUN
    i. Preparation of necessary Guidelines on technical and functional aspects during project implementation

2. **Project Monitoring and Control of System Integrators**
    a. Select System Integrators for implementation of GUN in each of the identified cluster through the process of EOI and RFP
    b. Finalizing details of the project/DPR
    c. Milestone and timeline approvals
    d. Reviewing Functional Requirements
    e. Define, quantify and detail Service Levels
    f. Interacting with vendor(s) on an on-going basis for any exceptions / changes or additions to the SLAs and Expected performance requirements and subsequent initiation of changes to be made to the contract using standard change control procedures etc
    g. Helpdesk management
    h. Monitoring and reviewing exit management plans provided by vendor, assessing impact of exit procedures suggested by vendor on key stakeholders

A dedicated team at BBNL is required to discharge the above activities, though some of the above may be specialist function then that may be outsourced. The team needs to be made operational across three layers of project execution i.e corporate layer, cluster layer and the State layer. The **corporate layer** comprises of senior functionaries who shall closely review the project progress on scheduled basis. This layer shall exercise the decisions related to any exceptions / changes or additions to the project implementation strategy. This layer shall also review and authorize initiation of changes to be made to the contract using standard change control procedures etc. This layer shall seek necessary approvals from Central Mission Team. It is assumed that no new hiring shall be undertaken at this layer and existing team of BBNL shall be assigned this responsibility. As depicted in the diagram below this layer shall govern the cluster and state layer of program execution.

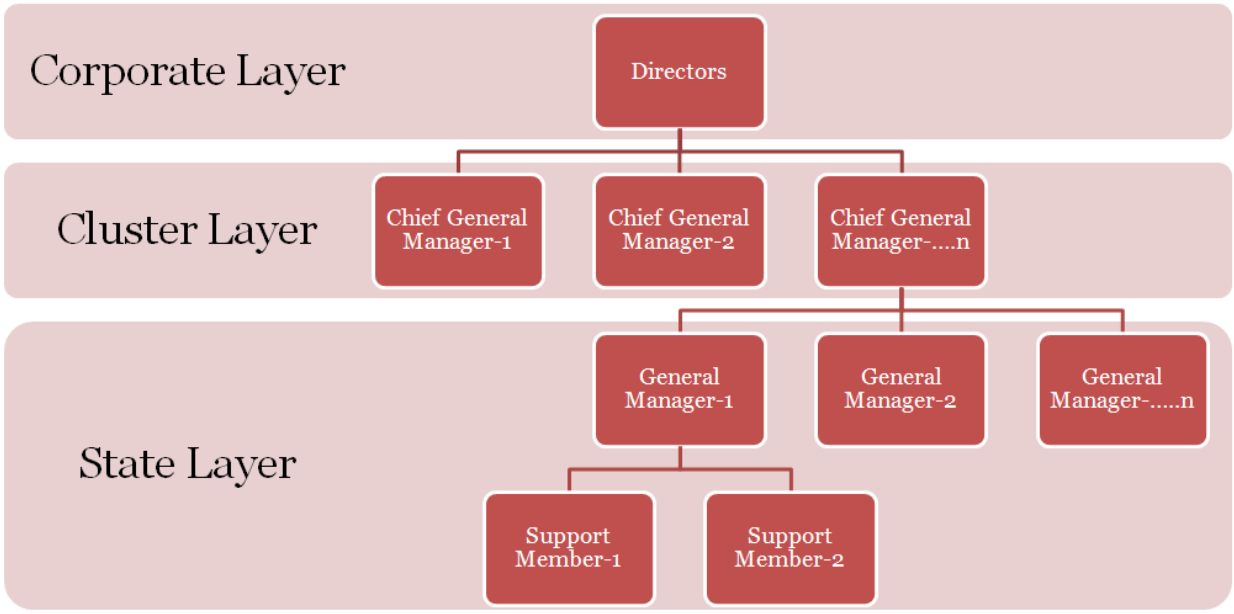


Figure 21: Implementation Team Structure

The **cluster layer** shall consist of officers of the rank of CGM's who shall manage one or more clusters during project implementation phase. This layer shall be responsible for monitoring and reporting the project progress to the corporate layer. This layer shall work in close coordination with project governance team of cluster SI. This layer shall leverage the monitoring and evaluation framework (refer section 8*:Monitoring and Evaluation Framework* of this report) for measuring the progress and provide day to day guidance to system integrator during implementation phase. Based on the survey a total of 7-8 clusters shall be formed across the country which will headed by a cluster manager each. It is assumed that no new hiring shall be undertaken at this layer and existing team of BBNL shall be used.

The **state layer** shall consist of officers of the rank of GM's who shall manage one or more States in a cluster during project implementation phase. This officer shall be supported by a team of two members who shall validate the compliance of project up to GP level. In cases of large states, based on number of District/Block/GP state can be bifurcated into divisions, and a same model of a GM and two support team members shall be assigned the management of that bifurcated part.

6.7. High level Implementation Plan

The implementation plan for GUN over NOFN is envisaged to comprise of 3 phases –

6.7.1. Preparatory Phase

This phase will involved the following activities

i. Setting up of project governance structure – This will include setting up of Program Advisory Group, Steering Committee, Empowered committee etc for delegation of duties and decision making at appropriate levels.

ii. Preparation of project delivery framework – This will entail preparation of detailed project delivery manual, project plan and other relevant guidelines and frameworks as required for successful delivery of the project.

iii. On-boarding of required resources – Mobilization of required resources at each level

6.7.2. Empanelment Phase

The implementation approach envisages empanelment of OEMs and SIs for implementation of GUN over NOFN as detailed in earlier sections. This phase will comprise of following activities:

i. Dark fiber availability and price discovery – This activity will involve engaging with service providers in the market to get information and commercial terms on leasing of dark fiber. This activity could be undertaken based on a Request for Information (RFI) process.

ii. Desktop Survey – Based on the information received from dark fiber vendors, a detailed desktop based survey will be conducted to decide on appropriate implementation choices such as topologies, equipment capacities etc.

iii. Finalization of technical design and specifications – Based on desktop survey conducted the technical design of overall solution and equipment specification will be finalized.

iv. OEM and SI Empanelment – The implementation approach envisages identification of OEMs for key equipments that meet the technical specification requirements. Selection of SIs who will carry out the final implementation work is also envisaged.

High level plan for the above 2 phases is provided below -

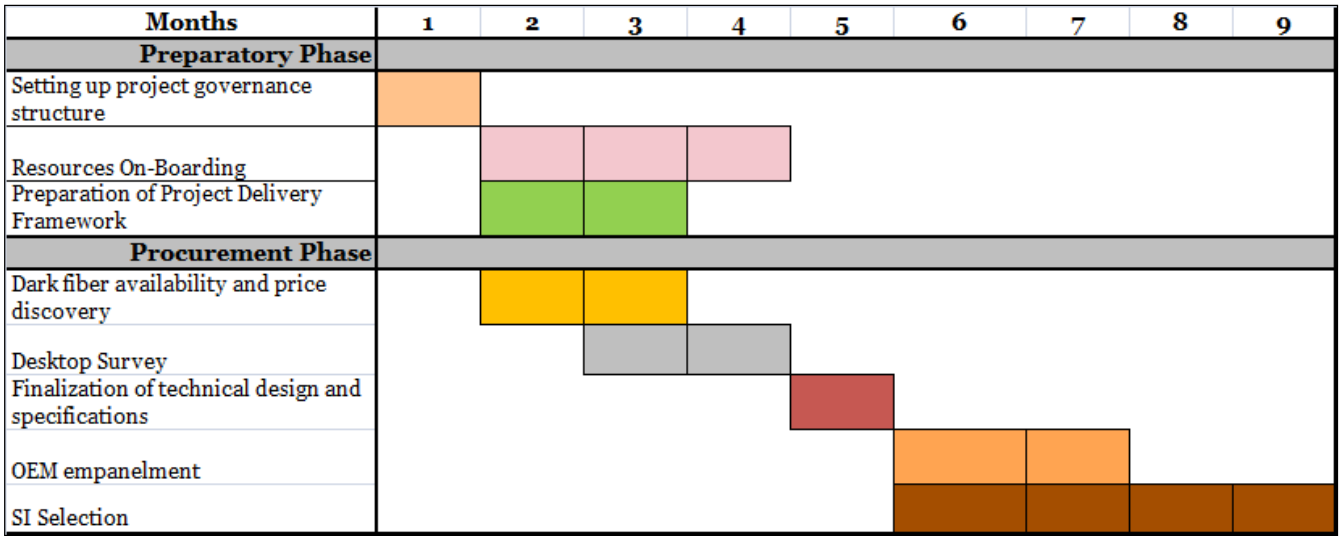


Figure 22: High Level Implementation Plan

6.7.3. Implementation Phase

After the completion of above 2 phases, implementation phase will be initiated wherein the actual installation and commissioning task would be carried out by selected SIs. Broad framework for cluster level roll out is provided below:

A	Installation and commissioning time at one GP		3 days
B	Average number of GPs in one District		400
C	Number of team days to complete installation of one District	A x B	1200 team days
D	Number of implementation teams simultaneously deployed by in one District		10 teams
E	Number of days required to complete installation of one District	C / D	120 days
F	Months needed to complete one District	E / 30	4 months
G	Number of Districts simultaneously undertaken by SI		20 Districts
H	Months needed to complete one Cluster of 100 Districts	F x 100 / G	20 months

Above calculation suggests that it will take around 20 months for completion of roll out in one cluster. With implementation of all clusters being done simultaneously by different SIs, the nation-wide roll out is envisaged to be completed in 20 months time.

Total implementation time across 3 phases = 29 months.

It is suggested that a 20% buffer time should be added to the overall implementation timeframe to accommodate for any unforeseen delays. The overall implementation time would be then 36 months i.e. **3 years**.

7. Operations and Maintenance Strategy

BBNL is creating the GUN network over NOFN network to provide end to end services between District and GP, Along with this BBNL will create the required infrastructure to manage this network infrastructure. This section elaborate on Operations and Maintenance (O&M) strategy for Network Infrastructure deployed for customer services and infrastructure created to manage the Network Infrastructure i.e. DC/DR, NOC, DCN, Application etc.

Figure alongside represents the overall O&M ecosystem. To manage the overall infrastructure smoothly it is suggested that a framework of back to back SLA with respective vendors. As BBNL will be leasing the fiber from other Telecom Service providers (TSP) that have exiting laid fiber between Block and District, the respective TSP will be managing their fiber and will provide committed SLA. Similarly Maintenance of the Network shall also be outsourced to implementation vendor bound with SLA. To manage all these agencies and SLA during implementation and O&M, there would be a need to establish a performance monitoring and SLA measurement framework for the entire program.

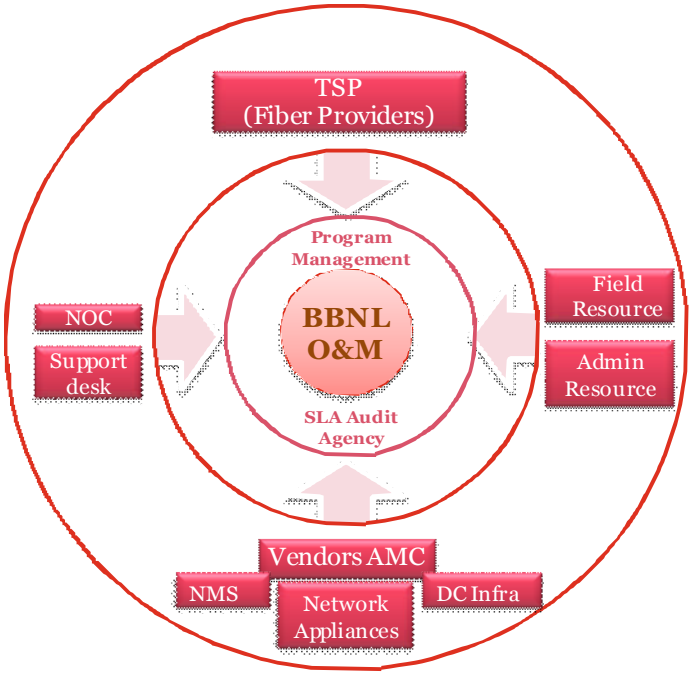


Figure 23: O&M ecosystem

The operations and maintenance (O&M) will also require certain resources to be deployed. This includes resources for Field Support, administration as well as for central management (NOC and customer support desk). The requirement of required resources is derived in this section separately.

7.1. O&M of Network Infrastructure

The BBNL GUN Network primarily includes three sections (i) Block to District backward aggregation section (ii) NOFN Network and (iii) forward extension section at GP. Out of these three parts of network, O&M of NOFN network has already been planned by BBNL. This section will include O&M of the two new sections of network proposed under GUN. To

derive the adequate O&M strategy it is important to understand the kind of faults that may arise during the operations phase and their impact on overall services.

Similar to the project implementation, the lean structure of BBNL poses a big challenge to Operations and Maintenance of the network of the scale of GUN over NOFN. The implementing agency will be responsible for overall maintenance (referred as O&M agency) of the network. Maintenance contract and the expected SLAs shall be defined in the tender itself. The O&M agency shall be responsible to maintain the SLA for whole network excluding:

iv) NOFN Network

v) Dark fiber between Block-District and PoP

vi) ISP Bandwidth

The O&M agency will be responsible for timely escalation and tracking of issues pertaining to solution components for which SLA maintenance is not part of their Scope of Work. SLA of NOFN network will be managed separately by BBNL as per NOFN O&M strategy and SLA of other two components (Dark fiber and ISP link) will be back to back from respective provider. BBNL would sign a centralized master service agreement with following entities for the purpose of tracking SLAs:

- System Integrators – responsible for overall SLA management including escalation and tracking of issues pertaining to contracts of other vendors
- Dark Fiber Providers – responsible for maintenance and SLA management of dark fiber
- ISP Bandwidth – responsible for SLAs pertaining to international bandwidth
- NOFN maintenance agency – responsible for maintenance and SLA management for connectivity between Block and GP
- POP providers – Responsible for maintenance of POPs at both District and Block level. GP PoP will be the property of Gram Panchayat, NOGN and GUN O&M agencies will be responsible to manage their respective appliances.

As part of its services SI in each cluster shall administer the SLA with above entities on behalf of BBNL. All breaches, compliances and escalations shall be compiled and reported by SI to BBNl. BBNL shall undertake the centralized payment based on report submitted by SI.

7.2. Network SLA requirements:

The overall SLA that required to be delivered to the end customer is very important as this derive the overall service quality of a service provider. BBNL GUN network SLA will have dependency on (i) SLA of Fiber provided on lease by respective service provider, (ii) SLA of NOFN Network (iii) O&M SLA of Network appliances and access network. A matrix with probable type of faults and forecasted frequency of faults is given below to forecast a probable SLA, however actual SLA will depends on actual SLA of NOFN and SLA negotiated with fiber providers.

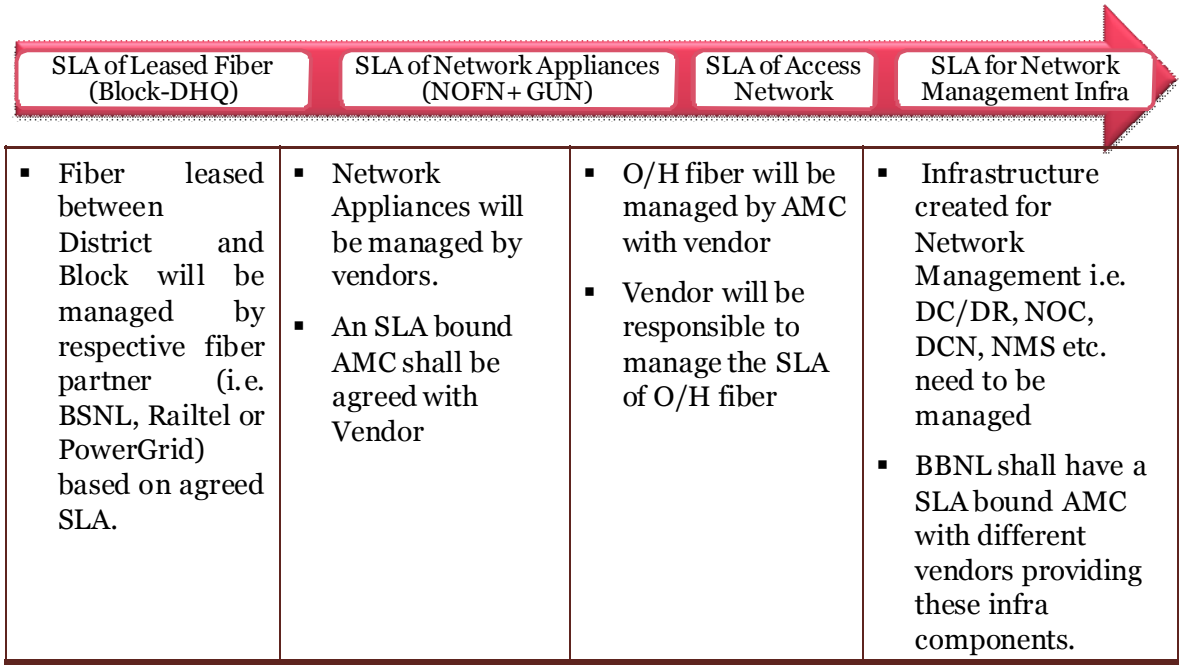


Figure 24: SLA Components

7.2.1. SLA Performance parameters for GUN services:

The SLA for the GUN overlay on NOFN will be defined by certain performance parameters. These performance parameters need to be monitored using the NMS tool to be deployed. These performance parameters are briefed below:

I. Service availability SLA:

Availability is based on the total number of minutes in a billing month during which the Gram Panchayat user connected to the District is unable to transmit or receive network traffic due to problem/issue in GUN Network. Percentage availability is ascertained by dividing the total number of minutes for which the internet service was available in a month by the total number of minutes in that month.

II. Service restoration SLA

It is the duration within which the support team needs to resolve the respective incident. This time will be calculated when an incident is assigned in the fault ticket management system till the issue or incident is successfully resolved and the status of the incident is changed to "CLOSED/RESOLVED". In case ticket is re-opened the response time and resolution time will be added to the time taken for response and resolution of the incident earlier. Resolution time includes travel time of engineer or additional time taken to resolve the issue. The O&M vendor would require to provision for adequate manpower in the field to meet the service restoration SLA.

III. Service quality SLA

Service quality includes various parameters as briefed below:

a) Bandwidth availability

Bandwidth describes the maximum data transfer rate of a network or Internet connection. It measures how much data can be sent over a specific connection in a given amount of time. The GUN network need to deliver 50 Mbps aggregated B/W for GUN users in GP. Unavailability of this B/W at GP would define the breach of Bandwidth availability SLA.

b) Latency

Latency is the average roundtrip network delay, to adequately determine a consistent average monthly performance level for latency parameters for the network connectivity. The Roundtrip Delay is expressed in milliseconds (ms). The observation period is one calendar month. Required latency parameter is to reach from GP to District interconnect of GUN.

c) Packet Loss

Packet Loss is defined as the average number of packets that are not successfully received. Packet Loss is the average ratio of total packets that are sent compared to those that are received. Ratios are based on packets that are transmitted from a network origination point and received at a network destination point (network edge to network edge).

