WORK PLAN-ROADMAP

6G TECHNOLOGIES DIVISION

INDEX

Contents

1. Introduction

India's economy is striving to attain $ 5 trillion by 2024, which will require creation of a world class quality infrastructure to facilitate manufacturing and service companies to grow. India's ecosystem of regulatory and voluntary standards needs to be upgraded to ensure delivery of quality products and services to the Indian citizens as well as for making India a leading player in the world market. Indian government is making continued efforts to improve ease of doing business in country to enhance foreign direct investments and promote make in India initiatives. An agile technical regulation is must for seamless integration of technology and enhancing India's role as standard-setting nation on the world stage rather than a standard follower.

Under the visionary leadership of Secretary (Telecom), 6G Technologies Division has been created in Telecommunication Engineering Centre in January 2022 to cater to changing work environment, emerging mobile technologies and enhanced role envisaged for TEC in niche technologies. In addition to 6G Technologies, this division has been entrusted with responsibility of Quantum Communication, Next Generation Passive Optical Network, Green Telecommunication and Emergency and Mission Critical Communication.

This document is envisaged to provide a roadmap for structured and guided study of the work allocated to the 6G Technologies Division. This document is intended to be a ready reckoner to help to break down the whole task into executable Annual Action Plans. Resource requirement commensurate to the exploratory and translatory nature of assignments has also been worked out in the document.

This document covers works envisaged in five technologies verticals and in two general items of interest namely-6G Technologies, Quantum Communication, Green Telecommunication, Emergency and Mission Critical Communication, Next Generation Passive Optical Network, and General Administration and projected Human Resource Requirements. Some of the works mentioned in the document may not be directly studied in TEC but as they form input to the study and are a larger part of the ecosystem

therefore, they have found mentioning in the document to keep a track of the development happening elsewhere.

The focus of the work items considered for study is to provide necessary leg up to the Indian industry in creating an ecosystem through awareness and requirement building, validation, incubation, and acceleration of the product to the market in the area of 6G, Quantum Communication, Next Generation PON and Green Technologies.

2. Subdivision: 6G Technologies

At present it is unknown as to what will be 6G technologies but it would better and overcome the limitation of 5G. It is expected to have data rate from 100 Gbps to 1Tbps with radio latency in microseconds. It would better the human experience of 5G and open new frontiers in technologies and use cases. It would expand human experience across physical, biological and digital worlds and enable industrial operations beyond Industry 4.0, through extension of performances such as positioning, sensing, ultra-reliability, energy efficiency and extreme real-time.

End of the 5G would be the beginning of 6G. It is expected that 5G would evolve into an all-virtual network starting with vRAN 1.0, a deployment with only the CU in the cloud, followed by vRAN 2.0, a deployment with the DU also virtualized and implemented in the edge cloud and finally vRAN 3.0, a deployment in which the virtualized DU implementation becomes truly cloud native and decomposed; Slices sorted by use case categories uRLLC, mMTC and eMBB. Decomposition is expected into cell, slice and master units with the flexibility to locate the different vDU slices at the cell site, far edge or edge cloud. An evolved 5G vRAN would become stepping stone for 6G as it has all the ingredient for realization of 6G vision.

6G is expected to be a hybrid of wireless and optical technologies with ubiquitous intelligence. At present, the technologies which surpass the 5G in terms of data rate and latencies are gigabit PONs, gigabit Ethernet reliability. Terabit Ethernet is in offing. 6G would require study of all contemporary technologies but not limited in the following areas to untangle and bundle the technologies in order to visualize the vision of 6G:

2.1. Technologies

2.1.1. New Wireless Access Technologies

2.1.1.1. Required Capabilities

Along with eMBB, uRLLC, mMTC two more dimensions, Sensing and Intelligence have been added to 6G capabilities to improve the reliability of wireless network and offer newer uses cases such high resolution imaging and précised positioning etc. Intelligence at scale would enable digital twins to augment human productivity. Following capabilities are envisioned from 6G:

- Peak Data Rate (100Gbps-1Tbps)

- Latency (100 µs with 100Mbps)

- Device Density (100 Devices per m3)

- Sensing- ubiquitous

- Intelligence- at scale

- Energy Efficiency (10x More Energy Efficient than 5G)

- Positioning accuracy [10 cm (indoor), 1 m (outdoor)]

- Extreme Ultra Reliability (Max. 1 Out of Million Outage)

2.1.2. Spectral Efficiency- some node consolidation to happen to achieve spectral efficiency

2.1.3. Energy Efficiency: As densification is to increase highly energy efficiency network is envisaged. Energy Efficiency Studies at ITU-T SG-5 would be integral to standardisation of IMT2030 and beyond.