7.2.2. SLA forecast for GUN services:

The SLA required at GP will depends on various factors like SLA of leased fiber, power availability at PoPs, equipment uptime, ISP B/W and resource deployed to restore the faults. The higher the resources deployed for O&M will result in lower service restoration time and

hence increasing the overall SLA. In the case of rural areas this picture become more prominent because of travel time required.

Hence the requirement of SLA parameters will influence the resource deployment. As the GUN services are not emergency services and comparatively longer service restoration can be acceptable, District level field support teams shall be deployed. However when BBNL would be delivering the services to other service providers (TSPs, ISPs, MSPs etc.), SLA requirement could be higher. This may enforce the deployment of field support teams at block level. This would inherently increase the overall maintenance cost.

As GUN will be initially used for GUN services, the District level field support is proposed. This shall be increased to Block level in future case to case basis, as per the business requirement of customers. The additional O&M cost for the same shall be funded from the B/W cost recovered from the respective customer in a respective District.

The SLA envisaged for GUN services are given below:

S. No.	SLA Parameter	During the day hours (Morning 7:00 AM to 7:00 PM)	During the Night hours (Evening 7:00 PM to Morning 7:00 AM)
1	Service Availability	90%	75%
2	Service Restoration Time	12 Hours (Excluding Night hours)	
3	Bandwidth availability	>= Committed B/W	
4	Latency	< = 30 ms	
5	Packet Loss (drops)	<= 1%	

7.3. Resource Requirement for O&M:

The forecasted faults need to be addressed by adequate resources to provide best services to GUN users/clients. The overall GUN Network Infrastructure will be managed from BBNL NOC supported by field resources. The requirements of these resources are forecasted below:

7.3.1. Resource required for Network Operations Center (NOC) and Helpdesk

The Network Operations Center (NOC) will be the facility used for network monitoring & management. The NOC required to manage the infrastructure created for GUN project shall have the following functions & responsibilities:

- Network Monitoring and management for

- System / Link Efficiency
- Connections / Disconnections
- Service Disruption
- Potential problems
- Manual troubleshooting and diagnostics
- Change Management

- Service Provisioning and Network Planning
- Customer Helpdesk

BBNL is already planning to deploy a NOC facility in redundancy and load sharing at two different locations across India. The same facility shall be used to deploy additional resource required to manage the additional infrastructure deployed under this project. The details of additional infrastructure to be deployed are given below. These resources shall be distributed across both the NOC:

S. No.	Details	No. Of Resources/shift	Total number of Resources
1	NOC Manager	2 (8*5, Business day, Business hours)	2
2	Network Monitoring and management - L1 (BBNL Core Network)	8 (24*7) + 4 (8*5, Business day, Business hours)	36
3	Network Monitoring and management - L1 (BBNL CPE infra –Institute and WiFi)	4 (24*7) + 20 (8*5, Business day, Business hours)	36
4	Network Monitoring and management – L2	4 (24*7)	16
5	Network Planning and L3 support to NOC	2 (24*7	8
6	Service Provisioning and Network Planning	8 (8*5, Business day, Business hours)	8
7	Shift Lead	2 (24*7)	8
8	Service helpdesk - Wholesale Business	4 (24*7)	4
9	Service helpdesk - Wholesale	8 (8*7, Business hours)	8

S. No.	Details	No. Of Resources/shift	Total number of Resources
	Business		
10	Multi-Lingual Service helpdesk - Wi-Fi Broadband services	10 (24*7)	10
11	Multi-Lingual Service helpdesk - Wi-Fi Broadband services	50 (8*7, Business hours)	50

Table 18: Resource Requirements

7.3.2. Field Operations Management:

There will be requirement of resources for field operations. These resources will provide field support to NOC and will be responsible for administrative work. Responsibilities of resource required in field include:

- Field Support Engineer:
  - Support to NOC in fault restoration
  - Proactive maintenance
- Overhead fiber restoration team:
  - Vehicle with driver-1
  - Splicer-1
  - Helper-2
- Administrative
  - Coordination with all vendors
  - Coordination with customers
  - Monitoring O&M of Network
  - Schedule site visits and up-keeping check

It is recommended that field engineers and fiber restoration at District level will be provided by AMC vendors and administrative work will be owned by BBNL. BBNL has presently planed to deploy State managers (GMs) and Area Managers to manage a cluster of 4-6 Districts (around 100) to Manage NOFN. To manage the operations of GUN+ NOFN network it is recommended to place area managers at each District (Named here as District Managers). Hence there will be requirement of deployment of additional 500 officers from BBNL to manage the overall infrastructure.

7.3.3. NOC Operations Management

The Network Operations Center (NOC) will be the facility used for network monitoring & management. The NOC required to manage the infrastructure created for Gun project shall have the following functions & responsibilities:

- **Link (Services) Monitoring** – Each interconnectivity link needs to be monitored for the following key parameters:
  - Availability - Link Uptime/ down time
  - Throughput - Traffic to and out of the link and total traffic flow in a link.
  - Utilization- Traffic utilization In, Out in comparison with the allocated bandwidth, Total utilization in comparison with the allocated bandwidth.
- **Network Device Monitoring** – All the network devices in interconnected network devices need to be monitored for the following parameters:
  - Availability - Device status – up/ down, Interface status – up/ down
  - Throughput In, Out & Total - Overall traffic rate, State level traffic rate, State to National Data Center traffic rate, Data Center to Disaster Recovery traffic rate
  - Utilization In, Out & Total
- **Other Activities**
  - Service Provisioning
  - Network Planning
  - Change Management

BBNL is already planning to deploy a NOC facility in redundancy at two different locations across India. The same facility shall be used to deploy additional resource required to manage the additional infrastructure deployed under this project. The details of additional infrastructure to be deployed are given below in table- . These resources shall be distributed across both the NOC:

S. No.	Details	No. Of Resources/shift	Total number of Resources
1	NOC Manager	2 (8*5, Business day, Business hours)	2
2	Network Monitoring and management - L1 (BBNL Core Network)	8 (24*7) + 4 (8*7, Business day, Business hours)	36
3	Network Monitoring and management - L1 (BBNL CPE infra –Institute and WiFi)	4 (24*7) + 20 (8*5, Business day, Business hours)	36
4	Network Monitoring and management – L2	4 (24*7)	16
5	Network Planning and L3 support to NOC	2 (24*7)	8

S. No.	Details	No. Of Resources/shift	Total number of Resources
6	Service Provisioning and Network Planning	8 (8*5, Business day, Business hours)	8
7	Shift Lead	2 (24*7)	8

Table 19: NOC Resource Requirement

The tree below represents the overall O&M team structure; this includes both field and NOC operations:

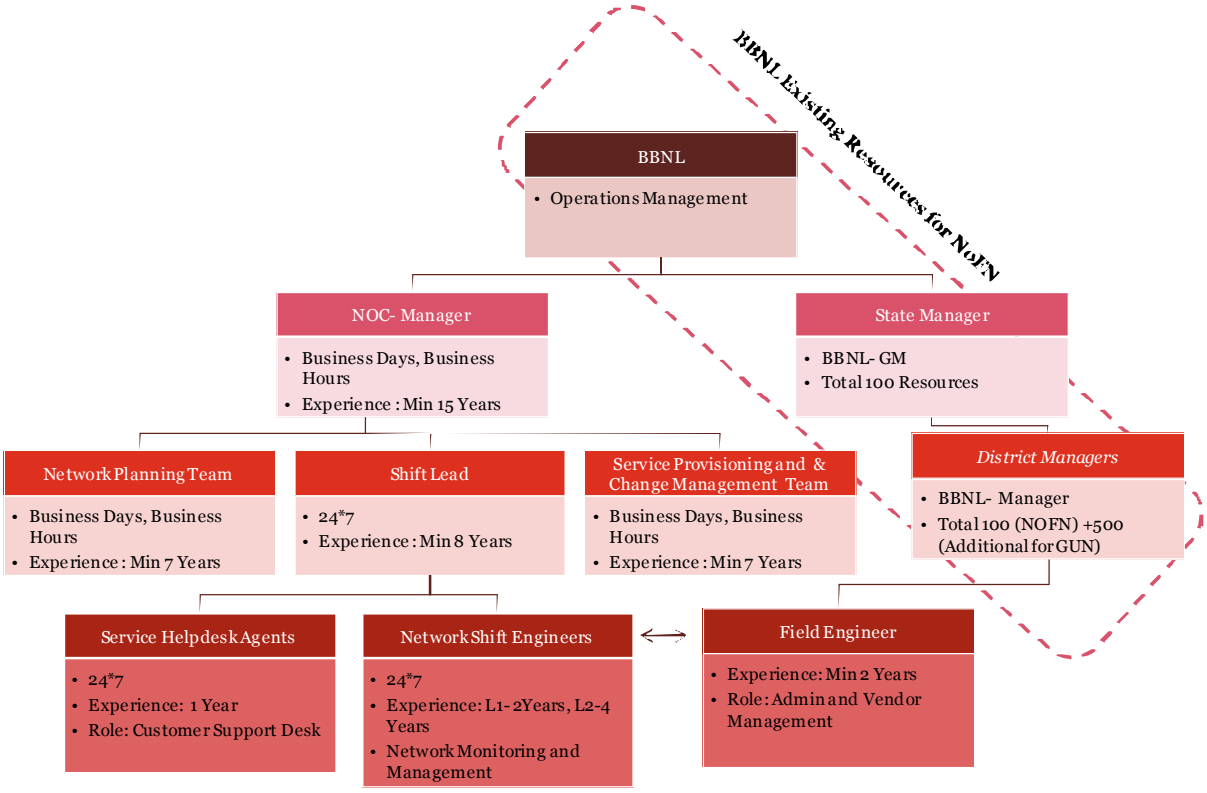


Figure 25: Operations Management Hierarchy

7.4. O&M Process Map

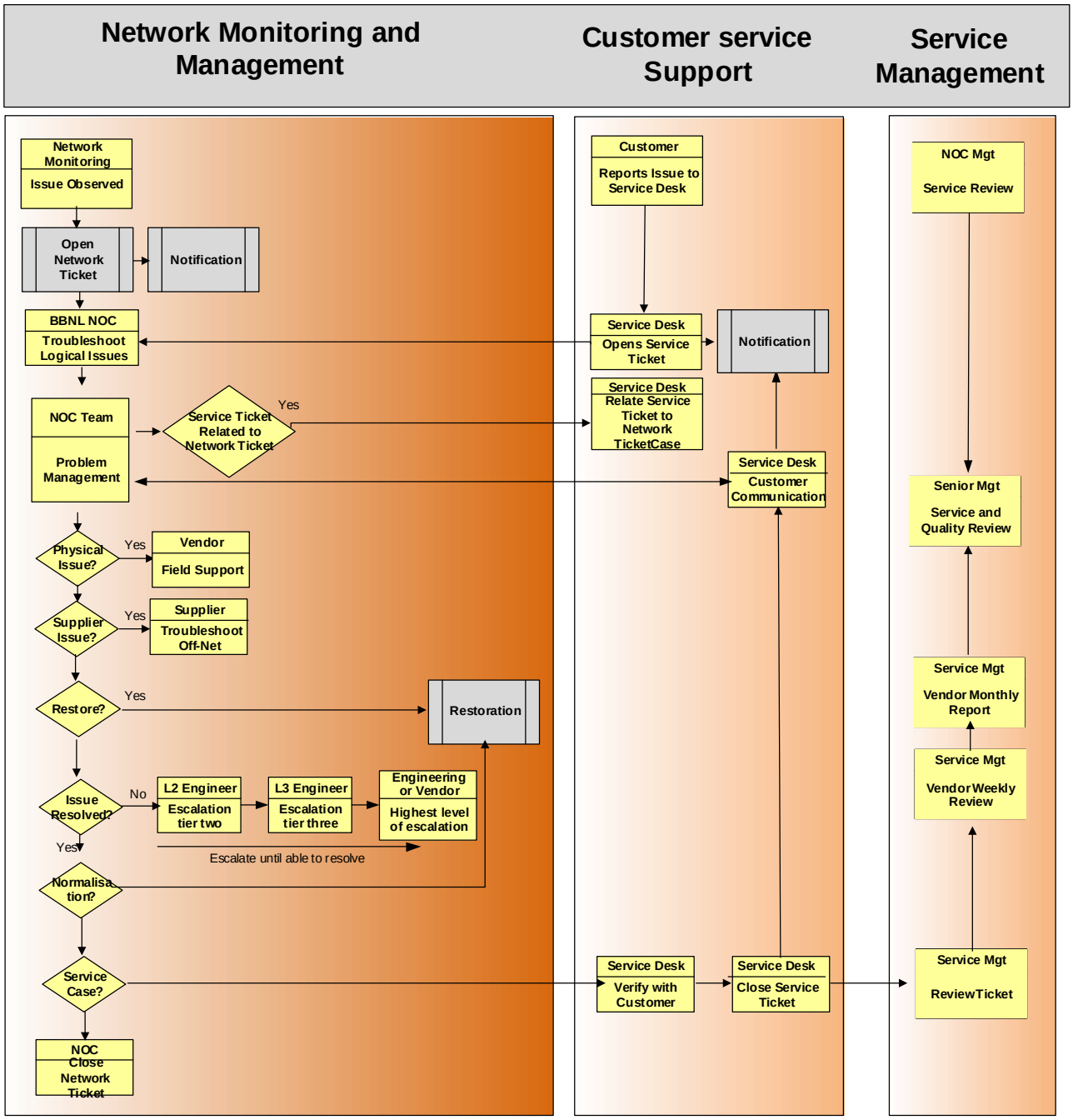


Figure 26: O&M Process Map

7.5. O&M GOVERNANCE STRUCTURE

To ensure effective management and monitoring of the operation and maintenance (O&M) phase of GUN program, strong governance structures are needed at the Centre (BBNL) as well as at the cluster level. To this extent, the following structures are proposed at the Central and cluster levels.

7.5.1. Central Level

Governance mechanism at the Central level:

i. A Project Monitoring and Review Committee with Secretary, Department of Telecom as the Chairperson to review the impact of GUN project during operation and maintenance phase and provide policy directions

ii. An Empowered Committee with CMD, BBNL as Chairperson to provide necessary approvals and provide policy and project implementation inputs during O&M phase.

iii. A Project Mission Team, below the Empowered Committee, which shall have the operational responsibility of the project including coordination with other agencies and providing directions and guidance to system integrators for effective operation and maintenance.

iv. Bharat Broadband Nigam Limited (BBNL) will provide secretarial and technical assistance to the project and coordinate with the system integrators. It has been stated that the Empowered Committee would take the help of subject matter experts as and when needed, and the Project Mission Team and BBNL would be assisted by Central Project Management Consultants (CPMC) for a period of 18 months during O&M phase.

v. Central Program Management Consultants (CMPC) will be constituted to manage and supervise the program at the central level for an initial period of 18 months of operation and maintenance phase. CPMC in a phased manner help BBNL to develop internal capacities to effectively manage O&M phase and subsequently handover the project management to BBNL at end of 18 months.

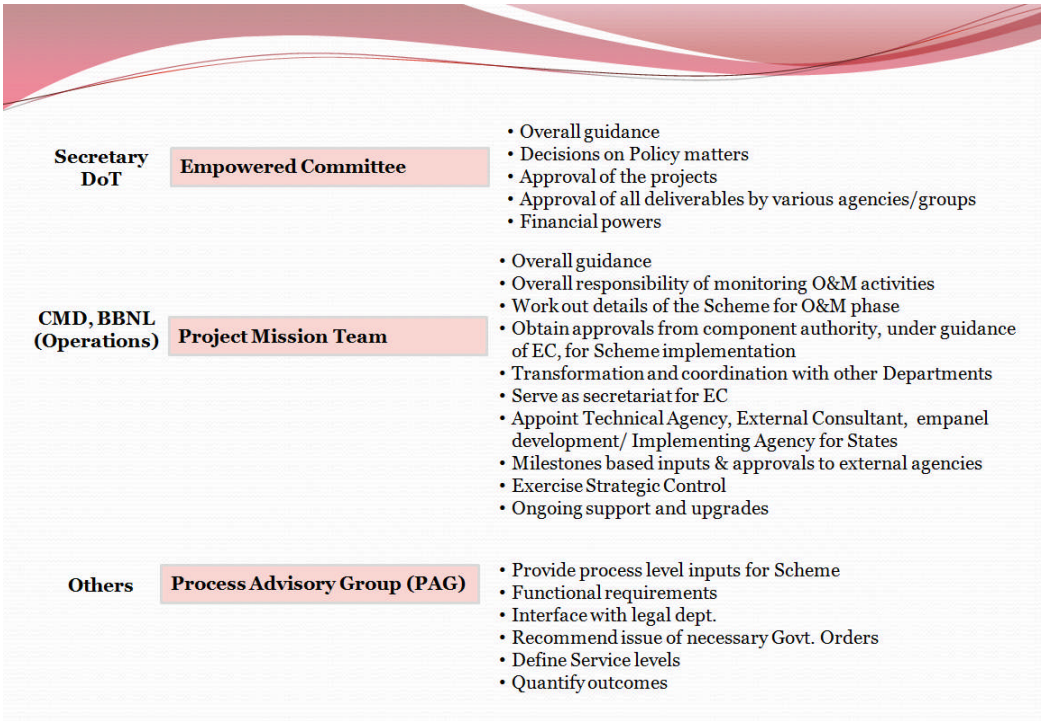


Figure 27: Overall Governance Structure at Center

7.5.2. Cluster Level

Governance mechanism at the Cluster level:

i. A Cluster Project Mission Team, reporting directly to the Central Project Mission Team, which shall have the operational responsibility of the project including coordination with other agencies in the cluster and providing directions and guidance to cluster system integrator.

ii. Cluster Management Unit (CMU) will be constituted to manage and supervise the program at the cluster level and also to collaborate with the system integrator in monitoring the program.

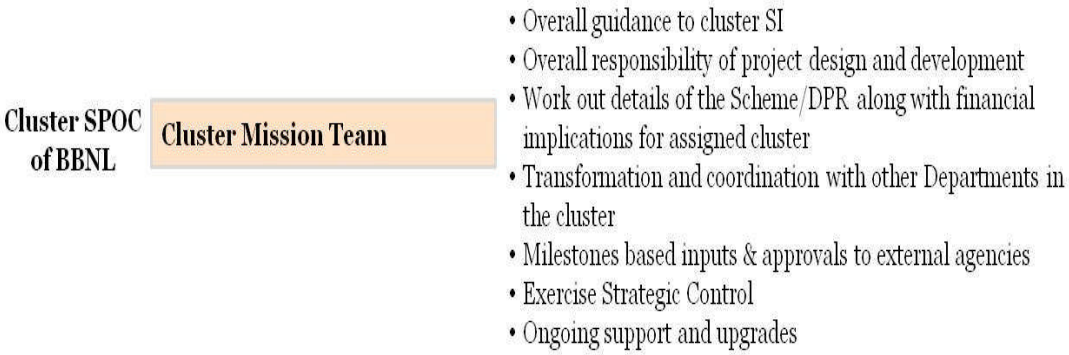


Figure 28: Overall Governance Structure at Cluster

8. Monitoring and Evaluation Framework

8.1. Principles of Effective M&E Framework

8.1.1. Definition of an M&E Framework

An effective M&E Framework will help BBNL to identify its desired outcomes from implementation of GUN over NOFN, prioritise its actions and understand the impact post its implementation. Following are the key set of activities that should be included while defining an M&E Framework:

- Linking strategic aims, objectives and priorities for BBNL across the implementation and O&M teams
- Enabling progress against these aims and objectives to be monitored by senior management
- Linking individual actions
- As a result, an M&E Framework can enable implementation teams to move away from a reactive 'fire fighting' approach to a forward-looking, proactive and informed approach.
- Crucially, M&E Framework will establish an on-going process for planning, monitoring and revising implementation and utilisation of the network.

8.1.2. Advantages of an M&E Framework

An effective M&E Framework can provide the following advantages:

- Well defined review structures which are replicated from top to bottom and across operational and support departments
- Recognition of high quality of implementation
- Clearly articulated priorities which are widely understood at all levels of implementation and O&M teams
- Usage of timely, accurate and relevant data for informed decision making

8.2. Suggested M&E Framework and Approach

The suggested M&E Framework would be spread across two phases:

1. GUN Implementation Phase
2. GUN O&M Phase

Each of these phases would have their separate set of KPIs for monitoring and evaluation. Initial base lines will have to be developed for each of the KPIs. These KPIs would be continuously measured, monitored and evaluated against the baseline to understand the progress of the scheme and whether the desired outcomes are achieved. The governance structure put in place will be monitoring the progress of the scheme through the KPIs.

8.2.1. Implementation Phase KPIs

Implementation KPIs are the indicators for measuring the progress of GUN implementation during the roll-out period. Given below are some of the key KPIs that should be measured and monitored in order get strategic handles on the implementation of GUN.

1. **District PoPs commissioned**
   - i. **Space taken**
   - ii. **Equipment delivered**
   - iii. **Installation done**

Number of Districts commissioned and made operational as per the acceptance reports submitted by field BBNL level team. This will give an indication into the work progress at the District level at each stage of setting up of the District PoP.

2. **Districts connected to ISP cloud**

ISP connectivity at District level is a must for delivery of Wi-Fi services at GP. Monitoring of this parameter will bring to fore any specific issues that need to be addressed with respect to connectivity to ISP.

3. **Districts connected to CUG**

ISP connectivity at District level is a must for delivery of Wi-Fi services at GP. Monitoring of this parameter will bring to fore any specific issues that need to be addressed with respect to connectivity to ISP.

4. **Implementation delays vis-a-vis the agreed plan at each of the following levels**
    i. **GP,**
    ii. **District,**
    iii. **State and**
    iv. **Cluster**

Delays from agreed plan at each of the levels of implementation units should be regularly monitored to highlight key issues that might come up during implementation for timely course correction and strategic manoeuvring.

5. **GPs completely monitored from central NMS**

This KPI will measure end to end availability of network from GP to District and monitoring of the same from NOC level. Monitoring of this KPI will highlight any issues in the intermediate network components so that timely action can be taken.

6. **Acceptance test defects at**
    i. **GP,**
    ii. **Block and**
    iii. **District**

This KPI measures the defects being reported during the acceptance testing at sites to approve the installation quality and related parameters.

7. **Institutes completely connected to central NMS**

This KPI will measure end to end availability of network from institute to District and monitoring of the same from NOC level. Monitoring of this KPI will highlight any issues in the intermediate network components so that timely action can be taken.

8. **Number of users using the Wi-Fi services**

Ultimate objective of GUN is to ensure usage of broadband at rural level. It is important to measure this KPI as it provides an insight into the achievement of ultimate objective and identify as soon as possible the roadBlocks in achieving of those objectives.

8.2.2. O&M Phase KPIs

1. **Usage/Availability Indicators**
    i. **Number of services available over GUN**
    ii. **Equipment Uptime/GP/Block**
    iii. **Average service ticket resolution time**

Service delivery to the public using GUN may be one of the vital parameter to measure the usage of this network. Higher number of services available through GUN indicates successful implementation of GUN. The higher equipment uptime and lower service ticket resolution time shall result in effective management of maintenance activities ensuring that the services made available over GUN are functional and accessible to all the stakeholders.

2. **Outcome Indicators**
    i. **Number of private players offering rural services**
    ii. **Increase in economic activities/contribution in GDP**
    iii. **Number of people employed within a Block due to GUN ecosystem**

One of the main objectives of GUN is to develop a platform for making rural service as a viable business model for private players. The higher number of services from private players offered through GUN will mean that the program has been able to achieve its objectives. Also the rural economic activities will get a boost due to higher broadband penetration. The increase in economic activities shall be a good indicator to show the impact of GUN in rural economy. Additionally it will be equally important to measure the number of people employed in GUN ecosystem which is a subset of second outcome indicator.

9. Legal and Regulatory Assessment[6]

9.1. Background

In October 2011 Government of India approved setting up of BBNL as a Special Purpose Vehicle (SPV) under Department of Telecommunications (DOT). Primary objective of BBNL was setting up of the NOFN to provide 100 mbps connectivity in each of the 2,50,000 GPs of the country.

In order to fulfill the above objective, BBNL acquired legal status as defined by the following –

1. BBNL was setup as a limited company under The Companies Act, 1956. Consequently, the Memorandum and Articles of Association of the company were drafted and registered to meet the intended objectives.

2. BBNL was granted the National Long Distance (NLD) license by DOT that enabled BBNL to provide wholesale bandwidth services across the country.

With the introduction of GUN over NOFN, BBNL will need to undertake additional activities that have legal implications. This section aims to highlight the legal impact of these activities as well as changes in legal status that need to be implemented by BBNL in order to perform those activities.

9.2. Additional activities due to GUN extension

In order to fulfill its objectives as conceptualized in GUN over NOFN, BBNL might have to undertake following additional activities –

1. **Delivery of community Wi-Fi services** – there are multiple models under which the community Wi-Fi services can be delivered to rural population. Following section provides an assessment of legal implications under different models

2. **Extension of network from Block to District** and allowing other services providers including TSPs and ISPs to deliver their services on this end to end network

[6] ***The contents of this section do not constitute legal advice and do not necessarily reflect the opinions of PricewaterhouseCoopers Pvt. Ltd. or of its employees. The contents herein provide general guidance, which may or may not be correct, complete or current at the time of reading. The content is not intended to be used as a substitute for specific legal advice or opinions. No recipients should act or refrain from acting on the basis of content of this email or document, if any, attached with it, without seeking appropriate legal advice or other professional counseling. PwC expressly disclaims all liability relating to actions taken or not taken based on any or all contents of this section.***

3. **Creation of access network** from GP to Government Institutes

9.3. Impact Assessment

9.3.1. Community Wi-Fi services

Delivery of community Wi-Fi services has multiple aspects that can broadly be categorized as

i. Acquisition of ISP license,

ii. Managing ISP infrastructure operations and

iii. end customer management and interfacing

Depending upon what BBNL chooses to undertake as its business activity, different models can emerge as listed below.

S. No.	Model	ISP License	ISP Operations	End Customer Interface
(i)	BBNL acts as bandwidth provider and all activities pertaining to ISP service delivery are taken care of by 3rd party	✗	✗	✗
(ii)	BBNL becomes an ISP but operations are provided by 3rd party	✓	✗	✓
(iii)	BBNL becomes an end to end ISP	✓	✓	✓

Table 20: Business Models (Legal Assessmenet)

Model (i) - BBNL acts as bandwidth provider

In this model the current NLD license held by BBNL shall suffice. Text given below extracted from License Agreement for Unified License, 5th Aug 2013 clearly indicates that NLD license will suffice for this purpose.

CHAPTER-X

NATIONAL LONG DISTANCE SERVICE

Scope of the NLD Service

2.1 (a) The NLD Service Licensee shall have the **right to carry inter-circle switched bearer telecommunication traffic** over its national long distance network. The Licensee may also **carry intra-circle switched traffic** where such carriage is with mutual agreement with originating access service provider.

(b) The Licensee can also, in respect of Basic Service, make mutually agreed arrangements with the concerned Service Providers for **picking up, carriage and delivery of the traffic from different legs between Long Distance Charging Center (LDCC) and Short Distance Charging Centers (SDCCs)**.

(c) In the case of Cellular Mobile Telephone Service traffic, the **inter-circle traffic shall be handed/taken over at the Point of Presence (POP)** situated in LDCA at the location of Level I TAX in originating/terminating service area. For West Bengal, Himachal Pradesh and Jammu & Kashmir such locations shall be Asansol, Shimla & Jammu respectively.

(d) The Licensee can **provide Leased Circuit / Virtual Private Network (VPN)** Services.

(e) Further, **only for provision of Leased Circuits/Close User Groups (CUGs) on leased circuits and for provision of national long distance voice service through Calling Cards, falling within the scope of, and, in accordance with clauses 2.1 (a) and 2.1(b) above, the Licensee can access the subscribers directly**. While providing the domestic leased circuits, the Licensee shall be required to make own suitable arrangements for leased circuits /agreements with the Access Providers for last mile. Public network is not to be connected with leased circuits/CUGs.

2.2(i) The Licensee can **provide bandwidth to other telecom service licensee** also.

2.2(ii) The Licensee may **share "passive" infrastructure** namely building, tower, dark fiber, duct space, Right of Way owned, established and operated by it under the scope of this Authorization with other Licensees.

2.3(i) Access to the subscribers for provision of National Long Distance voice services (excluding message services) through Calling Cards shall be strictly within the scope of and in accordance with clauses 1.1(a) to 1.1(d) above. Provision of other Intelligent Network based services (except Intelligent Network service for operation of Calling Cards) such as tele-voting and toll-free services is not allowed to Licensee. Provision of Value Added Services such as SMS/ MMS, ringtones etc. through calling cards is also not allowed.

2.3(ii) The charges and sharing of revenues for the service features, network architecture and resources used for providing NLD voice services through calling cards shall be such as are mutually agreed between the service providers within the framework of and in accordance with regulations, directions, orders or instructions as may be issued from time to time by TRAI and directions, orders or instructions as may be issued from time to time by the Licensor.

2.3(iii) The licensee shall clearly indicate to the subscriber the specifications of the service to be offered through Calling Cards at the time of entering into contract with such subscriber.

Figure 29: Universal Service License Text

No changes to Memorandum of Association are required to be done under Model (i)

Model (ii) - BBNL becomes an ISP but operations are provided by 3rd party

Without impacting BBNL's current status as NLD license holder, the ISP license can be acquired if BBNL chooses to opt for Model (ii). However this will need changes to Memorandum of Association that are highlighted in the ***section 9.4 Impact on Memorandum of Association***.

Model (iii) - BBNL becomes an end to end ISP

Similar to Model (ii) above, without impacting BBNL's current status as NLD license holder, the ISP license can be acquired if BBNL chooses to opt for Model (ii). However this will need changes to Memorandum of Association that are highlighted in the ***section 9.4 Impact on Memorandum of Association***.

9.3.2. Extension of network from Block to District

There is no impact perceived on legal status of BBNL due to undertaking of this activity. The current NLD license allows BBNL to undertake this activity.

9.3.3. Creation of access network

There is no impact perceived on legal status of BBNL due to undertaking of this activity as long as BBNL only provides the access network and do not delivery end user services to these institutes. The current NLD license allows BBNL to undertake this activity.

9.4. Impact on Memorandum of Association

After a review of the Memorandum of Association, following are the key changes that may be required to enable BBNL to offer ISP services.

After para III A (3), the following para as III A (4) may be added: *To develop and provide internet services, internet telephony, virtual private network and other related data, voice and video services, wide area communication network, value added services on network, lease and other transfer of network and related products and services and to carry on the business as Internet service provider using any available technology including provision of broadband communication services, satellite communication services and internet access solutions and to acquire, maintain, operate, manage and undertake technology and infrastructure for this purpose.*

After para III B (1), the following para as III B (2) may be added: *To purchase or otherwise acquire, take on lease or rent computer systems and digital/electronic equipment of all kinds;*

After para III B (6), the following para as III B (7) may be added: *To enter into any arrangements with any Government authority, undertaking or corporations controlled or owned by any Government or any person(s) including any individual, firm, body corporate or other association of individuals, whether incorporated or not, society and trust whether in India or abroad that may seem conducive to the company's objectives or any of them and to obtain from any such Government, authority, undertakings, corporations and person(s) any rights privileges and concessions which the company may deem desirable to obtain and to carry out, exercise and comply with any such arrangements, rights, privileges and concessions;*

After para III B (11), the following para as III B (12) may be added: *To import into and to export from India the technology in respect of products and services mentioned in clause III (A) on such terms and conditions as the company deems fit;*

After para III B (25), the following para as III B (26) may be added: *To do all such things as are necessary for the company or its nominee(s) to become members or to be otherwise associated with national and international associations, institutes or other organizations, so as to promote or strengthen the company's interests on such terms and conditions as may be determined by the company;*

After para III B (36), the following para as III B (37) may be added: *To enter onto license agreements with government departments, to pay license fees etc., to issue guarantees either itself or through a third party like financial institutions and scheduled banks etc and to comply with all rules, regulations and any subsequent amendments made thereon, for carrying on the business of the company.*

10. Project Budget

10.1. Budget Summary

S. No.	Details	Capex (Cr)	Opex/Anum (Cr)	Capex/GP (Thousand Rs)	Opex/Anum/GP (Thousand Rs)
Part-1 Block-District Network + eGP (ePRI) services + WiFi					
1	Passive PoP Infra	203.67	804.12	NA	
2	Active PoP Infra	683.45	82.61		
3	NOFN B/W cost (GP-Block)	0.00	525.00		
4	Access Infra for Community WiFi and eGP services	1,470.96	351.93		
5	NOC augmentation components	23.04	2.61		
6	O&M Resource Deployment by BBNL	5.88	43.31		
7	Training	3.74	0.00		
	Total	**2,390.73**	**1,809.57**	**95.63**	**72.38**
Part-2 Connectivity to two Institutions					
1	Access Infra at GP	2,269.27	190.40		
2	BBNL B/W cost (GP-Block)	0.00	350.00		
	Total	**2,269.27**	**540.40**	**90.77**	**21.62**
Part-3 Other costs					
1	Program Management Cost @1% of Capital outlay	46.60	0.00		
2	Performance monitoring and SLA audit		3.96		
G. Total		**4,706.60**	**2,353.93**	**188.26**	**94.16**
Contingency @5%		**235.33**	**117.70**		
G. Total with Contingency		**4,941.93**	**2,471.63**	**197.68**	**98.87**

Table 21: Budget Summary

10.2. Budget Details

10.2.1. Passive PoP Infra

S. No.	Details	Specifications/Details	UoM	Details	Qty (Total Unit)	Capex/ Unit	Installation cost / unit	Opex (Annual)/ Unit	Total Capex	Total Opex
A. Creation of DHQ PoP										
1	Leasing the rented premises	Total area 500 sq Ft, Network equipment area 100 sq ft	No.		600	240,000	-	240,000	144,000,000	144,000,000
2	Part New fiber to be laid to connect BBNL PoP with exiting PoP/chamber of TSP	Single mode, 1 Pair (2 core) fiber on lease.	No.		1,200	450000	0	45,000	540,000,000	54,000,000
3	Part New fiber to be taken on lease from TSP to connect with NII-2.0 PoP	Single mode, 1 Pair (2 core) fiber on lease.	No.		3,000	0	0	20,000	-	60,000,000
4	DG Set - N+1 Mode, Diesel Generating Sets with AMF Control Panel	15 KVA each	No.		1,200	255000	12750	25,500	321,300,000	30,600,000
5	Air Conditioning	2 Ton (N+1 Mode), Split type	No.		1,200	35000	1750	3,500	44,100,000	4,200,000
6	On-Line UPS	With isolation transformer suitable for single phase AC input & single phase AC output, Rating of UPS: 5.0 KVA,Indicative Back-up time: 120 Minutes (N+1 Mode)	No.		1,200	125000	6250	12,500	157,500,000	15,000,000

S. No.	Details	Specifications/Details	UoM	Details	Qty (Total Unit)	Capex/ Unit	Installation cost / unit	Opex (Annual)/ Unit	Total Capex	Total Opex
7	Civil, electrical and furniture		Lumpsum		600	1000000	100000	100,000	660,000,000	60,000,000
8	Cost of Power/DHQ-PoP	3 KVA Load	KVA		600	150000	-	262,800	90,000,000	157,680,000
9	DHQ PoP Facility Management		Lumpsum		600	0	0	1,200,000	-	720,000,000
B. Fiber connectivity DHQ to Block (OLT) Locations										
1	Existing Fiber of BSNL/Railtel/PGCIL on lease	Single mode, 1 Pair (2 core) fiber on lease.	KM	94.30 %	311,190	-	-	20,000	-	6,223,800,000
2	Part new fiber to be laid by TSP to lease to BBNL (part of the fiber to extend from exiting TSP PoP/chamber to BBNL PoP)	Single mode, 1 Pair (2 core) fiber on lease.	No.	5.70%	18,810	0	0	30,000	-	564,300,000
3	Fiber termination box (FTB) at BBNL PoP (DHQ) for fiber provided by other than BSNL	19" Rack mount, 24 pair (48F), including Pig tails	No.		600	10,000	500	1,000	6,300,000	600,000
4	Fiber termination box (FTB) including Pig tails at BBNL PoP (BHQ) for fiber provided by other than BSNL	19" Rack mount, 6 pair (12F), including Pig tails	No.		10,000	4,000	200	400	42,000,000	4,000,000

S. No.	Details	Specifications/Details	UoM	Details	Qty (Total Unit)	Capex/ Unit	Installation cost / unit	Opex (Annual)/ Unit	Total Capex	Total Opex
5	Fiber termination box (FTB) including Pig tails at BBNL PoP (BHQ) for fiber provided by other than BSNL	19" Rack mount, 6 pair (12F), including Pig tails	No.	Existing FTB to be used	-	-	-	-	-	-
6	Patch cords - (FTB to equipment)	Single Mode, Duplex	No.	Average 3/block	30,000	1,000	50	100	31,500,000	3,000,000
7			Lot							
8			Lot							
									2,036,700,000	8,041,180,000

* TSP - Other service providers (SP having exiting laid fiber i.e. BSNL, Railtel, PGCIL or other telecom service providers)

Total (Cr)	**203.67**	**804.12**

Table 22: Passive PoP Infra

10.2.2. Active PoP Infrastructure

S. No.	Details	Specifications/ Details	UoM	Details	Qty (Total Unit)	Capex /Unit	Installation cost /Unit	Opex (Annual)/ Unit	Total Capex	Total Opex
A. DHQ PoP Equipments and Infra										
1	20 Gbps Bidirectional Throughput. with 2*10G and 2*1G SFP	MPLS-TP, QoS, IPv4/IPv6, Security, management, OAM, Redundnat Power Supply, Non blocking swicth fabric, 2@10 G SFP+ (Lx/Ex/Zx), 2@1 G SFP (Sx)	No.	10%	60	850,000	42,500	85,000	53,550,000	5,100,000
2	40 Gbps Bidirectional Throughput. with 8*10G SFP	MPLS-TP, QoS, IPv4/IPv6, Security, management, OAM, Redundnat Power Supply, Non blocking swicth fabric, 8@10 G SFP+ (Lx/Ex/Zx) ,	No.	50%	300	1,600,000	80,000	160,000	504,000,000	48,000,000
3	80 Gbps Bidirectional Throughput	MPLS-TP, QoS, IPv4/IPv6, Security, management,	No.	35%	210	2,400,000	120,000	240,000	529,200,000	50,400,000