2.1.4. Open Radio Initiative: An Open, Disaggregated and Virtualised RAN is visualised.

2.1.5. New Core Architecture

2.1.5.1. IT Infrastructure

Core of 6G is visualized as a fully virtualized Cloud Native architecture with Open APIs. It would have an AI optimized wide area network and data center co-design. It is expected to be a Heterogeneous cloud architecture i.e.- On-Premises, IaaS, PaaS, SaaS cloud. Initially, Hardware (HW) accelerators to guarantee optimized performance for specific 6G algorithms with an inherent greater degree of

parallelism, and higher performance and efficiency would be needed. Edge computing would have Artificial intelligence and Machine Learning in built.

2.1.5.2. New Security Architecture

It is expected to come with Advanced Cryptography such as AES 256 and quantum key distribution. Wireless network may get integrated with Quantum Communication infrastructure.

2.1.6. Transport Requirement for 6G

It is expected that 6G would operate in THz band which implies that cell radius would be very-very small. Therefore, cell densification would be a general deployment scenario. The would demand huge optical transport to carry Tera bit of data. It would require study transport requirement for core, metro, backhaul and fronthaul to deliver required bandwidth at demanded latency. It would also require to identify appropriate transport technologies for different domains. Study of stringent synchronization requirement and matching technologies would be no less important.

2.1.7. Mobile Device as Personal Data Assistant

It is expected that Mobile hand set would get converted as Data Assistant

2.1.8. Hybrid Wireless, Satellite and Optical Communication

6G is envisaged not just another terrestrial network, it is to incorporate idea of all contemporary optical and wireless technologies. It would a ubiquitous with integration of High Throughput Satellites with terrestrial network to cover deserts and ocean. It would require the study in different domain such but not limited to as given below;

- To understand LiFi capabilities in respect of 6G communication in access areas
- Integration of wireless technologies with Optical technologies
- Densification of optical technologies
- Slicing across RAN, Transport and core for seamless e2e eMBB, uRLLC, mMTC services

2.2. Spectrum

2.2.1. Spectrum requirement study for 6G technologies in coordination with ITU-R (WRC), WPC, TSDSI and TRAI

- To participate in Spectrum Coexistence studies (towards 6G and License Exempt Usage)

- To participate in 6 GHz spectrum for license-exempt wireless applications in India

- To participate in 6 GHz spectrum for IMT applications in India

- To participate in Dynamic Spectrum Access architecture

2.3. Standardization

Standardisation is the main activity at TEC. It would require participation in 6G pre-standardization activity at different national (CDOT, TSDSI) and international (3GPP, ITU, SCF, BF etc.) work groups, presenting India centric requirement.

In immediate future, it would require collaboration with TSDSI and CDOT and other stakeholders to delineate the followings;

- Use cases and services, KPIs, Key Technologies and network architecture and evolution
- Creation of Edge Intelligence standards for latency and privacy management.
- Creation of Edge Intelligence standards for latency and privacy management.
- Identification of Use cases from International and Indian Context
- To prepare GR/ER/IR/Guidelines as standardisation progresses.

2.4. Validation

- To develop Test Schedule and Test Procedure against Generique Requirement
- To develop Generique Requirement for Test Bed
- To development Test Schedule and Test Procedure against Non Generique product/service for Certificate of Approval
- To carry out technology approval of C-DOT/University developed systems

- Interoperability testing of components from different vendors

- Proof of Concept Testing

2.5. Indigenization and Development of 6G Ecosystem

- Help startups to test their product

- To help the startups in certification of the product

- To help the startups in IPR filling for their products

- To help startups to accelerate their product to the market

- To advocate the adoption of homemade products by TSP

2.6. Use Case Development

- To study the requirements of Indian retail consumers

- To study the requirements of Indian SME

- To study the requirements of Indian Industries beyond 4.0

- To undertake studies for latent technological needs in different sectors, especially in health, agriculture, transport and energy.

- To study different possible application of the upcoming technologies and impact on Indian economy.

2.7. Deployment Studies

- Study of different deployment models with respect to minimize the cost and reduce deployment time

- To study how existing infrastructure can gel with new technology to make best use of resources and reduce CAPEX requirement.