S. No.	Details	Specifications/ Details	UoM	Details	Qty (Total Unit)	Capex /Unit	Installation cost /Unit	Opex (Annual)/ Unit	Total Capex	Total Opex
	. with 16*10G SFP	OAM, Redundnat Power Supply, Non blocking swicth fabric, 16@10 G SFP+ (Lx/Ex/Zx) ,								
4	160 Gbps Bidirectional Throughput . with 16*10G SFP	MPLS-TP, QoS, IPv4/IPv6, Security, management, OAM, Redundnat Power Supply, Non blocking swicth fabric, 16@10 G SFP+ (Lx/Ex/Zx) ,	No.	5%	30	3,300,000	165,000	330,000	103,950,000	9,900,000
B. BHQ PoP Equipments										
1	10 Gbps Bidirectional Throughput . with 2*10G and 2*1G SFP Scalable to 8*1 G Ports	MPLS-TP, QoS, IPv4/IPv6, Security, management, OAM, Redundnat Power Supply, Non blocking swicth fabric, 2@10 G SFP+ (Lx/Ex/Zx), 2@1 G SFP (Sx)	No.	70%	7,000	525,000	26,250	52,500	3,858,750,000	367,500,000

S. No.	Details	Specifications/ Details	UoM	Details	Qty (Total Unit)	Capex /Unit	Installation cost /Unit	Opex (Annual)/ Unit	Total Capex	Total Opex
2	20 Gbps Bidirectional Throughput. with 2*10G and 2*1G SFP	MPLS-TP, QoS, IPv4/IPv6, Security, management, OAM, Redundnat Power Supply, Non blocking swicth fabric, 2@10 G SFP+ (Lx/Ex/Zx), 2@1 G SFP (Sx)	No.	20%	2,000	850,000	42,500	85,000	1,785,000,000	170,000,000
3	Cost of Power at existing POP - power requirement @ Block	200 W/Block	No.		10,000	-	-	17,520	-	175,200,000
									6,834,450,000	826,100,000
								Total (Cr)	**683.45**	**82.61**

Table 23: Active PoP Infra

10.2.3. NOFN Bandwidth Cost BHQ-GP

S. No.	Details	Specifications/Details	UoM	Qty (Total Unit)	Capex/Unit	Installation cost /unit	Opex (Annual)/Unit	Total Capex	Total Opex
A. NOFN B/W (eGP+ Wi-Fi+ Reserved)									
1	Cost of NOFN B/W at each GP - @30 Mbps	30 Mbps/GP	No.	250,000	-	-	21,000	-	5,250,000,000
2	Cost of OLT Port		No.	10000	-	-	-	-	-
3	Cost of ONT Port		No.	750000	-	-	-	-	-
									5,250,000,000
							Total (Cr)	-	**525.00**

Table 24: NOFN Bandwidth Cost

10.2.4. Community Wi-Fi and eGP Services

S. No.	Details	UoM	Qty (Total Unit)	Capex/Unit	Installation cost /unit	Opex (Annual)/Unit	Total Capex	Total Opex
A. ISP Equipments & NMS								
1	Cost of ISP License	No.	250,000	3,000,000	-	160	3,000,000	40,000,000
2	Cost of ISP equipments at DHQ Including router	No.	600	300,000	15000	-	189,000,000	-
3	Billing/Coupon Management and other ISP related components	No.	Lumpsum	300,000,000	30,000,000	30,000,000	330,000,000	30,000,000
4	Rack Collocation of central infrastructure at DC and DR	No.	4	-	-	700,000	-	2,800,000
5	Cost of Lawful interception system	Cluster	1	80,000,000	8,000,000	8,000,000	88,000,000	8,000,000
6	Cost of NMS Including Installation cost- in HA at DC and DR	Lot	Lumpsum	400,000,000	40,000,000	40,000,000	440,000,000	40,000,000
7	Server Hardware for NMS	Lot	12	800,000		80,000	9,600,000	960,000
							1,059,600,000	121,760,000
B. ISP B/W cost at DHQ								
1	Cost of ISP B/W, considering 1:50 contention ratio - 100 Mbps/DHQ	No.	600	0		3,000,000	-	1,800,000,000
								1,800,000,000
C. Access point								

S. No.	Details	UoM	Qty (Total Unit)	Capex/Unit	Installation cost /unit	Opex (Annual)/Unit	Total Capex	Total Opex
1	Cost of Outdoor Wi-Fi Access point with 1* External Antenna	No.	250,000	30000	1500	3000	7,875,000,000	750,000,000
2	Cost of Accessories (Including Pole, PoE Injector/Power adaptor, power and data cable etc., solar power backup)	No.	250,000	12000	600	1200	3,150,000,000	300,000,000
4	Cost of Power at existing POP - (12.5 W) power requirement @ GP	No.	250,000	-	-	1,095	-	273,750,000
							11,025,000,000	1,323,750,000
D. CPE Device for eGP service center								
1	L3 Router/Switch	No.	250,000	10,000	500	1,095	2,625,000,000	273,750,000
							2,625,000,000	273,750,000
E. Total cost of PoP/User Infra (A+B+C+D)							**14,709,600,000**	**3,519,260,000**

Total (Cr)	**1,470.96**	**351.93**

Table 25: Community Wi-Fi and eGP Services cost

10.2.5. NOC Augmentation Components

S. No.	Details	UoM	Qty (Total Unit)	Capex/ Unit	Installation cost /unit	Opex (Annual)/ Unit	Total Capex	Total Opex
A. NOC tools and resources								
1	NMS monitoring and management tool. Including Installation cost- in HA at DC and DR for	Lot	10,600	5,000	1,000	500	63,600,000	5,300,000
2	NMS for Monitoring of additional 1.5 Lakh ONT from existing CDOT NMS (access devices at GP for institutions)	Lot	150,000	800	200	80	150,000,000	12,000,000
3	Server Hardware for NMS in HA at DC and DR	Lot	20	800,000	40,000	80,000	16,800,000	1,600,000
B. DC/DR for NOC servers								
1	Rack Collocation of central infrastructure at DC	No.	4	-	-	900,000	-	3,600,000
2	Rack Collocation of central infrastructure at DR	No.	4			900,000	-	3,600,000
B. DC/DR for NOC servers								
							230,400,000	26,100,000
						Total (Cr)	**23.04**	**2.61**

Table 26: NOC Augmentation Components

10.2.6. O&M Resource Deployment

S. No.	Details	UoM	Details	Qty (Total Unit)	Capex/ Unit	Installation cost /unit	Opex (Annual)/ Unit	Total Capex	Total Opex
A. Central Resources									
1	NOC Manager	No.	2 (8*5, Business day, Business hours)	2			1,200,000		2,400,000
2	Network Monitoring and management - L1 (BBNL Core Network)	No.	8 (24*7) + 4 (8*5, Business day, Business hours)	36	-	-	300,000	-	10,800,000
3	Network Monitoring and management - L1 (BBNL CPE infra –Institute and WiFi)	No.	4 (24*7) + 20 (8*5, Business day, Business hours)	36	-	-	300,000	-	10,800,000
4	Network Monitoring and management - L2	No.	4 (24*7)	16	-	-	550,000	-	8,800,000
5	L3 support to NOC	No.	2 (24*7)	8	-	-	900,000	-	7,200,000
6	Service Provisioning and Network Planning	No.	8 (8*5, Business day, Business hours)	8	-	-	900,000	-	7,200,000
7	Shift Lead	No.	2 (24*7)	8	-	-	600,000	-	4,800,000
B. Call Center (Helpdesk)									
1	Service helpdesk - Wholesale Business	No.	4 (24*7)	4			400,000		1,600,000
2	Service helpdesk - Wholesale Business	No.	8 (8*7, Business hours)	8			1,200,000		9,600,000

S. No.	Details	UoM	Details	Qty (Total Unit)	Capex/ Unit	Installation cost /unit	Opex (Annual)/ Unit	Total Capex	Total Opex
3	Multi-Lingual Service helpdesk - Wi-Fi Broadband services	No.	10 (24*7)	10			400,000		4,000,000
4	Multi-Lingual Service helpdesk - Wi-Fi Broadband services	No.	50 (8*7, Business hours)	50			1,200,000		60,000,000
C. Field Resources - Admin									
1	BBNL District Manager - Incremental to NOFN	No.		500	0	0	600,000	-	300,000,000
D. IT Infrastructure									
1	Laptop - Field users and NOC	No.		600	50000	2500	5,000	30,000,000	3,000,000
2	High end Work stations - NOC	No.		50	95000	4750	9,500	4,750,000	475,000
3	Video Wall - NOC	No.		2	12,000,000	600,000	1,200,000	24,000,000	2,400,000
								58,750,000	433,075,000

Total (Cr)	**5.88**	**43.31**

Table 27: O&M Resource Deployment

10.2.7. Training

S. No.	Details	UoM	Qty (Total Unit)	Capex/ Unit	Total Capex	Total Opex
A. NOC tools						
1	Technical training for NOC team	Man weeks	456	30,000	13,680,000	
2	Training for Mid and higher management	Man weeks	20	30,000	600,000	
B. PoP equipments and technology						
1	Technical training for NOC team	Man weeks	456	20,000	9,120,000	
2	Technical training for Field team	Man weeks	700	20,000	14,000,000	
					37,400,000	
				Total (Cr)	**3.74**	**-**

Table 28: Training Cost

10.2.8. Access Infra at GP

S. No.	Details	Specifications/Details	UoM	Qty (Total Unit)	Capex/ Unit	Installation cost /unit	Opex (Annual)/ Unit	Total Capex	Total Opex
A. Access connectivity Infra at GP									
LMC Option-1 (O/H fiber)									
1	Supply and Laying of O/H Fiber (4 core) between GP (ONT) to Institution - 1 KM each/link (Including all required accessories for O/H laying etc.)		KM	500,000	18,000	10,000	360	14,000,000,000	180,000,000
2	Maintenance of O/H fiber	One team per district	KM	600	-	-	1,200,000	-	720,000,000
3	Cost of Spares required for maintenance	2% of installation material cost	Lumpsum	600	360	-	-	216,000	-
4	Fiber termination box (4 F) - with pig tails (@ GP PoP), Splicing/testing etc.	Existing FTB to be used	No.	-	-		-	-	-
5	Fiber termination box (4 F) - with pig tails (@ Institution),		No.	500,000	2,000	500	200	1,250,000,000	100,000,000

S. No.	Details	Specifications/Details	UoM	Qty (Total Unit)	Capex/ Unit	Installation cost /unit	Opex (Annual)/ Unit	Total Capex	Total Opex
	Splicing/testing etc.								
6	Patch cords (FTB to Modem/CPE)	3 Mtrs	No.	1,000,000	300	15	30	315,000,000	30,000,000
7	Passive accessories, RJ45 - patch cords etc..		No.	250,000	200	10	20	52,500,000	5,000,000
8	Cost of L2- CPE device for connectivity to institutions (ONT/Modem pair)		No.	500,000	3,000	150	300	1,575,000,000	150,000,000
9	Power Cost at GP PoP		No.	250,000	0	-	876	-	219,000,000
CPE Device									
1	L3 Router/Switch		No.	500,000	10,000	1,000	1,000	5,500,000,000	500,000,000
								22,692,716,000	1,904,000,000

Total (Cr)	**2,269.27**	**190.40**

Table 29: Access infra at GP

10.2.9. NOFN Bandwidth Cost BHQ to GP allocated for Institutions access network

S. No.	Details	Specifications/Details	UoM	Qty (Total Unit)	Capex/Unit	Installation cost /unit	Opex (Annual)/Unit	Total Capex	Total Opex
A. NOFN B/W (eGP+ Wi-Fi+ Reserved)									
1	Cost of NOFN B/W at each GP - @20 Mbps	20 Mbps/GP	No.	250,000	-	-	14,000	-	3,500,000,000
2	Cost of OLT Port		No.	10000	-	-	-	-	-
3	Cost of ONT Port		No.	750000	-	-	-	-	-
									3,500,000,000
							Total (Cr)	**-**	**350.00**

Table 30: NOFN Bandwidth Cost BHQ to GP allocated for Institutions access network

10.3. Alternate Cost Options

S. No.	Details	Assumptions	UoM	Qty (Total Unit)	Capex / Unit	Installation cost /unit	Opex (Annual)/ Unit	Total Capex	Total Opex
LMC Option-2 (Wireless base station)									
The costing given below is for Wireless last mile solution for two institutions in a GP having a Line of Site (LoS) on Pole. Since the pole is getting deployed for Wi-Fi services, additional pole costing at GP is not considered.									
1	Wireless base station Modem - ISM (License free) band (ODU/IDU), POE, cable and accessories (P2M)		No.	1	50,000	5,000	5,000	55,000	5,000
2	CPE RF Modem (ODU/IDU) with PoE, cable and accessories	two institutions	No.	2	15,000	1,500	1,500	33,000	3,000
3	Pole - 6 Mtrs	two institutions	No.	2	3000	300	0	6,600	-
4	Power backup at GP PoP		No.	1	10000	1,000	1,000	11,000	1,000
5	Passive accessories, RJ45 - patch cords etc..			1	500	50	50	550	50
								106,150	9,050

Placing NMS for Monitoring of L3 CPE device									
The costing given below will be 100% additional in case L3 CPE device will be required to monitored from BBNL NMS									
1	NMS monitoring and management tool. Including Installation cost- in HA at DC and DR for	Lot	No.	750,000	1,000	50	100	787,500,000	75,000,000
2	Server Hardware for NMS in HA at DC and DR	Lot	No.	20	800,000	40,000	80,000	16,800,000	1,600,000
Cost of Leasing 10 G BW from TSP									
The costing given below is for leasing a 10Gbps B/W line from TSP. This costing will be applicable where BBNL could not get the dark fiber on lease and need to take the B/W from other service provider on lease. The below costing is for leasing the 10 Gbps leased circuit for 5-50 Km distance.									
1	Cost of STM-1 Leased circuit 0-45 KM		No.	1	100,000	-	536,258	100,000	536,258
2	Cost of 10G Leased circuit 0-45 KM (STM-1 *26) and additional 50% discount	Lot	No.	1	200,000	-	6,971,359	200,000	6,971,359

Table 31: Alternate Cost Options

10.4. *Key Budget costing considerations and Assumptions*

SL No	Assumptions	Drivers for Assumption
1.	The New PoP at DHQ has been considered. A 500 Sq ft total area 100 Sq Ft of network rack space has been considered.	This will enable non-discriminatory access to BBNL network by all perspective users.
2.	15 KVA DG set has been considered on DHQ PoP in 1+1 Mode	Required to power PoP equipments, AC and other
3.	5 KVA UPS are considered with 120 Minutes backup in 1+1 Mode	Required to power Network equipments at PoP
4.	5 star, 1 Ton Split AC has been considered in 1+1 mode.	AC cooling required for network equipments. The same shall be increased in future if additional equipments required to be added.
5.	Power consumption at DHQ PoP is considered to be 3 KVA for power costing	Power consumption for GUN Network has been considered. Additional infra to be installed in future for services to other customer shall be coasted separately for those customers.
6.	1 Resource for 24*7 has been considered for facility management.	Resource will be required for PoP facility management, DG operations etc.
7.	New fiber to be laid to connect BBNL DHQ PoP with TSP fiber is considered to be 2 KM/District.	Cost of Laying this fiber is taken as 3,00,000/KM.
8.	The Average Fiber connectivity required to connect BBNL DHQ PoP with NKN/SWAN/NII PoP has been considered as 5 KM/District	NKN/SWAN/NII would already be connected by fiber of TSPs. Hence cost of leased fiber has been taken into consideration.
9.	Total pooled internet bandwidth at DHQ is considered to 100 Mbps (Contention Ratio of 1:50)	As per TRAI guidelines
10.	Annual cost of ISP license (@8% Adjusted Gross Revenue) has been considered on the revenue received from sale of coupons to wi-fi users at GPs.It has been assumed that there would be on an average 50 wi-fi users per GP	As per TRAI guidelines
11.	The Average incremental Fiber road distance from District – Block or Block to Block has been considered to be 33 KM	Study of Telecom GIS MAP of NIC

SL No	Assumptions	Drivers for Assumption
12.	The existing Fiber availability for lease between Block-District is 94.3%	Study of Telecom GIS MAP of NIC
13.	The Cost of leasing dark fiber from TSP has been considered to be as 20000/fiber pair/KM.	Based on our market study the average cost of leasing the fiber pair in India comes between 25000/- to 40000/- per KM depending on the type of City. Looking at the bulk fiber leasing requirement of BBNL it is envisaged that there could be additional 30-40% discounting on these prices during the negotiation. Hence the envisaged cost of leasing fiber could be between 15000-25000/pair/KM depends on the city and geography. The average cost of leasing fiber pair comes around 20000/KM. This is further substantiated by NOFN DPR report (prepared by TCIL) in which the fiber leasing cost is taken as 10000/core/KM making per pair cost as 20000/KM.
14.	ISP Setup including AAA server at DC/DR has been taken into consideration for costing.	
15.	Installation Cost is considered to be 5% of material Cost	
16.	Maintenance of O/H Fiber to be outsourced	Dedicated Fiber management team/District is considered.
17.	Field resources to provide onsite support to be provided by respective O&M vendor.	10 % AMC cost considered including OEM warrantee (6-7%) and onsite support cost (3%-4%).
18.	Additional power at Block/OLT considered as per power rating of the equipment to be installed	Equipment data sheet
19.	Additional power at GP/PoP considered as per power rating of the equipment to be installed	Equipment data sheet
20.	Poles required across all GP locations for mounting Wi-Fi access point	No poles have been provided under NOFN project
21.	Monitoring of CPE device (ONTs) would be done through existing NMS. Costing for additional capacity required in existing NMS has been considered	BBNL already deploying NMS to manage 6,00,000 ONT
22.	L3 CPE equipment has been considered to be installed at both the institutions and eGP service center	

SL No	Assumptions	Drivers for Assumption
23.	Last mile connectivity to institute has been considered by using overhead fiber for costing perspective.	It is assumed that at few locations underground fiber/Wireless solution will be required having the higher cost while at few locations institutes shall be connected directly by using UTP cable. Hence the overall cost will average out.
24.	The Average overhead fiber required to connect two institutions has been considered to be 1 KM	
25.	Additional rack space required in DC/DR to host additional servers has been taken into consideration	
26.	Additional Resources required in NOC to manage the GUN infrastructure has been taken into consideration	
27.	Additional Resources required in deployed by BBNL to manage the implementation and O&M of GUN has been taken into consideration	
28.	Additional Resources has been taken into consideration for customer support desk for GUN.	
29.	Separate Multi-lingual Helpdesk provisioned to support community wi-fi users	
30.	No additional cost for DCN network required to manage new equipments/network from NOC	DCN network is already established for NOFN project
31.	No taxes and other levies considered as part of costing.	

Table 32: Key considerations and assumptions

11. Risk Analysis

Project execution of the scale of GUN over NOFN can be impacted by a number of factors that can directly or indirectly affect the intended outcome(s) of the project. To be better prepared for managing such risks and minimizing their impact, it is important to do an analysis of the possible risks that are associated with the project.

The risks envisaged for the smooth execution of the project are listed below with the intent that a periodic check on them will ensure smooth implementation of the project.

Impact – High (H), Medium (M), Low (L)

Probability - High (H), Medium (M), Low (L)

Period – Inception (I), Commissioning (C), Exploitation (E)

S. No.	Risk	Impact	Probability	Period	Mitigation
1.	BBNL being a lean organization, there might be inadequate capacity at various levels to co-ordinate with various agencies and to supervise the project implementation.	H	H	I	The implementation structure outlined in section 6:*Implementation Strategy*, ensures that single implementation agency is responsible for implementing, commissioning and managing the network. Number of such implementation agencies is optimized by way of clustering the States together and granting the implementation work to that agency for the entire cluster.
2.	Availability of dark fiber	H	M	C	Some buffer on the expected price that came from

S. No.	Risk	Impact	Probability	Period	Mitigation
	lease at the budgeted cost. The budgeted price for leasing of dark fiber has been arrived at after some initial deliberation with market players. However actual price discovery may give different results				initial discussion with market players has been built into the budgeted cost of leasing. However, it is recommended that industry consultation may be carried out to further substantiate the pricing of dark fiber lease.
3.	High reliance on BSNL in all key aspects of project including dark fiber leasing etc	M	M	C	It is recommended that BSNL should be taken on board for implementation of the project
4.	GUN over NOFN is not subject to Cost and Benefits analysis	N	L	E	Cost benefit analysis is a standard tool for determining the efficiency of the planned projects. This analysis would generally be required for investment and infrastructure projects, but may not always be feasible for social sector projects where the benefits are intangible. It is difficult to associate cost benefit for access to broadband by rural population
5.	Lack of skilled manpower to run the communication	H	H	C,E	Maintenance of GUN over NOFN is to be outsourced and regular internal capacity building exercises

S. No.	Risk	Impact	Probability	Period	Mitigation
	network after it is operational				should be undertaken to ensure stakeholder interest as well as keep the network functional
6.	High reliance on anchor customer, i.e. MoRD on	H	L	I, E	BBNL may explore the option of engaging with other Government ministries to act as anchor customer. Additionally, BBNL may look at aggressively marketing spare capacity as well scaling up operations to meet the expectations of other potential customers.
7.	Non delivery of services by MoRD	M	M	E	MoRD should be taken on board with respect to the operational costs of the project as well as with the additional costs that they might have to incur in order to deliver their services. BBNL should engage closely with MoRD to enable their service delivery and provide possible assistance in resolving the issues pertaining the same.
8.	With time, the technologies and components will become obsolete	M	M	E	Technical solution of the project is based on the latest, but proven, technology components. Vendor consultations have been carried out to ascertain the right technology parameters. However regular review of the same will ensure that any timely upgrades are

S. No.	Risk	Impact	Probability	Period	Mitigation
					incorporated in the design
9.	It might be difficult to maintain the required SLA as the network stretches to remotest of areas of India	H	H	E	Proposed O&M strategy detailed in section 7*:Operations and Maintenance Strategy* takes this into consideration. Multi-layered SLA framework based on geography and services mounted should be used. Realistic SLAs should be defined and complied.
10	Interconnect issues with service providers may arise due to technology constraints	N	L	C, E	Standards based approach has been taken for the design of the system
11	Inordinate implementation delays would increase the project cost and severely limit the benefit realization	H	M	C	Strong and professional program management framework should be put in place that would ensure delivery of the project at the right time with right quality
12	Political Risk	H	M	C	Engagement with stakeholders at all levels including State and local bodies should be initiated to get them onboard with the project and encourage them use the network to deliver their services

Table 33: Risk Analysis

11.1. Sensitivity Analysis

In order to arrive at the key factors that can impact the project costs as well as magnitude of their impact on the implementation and maintenance costs, sensitivity analysis has been carried out. This section lists down the process of analysis, key data points and inferences drawn.

11.1.1. Process

Process of analysis is detailed below –

1. **Identification of key factors** that can potentially have a significant impact on the project – Based on the final cost matrix, key components were identified. Any component that has a share of equal to or more than 5% in the overall cost structure was identified to be potentially sensitive and used for further analysis. This was done across both Capex as well as Opex costs.

2. **Identification of sensitivity –** All the cost components identified in step (1) above were put though univariate sensitivity analysis test in order to identify the impact of that specific component on the overall cost structure as a standalone. Below are the steps that were taken to complete the sensitivity –

    i. Identify the most probable value (baseline) of each of the cost components and corresponding Capex and Opex costs

    ii. Based on practical application, the expected variation in the component from the baseline value was identified. This was translated in terms of percentage variation from the baseline value

    iii. Across the range of possible values identified in (ii) above, the impact on final cost was analyzed. The variation was translated into percentage terms from the baseline Capex and Opex cost values

    iv. The percentage variation in input component and corresponding changes in overall cost was plotted against each other on a graph and *sensitivity index* calculated the slope of the cost variation line

11.1.2. Uncertainty and Sensitivity Chart

Based upon the sensitivity analysis done in step (2) above, an overall uncertainty and sensitivity chart for the project and its components was created. The probability of variation of each component was given a value of high, medium or low based on market conditions and confidence in the accuracy of expected value. Below is the final graph.

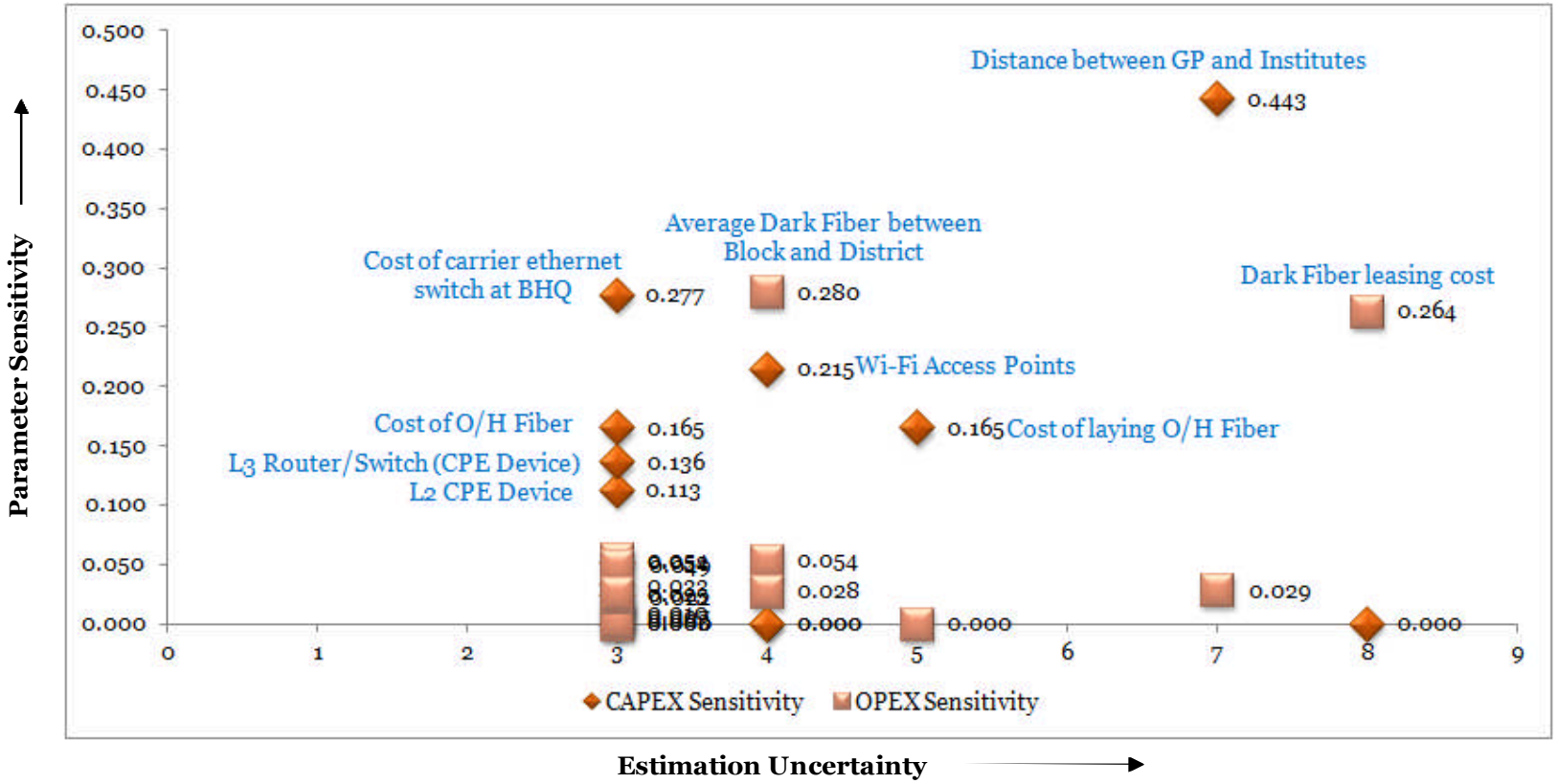


Figure 30: Sensitivity Analysis Graph

12. Bandwidth Demand Analysis

12.1. Bandwidth Demand Estimates

BBNL intends to make available the spare capacity, created as part GUN over NOFN project, to other service providers in the market on a non-discriminatory basis. The spare capacity will be offered to players from both Government as well as private Service Providers.

In order to arrive at the demand estimates, three different approaches were employed. They are –

1. Services based demand estimation approach
2. Monthly Per Capita Expenditure (MPCE) approach
3. Comparable country approach

The three methods are detailed in *section* *A.3:Demand Estimation Methodologies*.

Table below provides a summary of the demand as estimated from the different methodologies

Estimated Broadband bandwidth demand in rural India 2013 to 2024 (in Mbps)

Approach	2013-14	2018-19	2023-24
Services based approach	-	50 – 89	73 - 130
MPCE approach	4-4	17-19	39-49
Comparable country approach	15-15	33-46	35-120

Table 34: Bandwidth Demand Summary

12.2. Bandwidth Tariffs

The guiding principle for arriving at tariffs for providing bandwidth to service providers will be to encourage them to provide their services to rural population at affordable cost. Exact methodology to determine the tariffs will be decided by the BBNL board from time to time.

Appendices

A.1. GIS based survey

A.1.1. Objectives of GIS survey

1. Validation of distances between Districts and Blocks along the optical fiber route
2. Validation on topology options available between Districts and Blocks as per the available OFC route

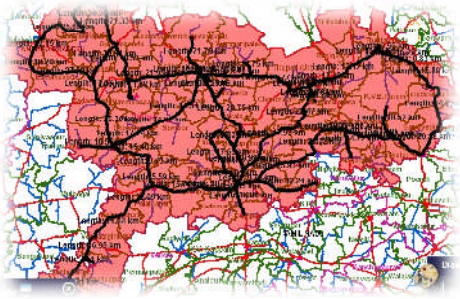


Figure 31: GIS Survey - Chittoor

A.1.2. Approach

1. Telecom GIS created and managed by NIC was used for doing the survey (http://telecomgis.bsnlgis.nic.in/). The telecom GIS provides OFC network created by the 3 CPSUs i.e. BSNL, PGCIL and RailTel across India
2. Representative samples of Districts were chosen across the country from every State. From each State an endeavor was made to select Districts with high, medium and low Block density so that an even spread of all types of District is represented in the sample. This created a list of around 61 Districts across the country.

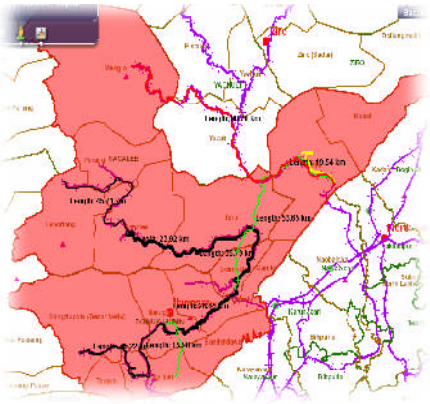


Figure 32: GIS Survey - Papum Pare

3. For each of the District an endeavor was made to create an optimized OFC route along the possible network topology. The possible topologies are:
    i. Linear
    ii. Ring
    iii. Hybrid

A.1.3. Survey Outcome

S. No	State	District	Total No. of Blocks	OFC Connected Blocks	Total Fiber (km)	Average km / Block	Topology	Blocks connected in linear	Blocks connected in Ring
1	Andaman & Nicobar Islands	North and Middle Andaman	3	0	120.09	0.00	Linear	0	0
2	Andhra Pradesh	Chittoor	66	66	1156.23	17.52	Hybrid	11	55
3	Arunachal Pradesh	Dibang Valley	3	3	79.02	26.34	Linear	3	0
4	Arunachal Pradesh	Papum Pare	10	8	319.9	39.99	Linear	8	0
5	Arunachal Pradesh	West Siang	18	13	537.57	41.35	Linear	13	0
6	Assam	CHIRANG	5	5	61.06	12.21	Linear	5	0
7	Assam	NAGAON	20	18	432.01	24.00	Hybrid	12	6
8	Bihar	ARWAL	5	5	83.57	16.71	Linear	5	0
9	Bihar	DARBHANGA	18	15	364.33	24.29	Hybrid	12	3
10	Bihar	PURBI CHAMPARAN	28	27	468.67	17.36	Hybrid	17	10
11	Chhattisgarh	KABIRDHAM	4	4	93.51	23.38	Linear	4	0
12	Chhattisgarh	SURGUJA	19	19	762.23	40.12	Hybrid	8	11
13	Goa	NORTH GOA	6	6	175.67	29.28	Ring	0	6
14	Gujarat	NARMADA	4	4	109.18	27.30	Linear	4	0
15	Gujarat	KACHCHH	10	10	629.94	62.99	Hybrid	3	7
16	Gujarat	RAJKOT	14	14	589.86	42.13	Hybrid	3	11
17	HARYANA	GURGAON	4	4	100.81	25.20	Hybrid	1	3
18	HARYANA	BHIWANI	10	9	257.12	28.57	Hybrid	2	7
19	HARYANA	PANIPAT	5	5	106.34	21.27	Ring	0	5

S. No	State	District	Total No. of Blocks	OFC Connected Blocks	Total Fiber (km)	Average km / Block	Topology	Blocks connected in linear	Blocks connected in Ring
20	HIMACHAL PRADESH	CHAMBA	7	6	193.44	32.24	Linear	6	0
21	JAMMU AND KASHMIR	SAMBA	4	4	80.75	20.19	Linear	4	0
22	JAMMU AND KASHMIR	BARAMULLA	12	9	161.1	17.90	Linear	9	0
23	JHARKHAND	JAMTARA	4	4	78.02	19.51	Linear	4	0
24	JHARKHAND	DUMKA	10	10	234.33	23.43	Linear	10	0
25	JHARKHAND	RANCHI	14	14	337.71	24.12	Hybrid	10	4
26	KARNATAKA	TUMKUR	10	10	388.98	38.90	Hybrid	1	9
27	KARNATAKA	CHAMARAJANAGAR	4	4	75.75	18.94	Linear	4	0
28	KERALA	IDUKKI	8	8	310.68	38.84	Hybrid	2	6
29	KERALA	THRISSUR	17	17	338.45	19.91	Hybrid	2	15
30	MADHYA PRADESH	BARWANI	7	6	333	55.50	Hybrid	3	3
31	MADHYA PRADESH	DHAR	13	12	412.47	34.37	Hybrid	2	10
32	MADHYA PRADESH	DATIA	3	3	102.6	34.20	Linear	3	0
33	MAHARASHTRA	RATNAGIRI	9	9	423.24	47.03	Hybrid	5	4
34	MAHARASHTRA	SOLAPUR	11	11	566.93	51.54	Hybrid	2	9
35	MAHARASHTRA	YAVATMAL	16	16	623.65	38.98	Ring	0	16
36	MAHARASHTRA	DHULE	4	4	244.28	61.07	Ring	0	4
37	MANIPUR	SENAPATI	6	6	178.92	29.82	Linear	6	0
38	MANIPUR	CHURACHANDPUR	10	5	266.99	53.40	Hybrid	3	2
39	MEGHALAYA	JAINTIA HILLS	5	5	127.33	25.47	Linear	5	0
40	MIZORAM	CHAMPHAI	4	4	260.49	65.12	Ring	0	4
41	NAGALAND	TUENSANG	8	5	154.25	30.85	Linear	5	0

S. No	State	District	Total No. of Blocks	OFC Connected Blocks	Total Fiber (km)	Average km / Block	Topology	Blocks connected in linear	Blocks connected in Ring
42	Odisha	KENDUJHAR	13	13	353.99	27.23	Linear	13	0
43	Odisha	BHADRAK	7	7	169.3	24.19	Linear	7	0
44	PUNJAB	GURDASPUR	16	15	382.15	25.48	Hybrid	2	13
45	PUNJAB	BATHINDA	8	7	176.61	25.23	Ring	0	7
46	PUNJAB	NAWANSHAHR	5	5	81.97	16.39	Linear	5	0
47	RAJASTHAN	CHITTORGARH	14	10	405.41	40.54	Hybrid	2	8
48	RAJASTHAN	JALORE	7	7	368.9	52.70	Hybrid	2	5
49	RAJASTHAN	SAWAI MADHOPUR	5	5	208.48	41.70	Linear	5	0
50	TAMIL NADU	THE NILGIRIS	4	4	115.37	28.84	Hybrid	1	3
51	TAMIL NADU	THIRUVARUR	10	10	198.42	19.84	Hybrid	2	8
52	TAMIL NADU	VILLUPURAM	22	22	533.52	24.25	Hybrid	8	14
53	TRIPURA	SOUTH TRIPURA	11	11	324.59	29.51	Hybrid	7	4
54	UTTAR PRADESH	AGRA	15	15	355.75	23.72	Hybrid	7	8
55	UTTAR PRADESH	AURAIYA	7	7	138.04	19.72	Hybrid	4	3
56	UTTAR PRADESH	GAUTAM BUDDHA NAGAR	4	4	108.85	27.21	Linear	4	0
57	UTTAR PRADESH	AZAMGARH	22	22	439.81	19.99	Hybrid	1	21
58	UTTARANCHAL	PAURI GARHWAL	15	15	668.66	44.58	Linear	15	0
59	UTTARANCHAL	CHAMPAWAT	4	4	54.76	13.69	Linear	4	0
60	WEST BENGAL	DINAJPUR UTTAR	9	9	346.81	38.53	Hybrid	4	5
61	WEST BENGAL	BARDHAMAN	31	30	679.4	22.65	Hybrid	14	16
		TOTAL	**667**	**629**	**18451.26**	**29.33**		**304**	**325**

Table 35: GIS Survey Results

A.1.4. Results Summary

Parameter	Result	Remarks
Average distance between Blocks and Districts	**29.33 km**	Assuming a 10% error margin, the project budget has been worked out on the basis of an average distance of **33 km** between District and Block
% Blocks surveyed where fiber from 3 CPSUs was present	**94.3%**	
% of cases where ring topology was formed (including cases where sub rings within a hybrid case)	**51.67%**	
% of case where linear topology was formed (including cases where linear topology was formed within a hybrid case)	**48.33%**	

Table 36: GIS Survey Results Summary

A.2. Dark fiber availability between District and Block

Based on the GIS survey done it inferred that the dark fiber is available from three CPSUs between District and Block in at least 94.3% of the surveyed Districts. Extrapolating this to country level will imply that there is enough reach available amongst the three CPUs to almost all Blocks of the country.