- To explore the possibility of resources sharing

- To study small cell deployment challenges in Indoor and outdoor environment

2.8. DOT Task Force & Innovation Group

2.8.1. Multi-platform Next Generation Networks

- Development of Network elements of Multi-Platform Next Generation Networks

- Wireless GPON

- Spectrum Hyper Efficiency in Networks

- Remote Near Physical Skilled Activity

- LEO Satellite overlay

- Drone Communications

- Any other in the scope of 6G activities and overall deliverables

2.8.2. Spectrum Policy Task Force

- To refarm mid-band and sub 1-GHz spectrum

- To consider feasibility of 6 GHz and 10 GHz bands

- To consider more candidate bands in mmWave bands

- To explore the feasibility of THz band

- To recommend options on secondary use of spectrum

- To consider new spectrum ownership and sharing models enabling flexible spectrum allocation

- To consider integration of emerging coverage solutions like satellite, drones, unmanned aerial vehicle etc. and consider their spectrum requirements

- To provide roadmap for channel measurements and new channel models for mmWave and THz bands

- To identify co-existence and dynamic sharing study items

- Any other in the scope of 6G activities and overall deliverables

2.8.3. Multi-Disciplinary Innovative Solutions

- Use case definition

- Developing indigenous globally competitive 'ahead of state of art' solutions and piloting them in real field environment

- Creating inputs for advanced research by practically establishing the limitations of available technologies

- Providing substantial implementation input for global standardization

- Pilot Trials

- Any other in the scope of 6G activities and overall deliverables

2.8.4. Devices

- Development of 6G ecosystem

- To enable secure, reliable, high speed and low latency communication links anywhere and anytime in order to connect all things (sensors, machines, people)

- To exploit AI/ML technology to enable Cyber Physical Fusion to advance socioeconomic development of the country

- Establish early global consensus on requirements, key technology components, and device architecture

- Any other in the scope of 6G activities and overall deliverables

2.8.5.   International Standard Contribution

- Mapping global 6G activities and capabilities definitions

- Contribution on WP-5D on "Research Views on IMT for 2030 and beyond (3GPP Annexure document 5D/886-E)"

- Pre-Standardisation activities on 6G and streamlining the process to be inclusive of all stakeholders

- Inputs to Standardisation activities on 6G in TSDSI

- White paper on India's competencies (India, Research Labs and Academia)

- Any other in the scope of 6G activities and overall deliverables

2.8.6.   Financing Research and Development

- Develop a roadmap for R&D, pre-standardisation, development of product and applications

- Propose and vet R&D proposal under 6G Mission

- Research ecosystem-industry-academia research partnership for IPR development. Standard development and proof of concept through research projects, PPP projects, testbeds and pilot rollouts;

- Any other in the scope of 6G activities and overall deliverables

3. Subdivision: Quantum Communication Technologies

Quantum Technologies and its Applications may impact many sectors, including healthcare, energy, finance, security, and entertainment. Quantum principles will be used for engineering solutions to extremely complex problems in computing, communications, sensing, chemistry, cryptography, imaging and mechanics.

Quantum communications will provide high security for transmitting sensitive data for terrestrial and space assets of the Nation. In the near term, it could be used to supply the secret keys and random numbers that are an essential resource for several tasks. Eventually, it could be used in a secure global communication network operating over

long distances with fibre as well as satellite links. It could also be used to move around information in a large scale quantum computer, to generate truly random number sequences for simulation and gaming and to ensure the authenticity of documents more securely than existing digital signatures.

The following work is proposed to be taken up by QC subdivision:

3.1. Standardization of QC Technologies

- To develop standards for long distance Quantum Communication channels and networks to Quantum Internet.

- To develop standards for indigenous protocols of quantum cryptography, not restricted to QKD, i.e., including protocols for quantum secure direct communication, quantum key agreement, quantum voting, quantum e-commerce, etc. and semi-quantum cryptography (where end users can be classical)

- To develop standards for quantum IOT sensors and quantum limited measurement protocols.

- To develop standards for Interfacing quantum sensors, clocks etc. with quantum communication networks to build advanced secure networks for remote-sensing, global positioning etc.

3.2. Quantum Key Distribution

- To develop GR/ER/IR for complete QKD protocol for end devices including repeaters (single photon based or entanglement based or both) in free space as well as fibre based channels.

- GR for fiber based point to point QKD

- SR for Fiber based Secure Communication Network

- GR for 1Gbps post quantum in-line network encryptor (PINE) supporting under NIST standardization Lattice and Code Based PQC key exchange algorithms candidates and AES-256

- GR for 10Gbps throughput post quantum in-line network encryptor (PINE10G-S) with standard PQC key exchange and quantum-safe symmetric crypto algorithms

- GR for 10 Gbps throughput post quantum in-line network encryptor (PINE10G-P) with proprietary PQC key exchange and quantum-safe symmetric crypto algos.