In addition to the above, an attempt to connect with major Telecom Service Providers was made to understand availability of their optical fiber network between District and Block. However, till the time of submission of this report, only **Reliance Communication** had provided some initial estimate on the availability of their country wide fiber availability as below [7]–

- Total country wide OFC network available
    i. Total ducting done – 4,00,000 km
    ii. Total OFC network available– 2,80,000 km
    iii. Total OFC network already lit – 1,90,000 km
- OFC Network – present in approx 100% of District Head Quarters and approx 60% of the Block Head Quarters
- In remaining 40% of the Blocks where OFC network is not available, the company has already completed the ducting which can be utilized for quickly laying the fiber

[7] The information presented here has been received from Reliance Communication based on informal interaction only. It is recommended that this information should be formally verified with the said Service Provider.

A.3. Demand Estimation Methodologies

A.3.1. Services based approach

The demand of broadband in rural India will get driven by the provisioning of the services enabled by broadband. In this approach, we have identified the major entities in rural India ecosystem and assessed the bandwdith usage by each one of them in enabling end-user services. The broadband will be consumed on wholesale basis by these entities and subsequently used for internal consumption as well as providing and speeding up the end-user services.

Following have been identified as wholesale consumers of bandwidth in rural areas:

1. **Anchor customers from government**
    - Ministry of Rural Development Services: rural health, rural education
    - Community Wi-fi
2. **Other government service providers**
    - Government ministries e-Governance enablement
    - Police stations
    - Post office
    - Utilities
3. **Private players**
    - Telecom operators
    - Banking institutions
    - Tower companies
    - Cable operators

Further on, we have identified the size of packet download for each service and the minimum speed required. This calculation gives us a reasonable estimate of bandwidth required

A.3.1.1. Assumptions and Enablers

- The data is based purely on secondary estimates primarily using government web-sites. It is recommended that an independent primary survey is conducted in selected rural areas to identify the services viability and bandwidth usage estimations
- For many services, enabling ecosystem has to be created before they are consumable by end-user. For example, for remote health consultations, video conference equipment have to be set-up at the rural health centre. Similarly willingness and investment by government ministries will be required to enable e-governance services.

- For private players, the services zone is limited to the surrounding area of GP. Taking it beyond the range will require investment by the private players.
- The safety, security and regular maintenance of the broadband equipment at delivery and at user end has to be enabled.
- For certain services, workforce to provide useful data is required. For example, doctors are required at one end (may be in a District) for provide remote health services. Similarly , for record digitalization initially, workforce is required.

A.3.1.2. Services

A.3.1.2.1. Government to Citizen (G2C) and Government to Government to Citizen (G2G2C) Services

1. **Bandwidth Consumers: Healthcare centers** – One of the primary unfulfilled needs of rural citizen is access to quality health care. As of today, near 70% rural Indians do not have access to critical medicines and 31% of rural population need to travel up to 30 kms to seek basic health care. Under National Rural Health Mission, Indian government has opened up sub-centers, primary health centers and community health centers

Type of Centre (staff strength)	Average Rural population covered	Count by 2014	Staff shortfall	Need for remote health care (C*D)
Sub-centre (3)	5,624	1,70,000	49% (without health workers)	83,300
Primary health centre (15)	34,876	28,000	4.6% (without doctors)	1,288
Community health centre (25)	173,235	5,500	70% (without specialists)	3,850

Table 37: Healthcare Centers Analysis

The sub-centers are the most peripheral contact point between primary healthcare system and community; primary health center is referral unit for 6 sub centers and community health center is a referral unit for 4 primary health centers. The staff strength and quality differs accordingly as the sub-centers have health workers, whereas the primary and community health centers have medical officers and lab technicians.

Additionally, an entrepreneur can open up a health centre in rural sector to provide broadband enabled services as listed below. Services enabled by high speed broadband connectivity in these centers will have an economic impact (rural employment), social impact (improved health care) and environmental impact (minimum travel).

- **Services in the health centre:** Doctor video conference and examination with patients, telemedicine, Patient vital signs monitoring (Pulse, Blood pressure) , Patient charts review (electronic health records), Electronic prescriptions, Imagery diagnostics (X-rays, ultrasounds, ECG), Billing / reporting applications, Clinic administration applications, health-related information through village kiosks
- **Equipment required:** Dedicated videoconferencing codecs, cameras, computer inputs, microphones in the primary healthcare centre
- **Bandwidth driver:**
  - Multi-party video conference for doctor consultations
  - High image quality - resolution and frames for electronic health records
  - Large scale files (X-rays, MRIs compressed size varies from 5 to 10 megabytes) download
  - At least 10 Mbps in each direction
- **Bandwidth Estimation :**

Wholesale bandwidth buyer	Service	Estimated Bandwidth requirement (in Mbps)	Average size of download in Mb	Expected download time in seconds	Concurrent users expected per GP	Remarks
Government Rural health centres (3 lakhs), private village kiosk for telemedicine	Doctor video conference and examination with patients	0.5-1	0.5-1	1-10	1	Online consultation - interactive in nature; high quality HD - up to 2 Mbps
83,000 government rural health centres have shortfall of doctors,medical staff	Patient vital signs and charts review (electronic health records, pulse, bp)	0.5-1	0.5-1	1-10	1	Monitoring electronic health records - already uploaded

Wholesale bandwidth buyer	Service	Estimated Bandwidth requirement (in Mbps)	Average size of download in Mb	Expected download time in seconds	Concurrent users expected per GP	Remarks
	Electronic prescriptions	0.5-1	0.5-1	1-10	1	Prescribing and sharing the prescription online
	Imagery diagnostics (X-rays, ultrasounds, ECG) - large picture download	3-4		1-10	1	Real-time image download along with consultation
	Billing / reporting applications, Clinic administration applications	0.5-1	1-2	60-120	1	Internal administation
	Health-related information(audio/visual)	0.5-1	3 onwards	120 onwards	Multiple downloads	Products and diseases related information - online and offline both
	Total	5.5-9				

Table 38: Bandwidth Estimation - Healthcare

2. **Bandwidth Consumers: Rural schools** – A number of initiatives have been taken to provide education to rural children, but the quality and availability of teachers is a big roadBlock. The teacher-to-student ratio in government-run rural school is much lower than Right to Education mandated 1: 40. Rural India has 12 lakh schools split into primary, upper primary and higher secondary as below:

Primary schools	With Upper Primary	With higher secondary	Upper Primary Only	Upper Primary with higher secondary	Total
758,669	215,403	30,116	134,709	71,451	1,210,348

Table 39: Schools Analysis

Of these 12 lakh schools only 65% have pucca building and 44% have regular head master / teacher. 42% of these schools are in 5-10 kms range from Block headquarters; and just 16% have computers already installed in the schools. Keeping these factors in mind and government program to increase computer penetration in schools, it is safe to assume that 30% of schools will have pucca building, regular teachers and will be in range of 5-10 kms from Block headquarters and have computers.

Services in the education centre: Internet audiovisual content, live learning (special courses, interaction based content), learning portals, education centre administration (email, internet, attendance systems). Remote tutions, vocational training courses online

- **Equipment required:** Video conferencing codec, headphones, computers
- **Bandwidth drivers:**
  - For audit visual content, download can happen first and viewed later resulting in bandwidth demand shifted to off hours. Bandwidth up to 5 Mbps is sufficient
  - Live learning - requires videoconferencing - bandwidth required is 3-4 Mbps on both sides
  - Learning portals - hosting content - bandwidth dependent on concurrent users - but with 50-70 users, 5Mbps is sufficient
  - Administration services - simple services, hence 2 Mbps is sufficient
- **Bandwidth Estimation :**

Wholesale bandwidth buyer	Services	Estimated Bandwidth requirement (in Mbps)	Average size of download in Mb	Expected download time in seconds	Concurrent users expected per GP	Remarks
Rural Schools (12 lakh schools)	Internet audiovisual content	0.5-1	1-2	120 onwards	Multiple downloads	Most of the content can be downloaded offline

Wholesale bandwidth buyer	Services	Estimated Bandwidth requirement (in Mbps)	Average size of download in Mb	Expected download time in seconds	Concurrent users expected per GP	Remarks
Only 65% have pucca building and 44% have regular headmaster / teacher	Live learning (special courses, interaction based content) through video conference. Remote tutions, vocational training courses online	0.5-1	1-2	2-10	1	Student-teacher interaction, specific content share
	Learning portals	0.5-1	3 onwards	120 onwards	Multiple downloads	Offline portals for content downloads
	Education centre administration (email, internet, attendance systems).	0.5-1	1-2	60-120	1	Internal apps
	Total	2-4				

Table 40: Bandwidth Estimation - Education

3. **Bandwidth Consumers:** Police Stations and outposts : Government has initiated number of programs to modernize and transform police stations and outpost for increased transparency, accountability and feeling of safety to normal citizens. In rural India, there are 9,525 police stations.
   - **Services for police stations:** Criminal records in live database, vehicle registrations, report filing, emergency responses (fire, burglary) by GIS alerts, videoconferencing for legal proceedings
   - **Bandwidth drivers:**

- For criminal records and vehicle registration database, the bandwidth requirements are medium as no advanced audio or video is needed, only normal graphics and photographs are enough. Hence, speed up to 1 Mbps will suffice for secure servers
- For GIS mapping and tracking in case of emergency response, wherein GIS ties together the phone numbers with locations and provide mobile access to maps, the bandwidth of 1 Mbps will suffice
- Only limited legal proceedings can be processed via videoconferencing as per the law of the land, hence this will require only a video call between two points for which the bandwidth of 2 Mbps will suffice

Wholesale bandwidth buyer	Services	Estimated Bandwidth requirement (in Mbps)	Average size of download in Mb	Expected download time in seconds	Concurrent users expected per GP	Remarks
Police stations (9,525 police stations)	Criminal records in live database	0.5-1	1-2	2-10	1	Interacting with centralized server and capturing basic text and images
	Vehicle registration data	0.5-1	1-2	2-10	1	Interacting with centralized server and capturing basic text and images
	Online report filing	0.5-1	0.5-1	2-10	1	Limited use only for first level data capture as per law of land
	Emergency responses (fire, burglary) by GIS alerts	0.5-1	1-2	2-10	1	Combining maps, location identification, phone

Wholesale bandwidth buyer	Services	Estimated Bandwidth requirement (in Mbps)	Average size of download in Mb	Expected download time in seconds	Concurrent users expected per GP	Remarks
						records
	Videoconferencing for legal proceedings	0.5-1	0.5-1	2-10	1	Limited use only for first level proceedings as per law of land
	Total	2.5-5				

Table 41: Bandwidth Estimation - Police Stations

4. **Bandwidth Consumers: Government organizations for e-governance** –:
   - **Services for e-governance:** Videoconferencing for government to government and government to community / citizen meetings, electronic data (for land records, tax, licenses, certificates - birth/death/caste/residence), UID and Election Card distribution, GIS applications
     - For example, for land inquiry, villager does not need to travel to District but can obtain land record in village itself by paying a nominal fees. Similarly for obtaining other documents, the broadband will enable in-village or near-village service in contrast to in-District service as of today. Certain government policies meant for empowering people in rural India such as MNREGA, PDS, Digital Literacy can be executed and monitored efficiently using broadband network
     - UID distribution and usage - One of the problems in UID reach to rural citizens is regarding data capture and connection with back-end Adhaar server. Additionally, if the UID card user approaches a bank or any other government outlet for subsidies, the verification require checking user's credentials by connecting to the server. The broadband connectivity can enable faster and reliable remote connection for increasing enablement and usage of UID card.
     - Election cards - From 1st October 2013, internet browsing centers at District level can operate as representatives of Election Commission of India (ECI) and perform works such as inclusion, deletion or correction of entries of electoral rolls. The work involves scanning of photographs, uploading them and verification of all necessary documents like ration cards. The same model can be enabled at GP level provided enough connectivity (broadband like) is established there.

- **Bandwidth drivers:** For the land record and certificates digitization and availability over a secured server, just the download capacity is needed. The downloads need not be real time and can be on moderate speeds, hence bandwidth of 2 Mbps line will suffice at the GP level where the villager can see these records after proper authorization. For the UID verification and electoral rolls distribution, high-speed connectivity is required for photographs and text uploads and downloads, which can be done in 2Mbps line.
- **Bandwidth estimations:**

Service Provider	Services	Estimated Bandwidth requirement (in Mbps)	Average size of download in Mb	Expected download time in seconds	Concurrent users expected per GP	Remarks
Government ministries (e-governance)	Videoconferencing for government to government and government to community / citizen meetings	0.5-1	0.5-1	1-10	1	For jansabhas, issue resolution, complaints
	Electronic data (for land records, tax, licenses, certificates - birth/death/caste/residence). Faster execution of delivery of government services - MNREGA, PDS	0.5-1	3 onwards	120 onwards	Multiple downloads	For data capture and download along with image, for online authentication. For these services, travel will be minimized / eliminated.
	UID and Election Card distribution	0.5-1	0.5-1	1-10	1	For online verification with back-end servers; photograph scans, inclusion / change of records
	Total	1.5-3				

Table 42: Bandwidth Estimation - eGovernance

5. **Bandwidth Consumers: Post offices**. There are 1.4 lakh post offices in rural India with 6 trillion deposit. Indian government has initiated "India post office technology project - 2012" for connecting all post offices and establishing hand-held microATMs in 1.3 lakh villages. Each post office caters to approximately 6,000 rural citizens today.
   - **Services**

- Digitization of records - existing accounts functioning through devices in contrast to manual, daily summary sent through broadband connection to centralized servers, advanced biometric signature verification, bill payments, MNREGA payments distribution
- Low cost banking services: Acting as financial institution / bank - savings, remittance, insurance, forex, micro loans
- Online Post office Mail tracking - increased speed, consistency, reliability

- **Bandwidth drivers:** For records digitization and availability over a secured server, just the download capacity is needed. The downloads need not be real time and can be on moderate speeds, hence bandwidth of 1 Mbps line will suffice. For the banking services and online verification, the bandwidth of 2 Mbps and for mail tracking 1Mbps will suffice.

- **Bandwidth estimations:**

Wholesale bandwidth buyer	Services	Estimated Bandwidth requirement (in Mbps)	Average size of download in Mb	Expected download time in seconds	Concurrent users expected per GP	Remarks
Post office	Digitization of records - existing accounts automation, advanced biometric signature verification, bill payments, MNREGA payments distribution	0.5-1	0.5-1	1-10	1	Information capture and upload
1.4 lakh post offices in rural India, 6 trillion deposits	Acting as financial institution / bank - savings, remittance, insurance,	0.5-1	0.5-1	1-10	1	Hand-held micro ATMs in 1.3 lakh villages, Verification through

Wholesale bandwidth buyer	Services	Estimated Bandwidth requirement (in Mbps)	Average size of download in Mb	Expected download time in seconds	Concurrent users expected per GP	Remarks
	forex					centralized servers
India post office technology project - 2012 - connecting all post offices	Online Post office Mail tracking - faster	0.5-1	0.5-1	1-10	1	
	Total	1.5-3				

Table 43: Bandwidth Estimation - Post Offices

A.3.1.2.2. Business to Citizen (B2C) and Business to Business to Citizen (B2B2C) Services

1. **Bandwidth Consumers: Telecom Operators/Internet service providers.** Indian telecom operators have reach to the rural villages already through mobile telephony and are expanding to acquire more and more subscribers. Telcos / ISPs can purchase broadband bandwidth in wholesale from government set-up and offer them as packaged service to the village entrepreneurs and rural citizens.

   - **Services:** The telecom operators can collaborate with village entrepreneurs to offer packaged services such as :
     - Agriculture information: As rural livelihood is primarily based on agriculture and husbandry, real-time and accurate information about mandi rates, fertilizer usage, weather forecast, local news etc. is extremely useful. The information needs to be delivered in regional language over mobile handsets or local TVs. The information on crop, weather and market access information should significantly improve the livelihood and productivity of Indian farmers even as government ramps up activities in the processed foods sector.
     - Media and entertainment: For rural village, the source of entertainment is with community consuming local music and videos. The village melas and festivals are another point of media consumption wherein stalls connected with improved bandwidth and local content are the selling kiosks
     - Remote health consultations (as explained in section above)
     - Remote education (as explained in section above)

- **Bandwidth drivers:** As explained above, for remote health consultations and education a 10 Mbps line for a kiosk/outlet is sufficient. The operator will like to package and bundle these services and utilize bandwidth on usage basis, with the upper cap of 50 Mbps and the lower cap of 10 Mbps.
- **Bandwidth estimations:**

Wholesale bandwidth buyer	Services	Estimated Bandwidth requirement (in Mbps)	Average size of download in Mb	Expected download time in seconds	Concurrent users expected per GP	Remarks
Telecom operators as suppliers	Agriculture information - mandi rates, fertilizer usage, weather forecast, local news in regional language	0.5-1	0.5-1	1-10	2-4	Primarily text, GIS but in regional language
1000 citizens in GP, 40% target market (teenage, power users), 50% acutal conversions from target, 1: 50 compression for concurrent users	Media and entertainment - local music, videos, games	3-4	3 onwards	1-10	4-5	Heavy content - audito, visuals, festival clips in local language. Can be enabled wirelessly

Wholesale bandwidth buyer	Services	Estimated Bandwidth requirement (in Mbps)	Average size of download in Mb	Expected download time in seconds	Concurrent users expected per GP	Remarks
	Selling bandwidth to village enterpeneurs - for offering remote health, education and other services - dedicated pipe for resell purposes	5			1-2	For reselling to private individuals / local bodies, NGOs, local businesses
Expected to be at max 2 - 3 operators		17-30				

Table 44: Bandwidth Estimation - TSPs and ISPs

2. **Bandwidth Consumers: Banking Institutions.** Government has initiated number of programs to financially include and provide secured banking services to rural citizens. 61% of the rural population is still unbanked and 1.5 lakh banking outlets in villages are being served by business correspondents. With advent of direct cash transfer and direct benefits transfer, the stage is set to enable a micro rural level banking set-ups. The financial inclusion of the poor can be enabled by giving them secured access to banking, enabling remittance as a good number of the villagers contact points are in the market. The banking services are "no frills savings accounts" with deposit, withdrawal and transfer.
   - **Services:** Basic banking , loan and insurance products information, remittance
   - **Bandwidth drivers:** Considering basic banking bandwidth requirements is for account holder verification from the centralized servers and information fetching, a 3-4 Mbps line for the rural bank is sufficient.
   - **Bandwidth estimations:**

Wholesale bandwidth buyer	Services	Estimated Bandwidth requirement (in Mbps)	Average size of download in Mb	Expected download time in seconds	Concurrent users expected per GP	Remarks

Wholesale bandwidth buyer	Services	Estimated Bandwidth requirement (in Mbps)	Average size of download in Mb	Expected download time in seconds	Concurrent users expected per GP	Remarks
Banking institutions	Basic banking	0.5-1	0.5-1	1-10	2	Deposit, withdrawal, transfer - user information / signature verification
61% rural unbanked	Loan and insurance products information	0.5-1	3 onwards	120 onwards	Multiple downloads	Audio / visual content
1.5 lakh banking outlets served by business correspondents	Remittance	0.5-1	0.5-1	1-10	1	User information / signature verification
	Internal administration - attendance, record keeping	0.5-1	0.5-1	1-10	1	MIS, email, internet
		2.5-4				

Table 45: Bandwidth Estimation - Banking Institutions

3. **Bandwidth Consumers: Tower Companies.** Of the total 0.65 million telecom towers in India, 0.4 million towers are in rural areas. The tower in remote rural areas have the typical issues of access, electricity, security and trained staff.
   - **Services:** Remote maintenance of tower, trainings to rural citizens for enabling low-cost workforce, digital advertisement space. The tower companies have civic infrastructure but with enablement of last-mile connectivity on broadband, they can remotely maintain their towers using advanced equipments. The tower company civic space can be used for providing

remote trainings to rural villages for on-site repair and maintenance of the towers. The digitization of the towers can help in remotely tracking the inventory levels and also used as an advertising space for FMCG companies.

- **Bandwidth drivers:** The bandwidth required for tower companies is up to 5 Mbps for its own usage for remote maintenance and basic training for rural citizens. Any further bandwidth requirement for advertisement can be on usage basis.
- **Bandwidth estimations:**

Wholesale bandwidth buyer	Services	Estimated Bandwidth requirement (in Mbps)	Average size of download in Mb	Expected download time in seconds	Concurrent users expected per GP	Remarks
Tower companies / Telecom operators as consumers	Remote maintenance of tower	0.5-1	0.5-1	1-10	1	For remotely shifting antenna positions, tracking inventory levels
4 lakh towers	Trainings to rural citizens for enabling low-cost workforce	0.5-1	0.5-1	1-2	1	Live training with audio / visual content
	Digital advertisement space	0.5-1	0.5-1	1-10	1	Digital billboards
	Total	1.5-3				

Table 46: Bandwidth Estimation - Tower Companies

4. **Bandwidth Consumers: Cable TV Operators.** As of now, most of the rural households have access to TV (own / shared / community). The government has already passed the mandate to digitalize cable TV in urban and semi-urban centers. The next five years will require digitalization of cable TV in rural areas as well, for which broadband internet will be the back-bone in delivering the digital content. Rural India has seen remarkable growth in cable tv with or without government support or any subsidy. A rural triple play offering can be envisaged riding on IP based next generation networks.
   - **Bandwidth estimation:**

Wholesale bandwidth buyer	Services	Estimated Bandwidth requirement (in Mbps)	Average size of download in Mb	Expected download time in seconds	Concurrent users expected per GP	Remarks
40 lakhs TV sets in rural (33% rural households) , growth 7-8% annual	IP TV - basic internet	0.5-1	0.5-1	1-10	2	Regulation on digitalization - CAS
	IP TV - channel content transmission		3 onwards	1-10	2	IPTV is still not mature on urban, will take time for rural; low penetration initially
	Data download by cable operators at central location and carry to specific outlets		20-25	1-10	20-25	
	Total	20.5-26				

Table 47: Bandwidth Estimation - Cable Operators

5. **Bandwidth Consumers:** Utility providers. As of now, most of the rural households utility providers are electricity and water suppliers. The services enabled by broadband are :
    - Advanced metering infrastructure enablement
    - Improved service delivery and outage management
    - Connectivity to smartphones and home PCs for real-time usage monitoring

- **Bandwidth estimations**

Wholesale bandwidth buyer	Services	Estimated Bandwidth requirement (in Mbps)	Average size of download in Mb	Expected download time in seconds	Concurrent users expected per GP	Remarks
Utilities	Advanced metering infrastructure enablement Improved service delivery and outage management Connectivity to smartphones and home PCs for real-time usage monitoring	0.5-1	0.5-1	1-10	2	Two utility providers
	Total	1-2				

Table 48: Bandwidth Estimation - Smart Utilities

A.3.1.3. Analysis Outcome

The final estimated demand as per this approach is as shown below

A.3.1.3.1. Demand estimate for First 5 Years

Summing all the bandwidth estimations, the total demand for BBNL broadband in rural area are between 50-89 Mbps as depicted below:

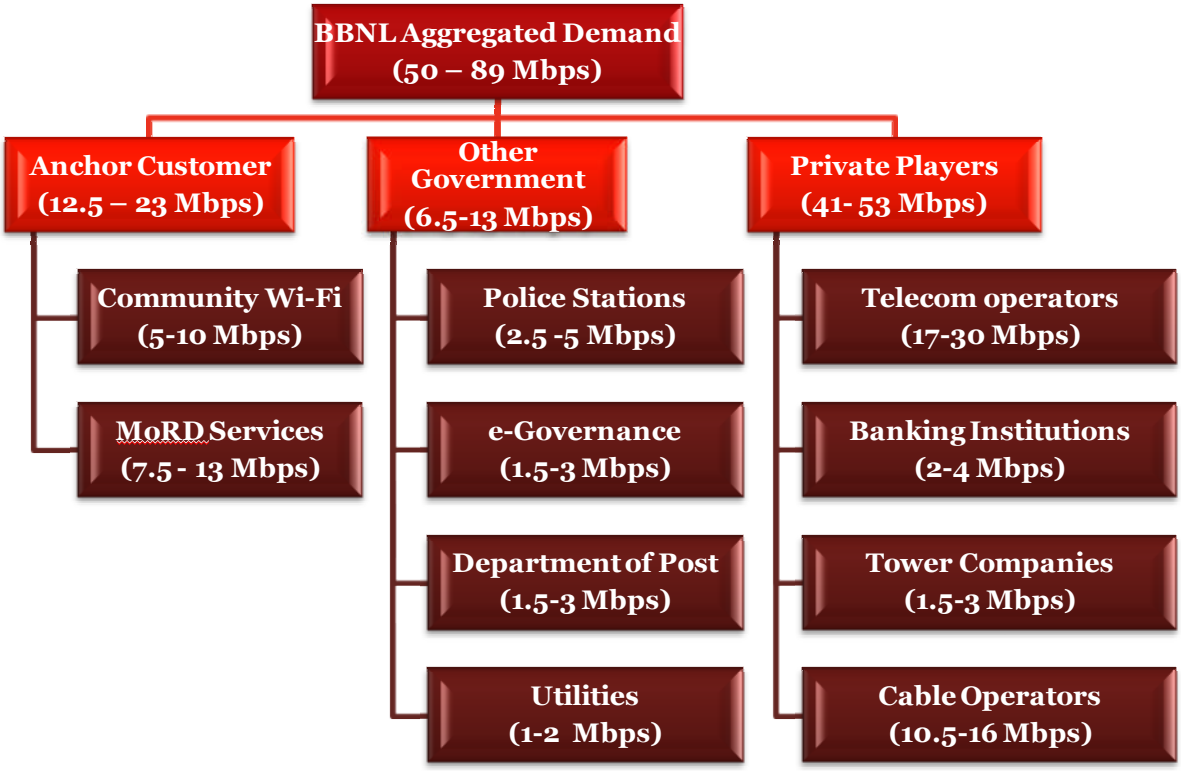


Figure 33: Demand Summary 1 to 5 years (Services based approach)

A.3.1.3.2. Demand estimate for 5 to 10 Years

Inputs	
Broandband growth (2011-12)	**~14%**
Broandband growth (2012-13)	**~10%**
Expected Broadband growth next 5 years	**~10%**

Estimate
At an estimated rural Broadband growth rate of **8%** from 2019 to 2024 the bandwidth demand in 10th year expected to be in the range of **68 to 114 Mbps**

Figure 34: Demand Summary 5 to 10 years (Services based approach)

Drivers for demand from year 5 to 10

- Increased awareness of broadband rollout and usage to citizens and private players , creation of knowledge based society
- Self-sponsoring ecosystems in rural areas encouraging more usage -Overall livelihood and life quality betterment in rural areas -economic betterment
- Private players entry in rural markets as it will be pure Opex mode - spread of 3G / 4G, healthy competition, small and medium enterprises growth
- Affordable smart phones and other user devices

- Government organizations increased usage in broadband - services automation
- Newer applications and bandwidth hungry high quality content demanding more bandwidth
- Better network equipment and technologies for utilization of last mile connectivity
- Government regulations, funding and incentives for broadband penetration

A.3.2. Monthly per capita consumer expenditure (MPCE) based approach

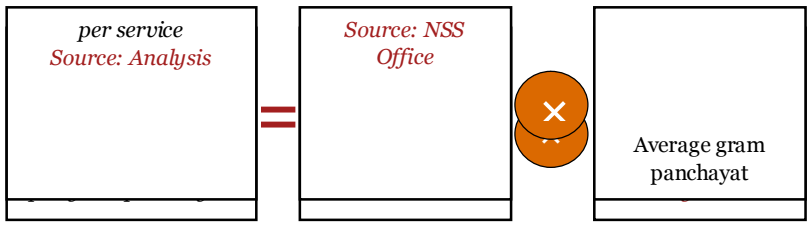
A.3.2.1. About the Approach

The National Sample Survey Office of India conducts country-wide household consumer expenditure surveys at regular intervals. These surveys generate estimates of average household MPCE, its breakup by commodity group, separately for the rural and urban sectors of the country. The MPCE uses the findings from 2011-2012 survey to extrapolate and project current and future demand based on certain assumptions (refer 4.2.3 for assumptions and enablers).

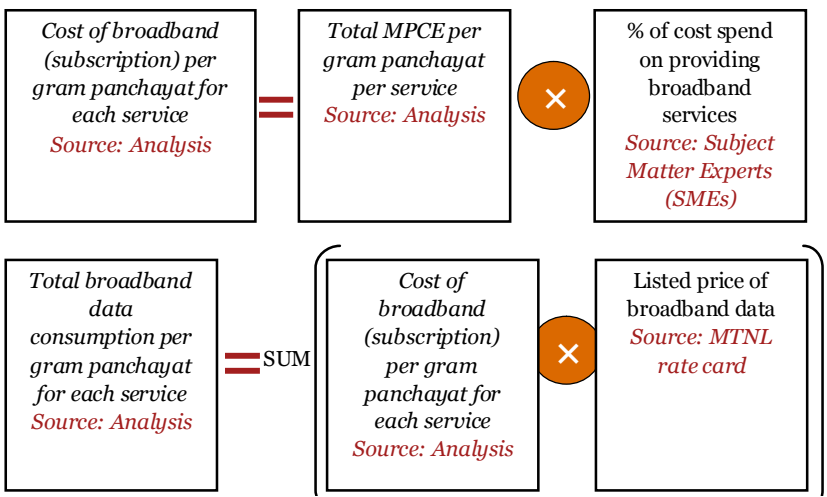
A.3.2.2. Detailed Methodology

This approach ascertains aggregate national broadband data demand through three key steps:

❶ The average monthly expenditure on services with applications of broadband data such as Health, Education, and Consumer Services such as Post Office etc. in Rural India is obtained from the NSS 2011-2012. The expenditure across these services is then aggregated per gram-panchayat based on average population of gram-panchayats in India.

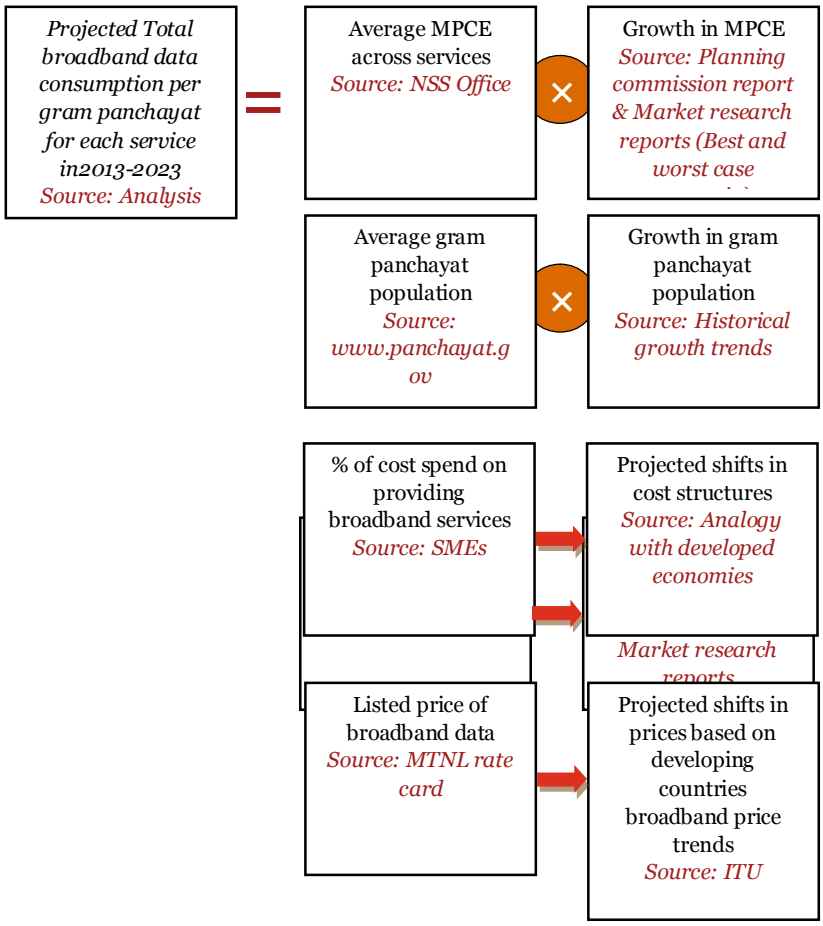


❷ Contribution of Direct and indirect broadband data consumption towards this expenditure in value is calculated based on the breakdown of the cost structure of each of these services to account for broadband data consumption. This value



term is converted into volume term based on the listed price of the broadband data. The data volume is then aggregated across service to have the total rural demand for broadband data.

❸ Projections for a time frame of 10 years i.e. 2013-23 is derived based on estimated growth rate of MPCE over next 10 years in a best and worst case scenario. Similarly, growth in Indian GP population which also takes into account rate of urbanization is estimated based on historical trends in population growth. In addition, shifts in patterns of per capita expenditure across these selected services and of broadband share per service due to changes in the cost structures are also considered while projecting the broadband demand for next 10 years. The changes in the broadband share per service are calculated based on the state of these service sectors in more developed economies. The changes in price for broadband data are estimated based on trends in price change of broadband prices in developing countries.



A.3.2.3. Assumptions and Enablers

The MPCE based estimation is enabled by a set of assumptions in place to provide for analysis and growth projections. These assumptions are as follows:

- For the current year estimations, MPCE is sourced from the National Sample Survey Office of India's (NSSO) report on customer expenditure. The MPCE for 2011-12 is reported to be Rs 772 across both food (cereals, grams, milk and milk products etc.) and non food (education, health, clothing and consumer services etc.) item groups in Rural India. The MPCE for the consecutive years is assumed to be growing between rates of 2-4% YOY for Rural India depending on a pessimistic or optimistic scenario. Therefore, the output for the consecutive year is a range of potential broadband demand.
- The NSSO report provides the distribution of the MPCE across an array of services. Of these services, few were shortlisted that use broadband data in their operations resulting in an indirect consumption of broadband data by consumers. These services are education, health, and other consumer services such as post office. In addition, consumers directly consume broadband data for entertainment and information through platforms such as mobile handsets. For the current year estimations, the percentage spend on these selected services as listed in NSSO report 2011-12 is used. For the consecutive year projections, growth rates have been assumed based on shifts in the expenditure patterns across services historically post discussion with SMEs in these service sectors. Similarly, growth at a rate of 0.01% is assumed in direct personal consumption based on the rise in penetration and usage of mobile handsets in Rural India.
- The current broadband share of these services in their cost structures is estimated through benchmarking the cost structures of an average government healthcare and education institution. Based on the findings of sixth AIES (All India Educational Survey) on income, expenditure and fee structures in schools, majority of expense is on salaries. An expense of 0.1% is assumed to be the broadband share in school expenses after accounting for consumables, capital, rent etc. Similarly, an expense of 0.1% is assumed as broadband share for health services and consumer services after accounting for administrative, HR and other utilities costs. The future broadband share of these services is projected through an assumed growth rate ranging from 0.1%-0.2% YOY based on the share of broadband in these services in developed economies.
- To convert this consumer expenditure on broadband share into value terms, the published price list for 10 Mbps broadband data plan from MTNL is used for 2011-12. Over the next ten years, this price is assumed to decrease with higher returns through penetration of broadband services and through introduction of new services that consume broadband data based on similar trends in the price changes in the telecom industry.
- Average per GP population for the year 2011-12 is sourced from the www.panchayat.gov. This number is adjusted for the consecutive years based on projected rate of growth estimated after looking at historical trends.

A.3.2.4. Analysis Outcome

Based on the analysis undertaken in the MPCE based approach, the broadband bandwidth demand for rural India over 2013-2024 is estimated to be:

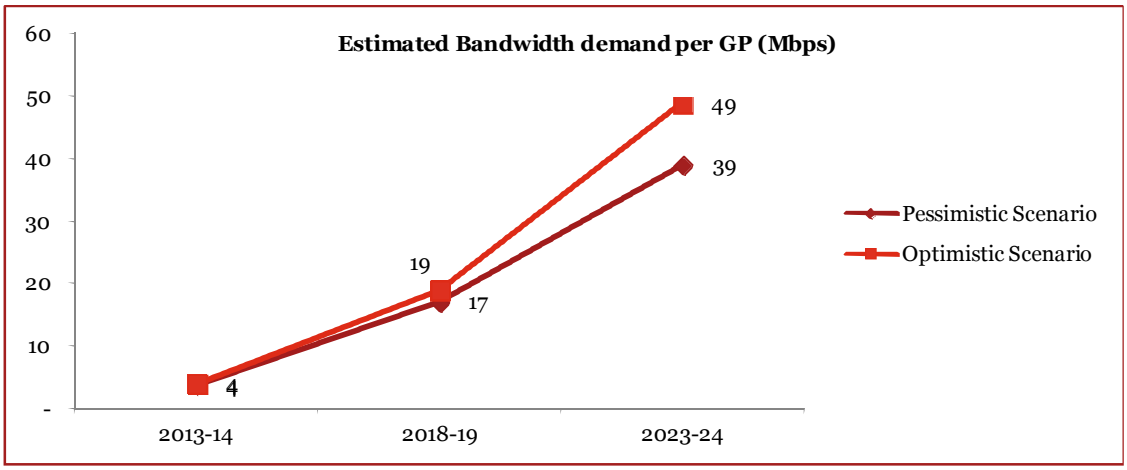


Figure 35: Bandwidth Demand - MPCE approach

Estimated Bandwidth demand per GP (Mbps)			
Year	2013-14	2018-19	2023-24
Optimistic Scenario	4	19	49
Pessimistic Scenario	4	17	39

Table 49: Bandwidth Demand - MPCE approach

The NSSO 2011-12 report states the MPCE spend in rupees at 772 for 2011-12. Of these Rs.772, approximately 18.34% i.e. Rs. 141.6 are spent per person indirectly on education (3.67%), health (6.30%), and consumer services (8.36%), and directly (0.01%) on personal entertainment and information. When aggregated for the entire GP, this expenditure totals to Rs. 495,492 on an average for a GP with a population of 3500 people.