- GR for Post Quantum In-line network encryptor (PINE, PINE10G-S, PINE10G-P) with quantum key distribution (QKD) framework

3.3. Quantum Communication Infrastructure

Because of evolution of Quantum computation whole cryptography including that of Telecom (key exchange during calls, key exchange during Internet session) will come under threat. Hence, this is the high time to provide TSPs and ISPs a platform to test various protocol stacks for Quantum Key distribution which can be extrapolated in the Telecom network. In line with EU and other developed countries, India is ambitiously pursuing to secure its assets from snooping and eavesdropping. The IndiaQCI will safeguard sensitive data and critical infrastructures by integrating quantum-based systems into existing communication infrastructures, providing an additional security layer based on quantum physics. It will reinforce the protection of India's governmental institutions, their data centres, hospitals, energy grids, and more, becoming one of the main pillars of the India's new Cybersecurity Strategy for the coming decades. QC division has taken upon itself

- to prepare a secure end-to-end quantum communication infrastructure that, besides cybersecurity, could be used for many useful applications and services, such as digital signatures, authentication, and clock synchronisation.

- To prepare a pan India plan **'IndiaQCI'** 'for securing existing and upcoming communication assets using quantum communication networks.

- To devise methods for Integrated secure network planning and deployment of PINE systems with QKD.

- To carry out Security evaluation of the deployed integrated PINE systems with QKD.

- To devise methods and help telecom service provider to test algorithm of their use cases before implementation in the 5G telecom network using Quantum simulators.

3.4. Validation

- To develop Test Schedule and Test Procedure against Generique Requirement

- To development Test Schedule and Test Procedure against Non Generique product/service for Certificate of Approval

- To carry out technology approval of C-DOT/University developed systems

- Interoperability testing of quantum components from different vendors

- To do standardisation and security certification of QKD-based secure communication solutions.

3.5. International Collaborations

- To contribute in ETSI's QSC (Quantum Safe Cryptography) Working Group activities

- To contribute in ITU Working Group activities on QC

- Seek EU cooperation in development of 'IndiaQCI'.

3.6. National Co-ordination

- Coordination with National Supercomputing Mission, Nano Science & Technology, Technology Development programme etc. and several agencies including SERB, Department of Space, Defense Research and Development Organization, Department of Atomic Research, Ministry of Electronics and Information Technology, C-DOT and TSDSI etc.

- Coordination with IISER, Pune- a dedicated Technology Innovation Hub (TIH) in quantum technology

3.7. National Mission on Quantum Technology and Applications (NM-QTA)

A National Mission in Quantum Technologies and its Applications has been formed under Department of Science and Technology to spearhead and accelerate the development of QT components in the country through creation of necessary infrastructure and facilitation of ecosystem building. It is providing financial support in the following areas;

3.7.1.   R&D Infrastructure development Projects-

3.7.2.   Fabrication, testing, calibration etc. infrastructures are required to build Quantum Information Processing (QIP), communication, sensing devices and materials.

3.7.3.   Technology Development Projects

3.7.4.   Translation projects

3.7.5. Acceleration of commercially viable devices, technologies and protocols to the market.

3.7.6. International Collaborations

3.7.7. Technology Business Incubators (TBI)

- Upgradation of IOT experience center in TEC to include Quantum IOT use cases

- Setting up of Quantum Test lab in TEC

- Upgradation of TEC Quantum Test lab based on industry requirements for certification

3.7.8. Start-ups

3.7.9. Any other activities under entrepreneurship development

- Capacity Building Programmes for entrepreneurs and startups through seminars /workshops

- To foster and develop an entrepreneurial ecosystem that is active and responsive and aims to rapidly bring new developments in the field into the market while patenting, protecting and commercializing the associated intellectual property.

3.7.10. Industry Collaborations

- Development of QT use cases in coordination with industry and other stakeholders

- Development and formulation of standards and specifications for QT

- Pilot trials and POCs in QT

3.7.11. Any other Activities-Human Resource Development

- Competency building of TEC officers which may include foreign training and study visits to development labs.