For the year 2013-14, as the MPCE spend increases to approximately Rs. 803, from 772 in 2011-12, the expenditure on these selected services also changes to Rs 147.3 from Rs. 141.6 at the same 18.34% share. The total expenditure by a GP changes to Rs. 526,288 from Rs. 495,492 due to increase in the average GP population from reported 3500 to estimated 3573 people.

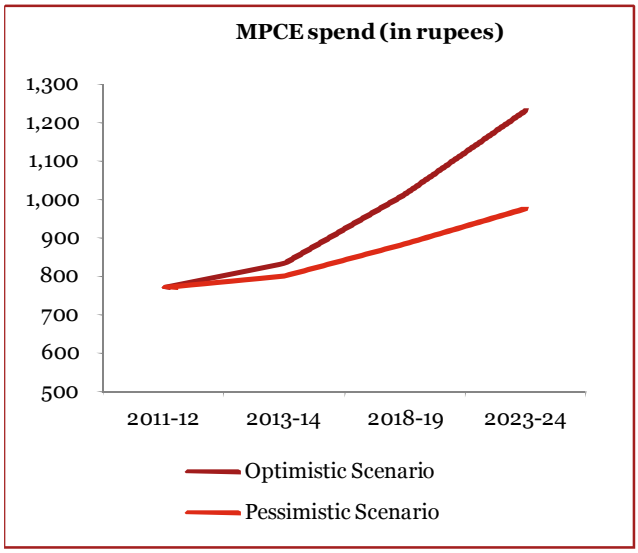


Figure 36: MPCE Spend

However, over the next 5 years, not only the MPCE and population changes but the share of expenditure on these services is also estimated to change. From an 18.34% share, these services are estimated to account for 20.5% of total MPCE share per person in 2018-19 and an even higher 23.63% in 2023-24. This increase in share of spend on these services is partly due to the change in the pattern of expenditure with health and education sector gaining more penetration in rural India and partly due to changes in the lifestyle of rural population due to higher exposure to urban lifestyle due to mass mobilization. With increased government focus on providing greater access to healthcare and education through public programs and policies, SMEs predict a small but steady increase in share of expenditure per person on these services.

MPCE spend (in rupees)				
Year/Scenario	2011-12	2013-14	2018-19	2023-24
Pessimistic	772	803	887	979
Optimistic	772	835	1,016	1,236

Table 50: MPCE Spend

Total expenditure by GP (in rupees)				
Year	2011-12	2013-14	2018-19	2023-24
Average GP population	3500	3573	3648	3724
Total expenditure (Rs.)	495,492	526,288	663,800	861,611

Table 51: MPCE spend GP

As a non-profit government institution, these services are assumed to be operating at zero cost. Therefore the expenditure per GP for a service is assumed to be equal to its total operating cost. Based on this premise, the total operating cost is divided under cost heads such as administration, rental, utilities, capital etc benchmarked against the typical cost structure of such institutions and the broadband share of total cost incurred by a service sector is calculated. For instance, in the education sector, the broadband share of the total cost is approximately 0.1% in 2011-12. At a GP level, this share equals to an expenditure of approximately Rs.50. On aggregation of broadband share across services, the total expenditure in 2011-12 on broadband per GP is approximately Rs.716. At the listed price of 10 Mbps broadband in 2011-12, this expenditure amounts to 4 mbps broadband bandwidth demand per GP.

Over the next 10 years, the broadband share of the consumer spend across services is expected to increase from Rs. 716 to Rs. 5267 in an optimistic scenario. This staggering jump in the demand is a result of an expected increase in the broadband share of consumer spends across these services and

expected decrease in the prices of broadband. The increase in the expenditure directly translates into a growing demand for broadband bandwidth over the next 10 years.

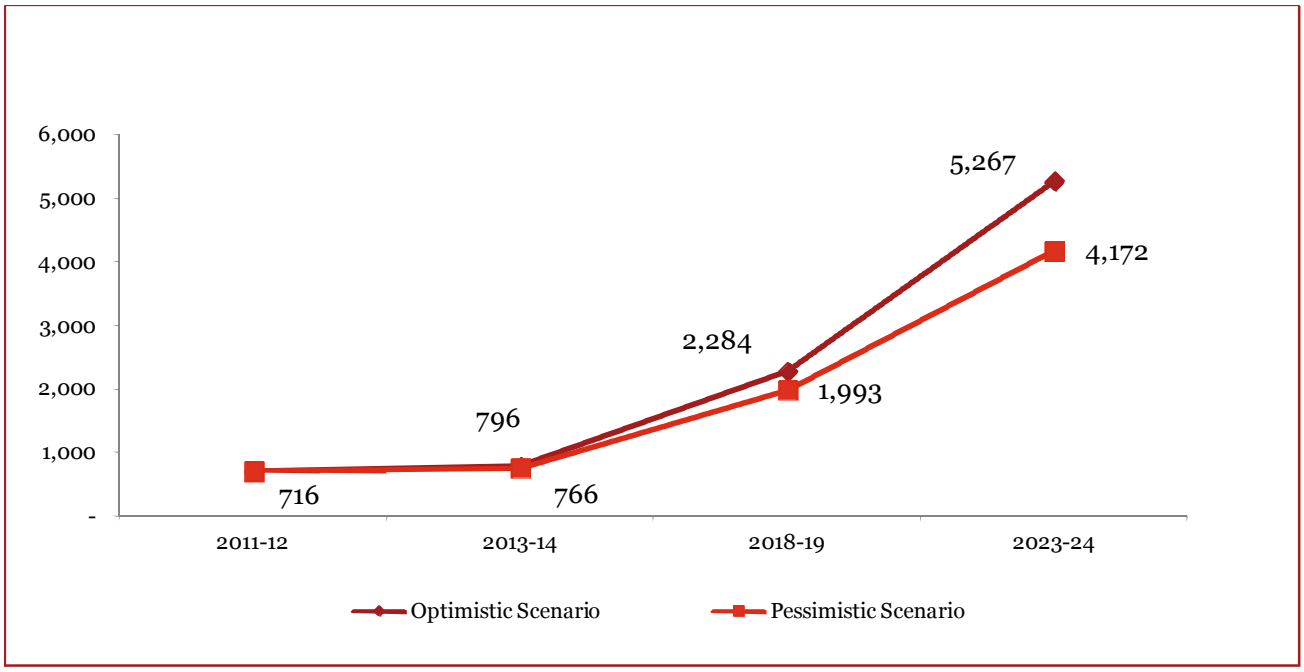


Figure 37: MPCE spend per GP

A.3.3. Comparable Countries based estimation

A.3.3.1. About the Approach

The comparable countries based estimation uses the adoption rate and growth rate of broadband in countries across the world to draw a parallel to project the current and future demand for broadband in India at a national level and rural level. The growth in broadband is estimated using two key metrics i.e. bandwidth usage through international internet bandwidth and penetration of broadband subscriptions through number of fixed broadband connections. The key assumption forming the foundation of this analysis is that India is likely to traverse the same path as the world in terms of broadband demand over the years. (Refer to section 4.3.3 for assumptions and enablers) Based on regression analysis of data on these two metrics from these countries, certain correlations are identified and then used to arrive at a projected demand for broadband bandwidth in Rural India in 2013-23.

A.3.3.2. Detailed Methodology

This approach ascertains aggregate national broadband data demand and simultaneously the rural demand through four key steps:

❶ Identification of growth rate of Internet bandwidth across countries

- The supply of international internet bandwidth was evaluated for this analysis globally; to identify the growth rate of Internet bandwidth across countries. Based on this growth rate, the supply of internet bandwidth is estimated for. In addition, growth in the fixed broadband connection/subscriptions from 2001-12 in India was studied to understand the historical growth rate in India specifically. Both these growth rate estimates were then used to project two scenarios of growth rate of internet bandwidth in India.

International Internet Bandwidth (MBPS)	MBPS available in each country for transaction of data on internet *Source: Measuring Information Society, ITU*
Fixed broadband connection/ subscriptions	Number of fixed broadband connections over 2001-12 *Source: ITU data*

❷ Estimating the projected fixed line subscriptions for India for 2013-23 through regression

- Based on the data collected for a host of countries, potential correlation is deduced using regression analysis between the supply of Internet bandwidth and demand for fixed line subscriptions. This relationship is used to predict the demand for fixed line subscriptions in India with certain confidence based on the supply of internet bandwidth estimates from step 1.

❸ Projection of broadband growth for India at GP level

- Based on the identified correlations and patterns, the adoption rate and growth for broadband in India is projected at a national level for 2013-23. Further, an analogy from the wire line tele-densities at urban and rural level in India (Source: TRAI) is used to split this national demand into urban and rural demand. The per person bandwidth demand in rural India is then projected at per GP level based in the estimated rise in the population of GPs in India.

❹ Understanding the demand supply relationship and behaviour over long term

- The adoption and growth rate of broadband in these selected sample countries is further studied over a time span of 3-4 years to determine the relationship between demand and supply of broadband bandwidth to make a more robust estimation of demand of broadband bandwidth.

A.3.3.3. Assumptions and Enablers

The comparable countries based estimation is enabled by a set of assumptions in place to provide for analysis and growth projections. These assumptions are as follows:

- The growth rate of international internet bandwidth in India is estimated based on the growth rate of International Internet bandwidth in other developed countries. This growth rate is approximately 40% internationally for developing countries. On the other hand, India's historical growth has only been 10%. Hence, estimation is provided at a national average growth rate of 10% and international growth rate of 40% to build a two scenario projection.
- The proportion split of wire line tele-density in India across rural and urban India is used as a proxy for the proportion split in fixed broadband connections in urban and rural India for projections. This proportion of approximately 70-30% is assumed to hold over the next 10 years as well.
- A consumption of 1 mbps is assumed as bandwidth demand per person in rural India to determine the aggregate national and GP level demand.
- Average per GP population for the year 2011-12 is sourced from the www.panchayat.gov. This number is adjusted for the consecutive years based on projected rate of growth estimated after looking at historical trends.

A.3.3.4. Analysis Outcome

Based on the analysis undertaken in the Comparable Countries based estimation, the broadband bandwidth demand for rural India over 2013-2023 is estimated as follows:

- The broadband bandwidth supply in India is estimated to increase from 652 bps per person in 2013-14to a 16,915 bps per person by 2023-24 based on the international internet bandwidth growth rate of 40%, assumed as the basis for optimistic estimation.
- At a R square of 91.88%, the regression analysis demonstrates a strong correlation between the international internet bandwidth supply and demand for the fixed broadband subscriptions globally. Using the regression equation, the demand for fixed broadband connections in India is estimated to increase from 0.012 subscribers per 100 people nationally in 2013-14 to 0.030 subscribers per 100 people nationally by2023-24.
- This demand is split in a 70:30 proportion between urban and rural India respectively based on the split of wire-line tele-density. At this ratio, the demand for fixed broadband subscribers per 100 people for rural India is estimated to increase from 0.004-0.031 over the next ten years.

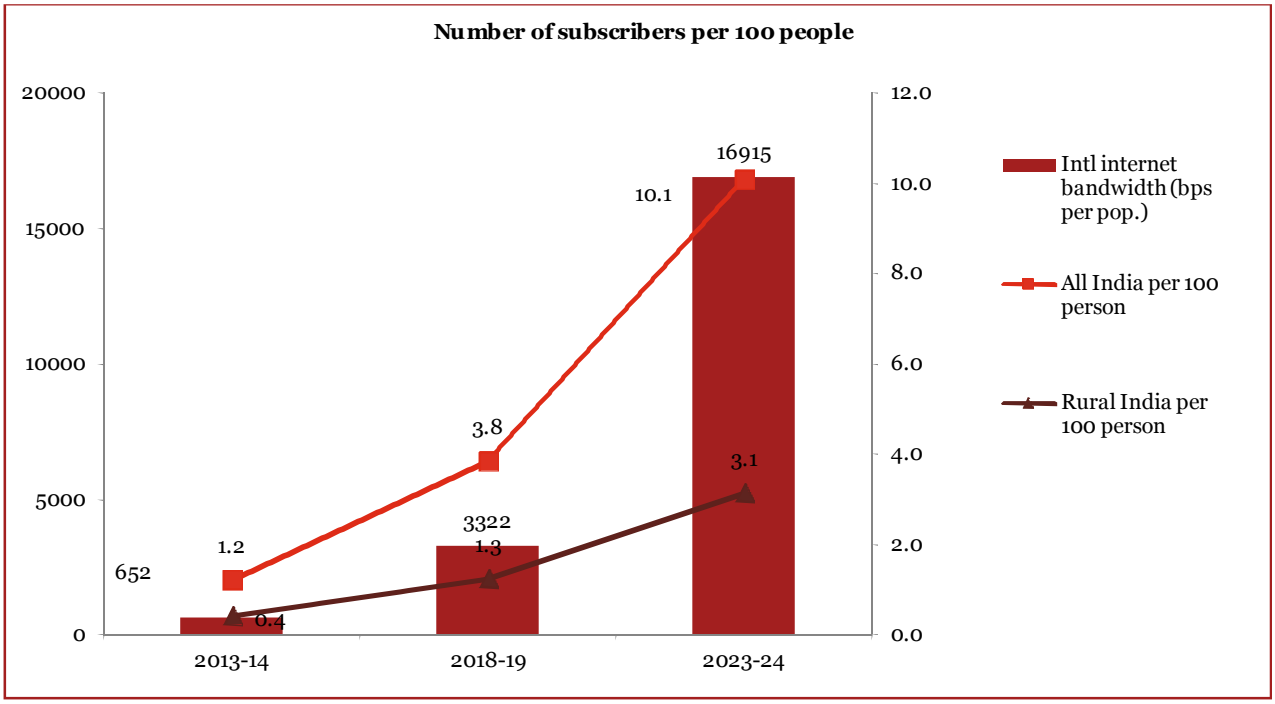


Figure 38: Subscribers per 100 people

- The demand for broadband bandwidth is assumed to be 1 MBPS per person for rural India. Using the GP population data from the government reports, the demand for broadband bandwidth is projected at 15 mbps per GP in 2013-14. As per the optimistic scenario estimation, this demand is expected to increase to approximately 120 mbps per GP by 2023-24.
- A similar analysis as per the pessimistic scenario estimation at 10% growth rate of internet bandwidth supply, results in fixed broadband bandwidth demand of approximately 35 mbps per GP by 2023-24.

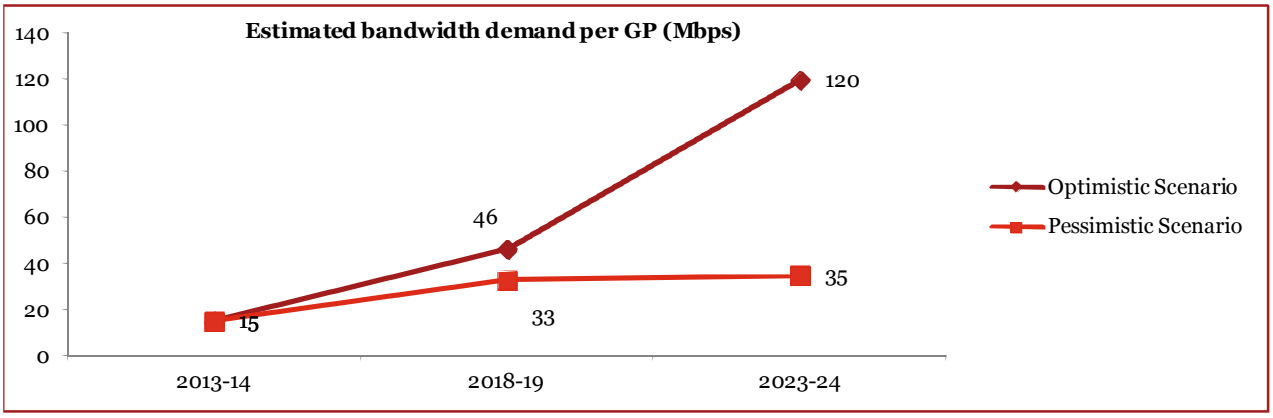


Figure 39: Bandwidth estimation per GP

A.4. Consultations Held

Following meetings have been held till now with stakeholders –

	Date	Location
DoT and USOF	6-Jan-2014	Sanchar Bhawan, New Delhi
USOF	17-Jan-2014	BBNL, Mandigaon Road, New Delhi
DeitY / NIC	21-Jan-2014	Electronics Niketan, CGO Complex, New Delhi
MoHRD	3-Feb-2014	Shastri Bhawan, New Delhi

In addition to the above, visit to NOFN pilot site at Arain Block, Rajasthan was conducted on 23 rd and 24th of January, 2014.

A.5. Abbreviations

Abbreviations	
AC	Air Conditioning
BBNL	Bharat Broadband Network Ltd
BHQ	Block Head Quarter
BOM	Bill of Material
BSNL	Bharat Sanchar Nigam Ltd
BSS	Business Support System
BW	Bandwidth
CAPEX	Capital Expenditure
CPE	Customer Premises Equipment
CPSU	Central Public Sector Undertaking
CUG	Close User Group
DC	Data Center
DCN	Data Communication Network
DeitY	Department of Electronics and Information Technology
DHQ	District Head Quarter
DoT	Department of Telecommunications
DPR	Detailed Project Report
DR	Disaster Recovery
Gbps	Giga bits per second
GP	Gram Panchayat
GPON	Gigabit Passive Optical Network
GUN	Government User Network
IETF	Internet Engineering Task Force
IP-MPLS	Internet Protocol- Multi Protocol Label Switching
ISP	Internet Service Provider
ITU	International Telecommunication Union
Mbps	Mega bits per second
MoHFW	Ministry of Health and Family Welfare
MoRD	Ministry of Rural Development
MPLS-TP	Multi Protocol Label Switching
MSP	Managed Service Provider
MTTR	Mean Time To Resolve
NDC	National Data Center
NIC	National Informatics Centre
NII	National Information Infrastructure
NKN	National Knowledge Network
NMS	Network Management System
NOC	Network Operations Center
NOFN	National Optic Fibre Network
NTP	National Telecom Policy
OAM	Operation, Administration and Management
OEM	Original Equipment Manufacturer
OFC	Optical Fiber Cable
OLT	Optical Line Terminal
ONT	Optical Network Terminal
OPEX	Operational Expenditure

Abbreviations	
OSP	Other Service providers
OSS	Operations Support System
PGCIL	Power Grid Corporation of India Ltd
PMO	Project Management Office
PoE	Power over Ethernet
PoI	Point of Interconnect
PoP	Point of Presence
PSU	Public Sector Undertaking
QoS	Quality of Service
SDC	State Data Center
SPV	Special Purpose Vehicle
SWAN	State Wide Area Network
TSP	Telecom Service Provider
USOF	Universal Service Obligation Fund of India

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