3.7.12. Monitoring and Evaluation

- Evaluation and feedback will be provided in a timely manner to ensure progress towards the stated goals of each project

3.7.13. Quantum Communication Targets by NM-QTA

Table 1 QT Targets

S.No.	Description	Unit of Measurement	Baseline (present)	Target
1	QKD over fiber using any approach/ implementation and minimal data rate – distance	Fiber length in km across which QKD is done with minimal data rate	0	100km without trusted node and up to 500 km with trusted nodes
2	QKD over fiber 10Km or longer – data rate	Max data rate in bits per second achieved	0	100 and finally 500Kbits/second
3	Satellite based QKD – ground stations established	Number of ground stations established	0	2
4	Satellite based QKD – custom built satellites built and placed in orbit	Number of satellites for QKD in orbit	0	1
5	Satellite based QKD – maximum range achieved	Range in Km with modest data rate	0	~1000
6	Satellite Based QKD – Minimum key rate achieved	Kbps	0	~10kbps
7	Free space QKD using any protocol and implementation - distance	Distance in Km over which modest data rates are obtained	0.002	5
8	Multi-node Quantum network with quantum repeaters at each node	Number of nodes	0	2-3
9	Single photon source	Number of sources	7	100
10	Entangled photon source	Number of sources	5	30
11	Superconducting single photon detectors	Refresh rate (milliseconds)	0	5
12	Integrated photonics	Number of independent elements integrated	3	10
13	High temperature photonic memory	Lifetime (microseconds)	~1-2	~1000-2000
14	Quantum teleportation – distance	Maximum distance (in Km) over which teleported	0	100
15	Timing synchronization in a quantum network	Accuracy in picoseconds	-	~2-3
16	Multi-Institutional and Multi-PI consortia addressing challenging problems in quantum communications	Number of collaborative networks/consortia	2	15

3.7.14. Quantum Communication-Deliverables

Following deliverables are expected within five years;

- A 100 km fiber based QKD link without trusted node and upto 500 km fiber based QKD link with trusted nodes

- Satellite based QKD link with a range of about 1000 km

- Quantum network with 2-3 nodes and quantum repeaters at each node

- Single and entangled photon sources

- Superconducting single photon detectors

- High temperature photonic memory

- To conduct QKD and non-QKD technology demonstration experiments onboard satellite platforms, and subsequent demonstration of long distance Satellite Based QKD between two Indian ground stations.

4. Subdivision: Emergency and Mission Critical Communication

When the disaster strikes, power goes out, terrestrial modes of communication become inoperable. Keeping this baseline in mind, communication facilities for public protection and disaster relief should be planned accordingly. We have quite good telecommunication infrastructure in place which can be used to forewarn the people for impending disaster which sometimes can be just a few minutes away. The telecommunication facilities need to be tuned to those challenges where message dissemination is required to be really fast and in real time.

The use of satellite, computers, electronics, better communication facilities are going to make significant difference in disaster management. Accordingly, this subdivision would be carrying out the following functions:

- Understanding the requirements of NDMA

- Understanding the compatibility of TSP's Alert Communication System vis a vis NDMA requirement

- To understand the security requirements and measures in the cell alert system so that TSPs system is not compromised

- To understand priority call routing during disaster and suggest suitable measures for automatic implementation

- Preparation of GR/SR/IR for disaster alert systems

- Preparation of test schedule and test procedure for the Alert system

- Technology Validation of CDOT developed disaster alert system

- Providing input to NDMA and DOT-DM

- Ensuring appropriate technology for Emergency and Mission Critical Communications for Public Protection and Disaster Relief (PPDR)

5. Subdivision: Green Telecommunication

Energy costs are among the largest operating expenses for telecom network operators, and energy consumption from telecom networks is an increasing contributor to global greenhouse gas (GHG) emissions. As an ever increasing number of people around the

world become connected by fixed and mobile telecommunications networks, the challenges related to providing electricity to these expanding networks are becoming greater as well. While telecom is relatively energy-lean, the telecom networks are still driven largely by fossil fuel energy and the energy costs represent a significant Opex item. With the double whammy of increasing energy consumption and rising cost of fossil fuel, it is important that the focus shifts to *energy efficient technologies* and *alternate sources of energy.* TEC has done a lot of study in GT and would continue so in the following areas.

5.1. Renewal Energy and New Energy Storage technologies

GT subdivision would undertake study on Renewal Energy and New Energy Storage technologies solutions for Telecom and Data Centre sites in the following areas and prepare standards/guidelines/GR/ER/TSTP as required:

- Solar
- Hydrogen Fuel cells
- Sodium ion batteries
- Liquid metal batteries
- Solid state batteries
- Super capacitors
- Quantum phase battery-
- A battery technology that relies solely on quantum mechanics to store energy in batteries without any loss, despite the batteries being open to an environment.

5.2. Energy Efficiency Studies

- To study new Energy Efficiency Measurement Methods
- To participate in energy efficiency studies at ITU-T SG5.
- To participate in energy efficiency studies at ATIS and ETSI, and ISO.
- Joint studies with NGO working in this field like Green Grid and ITI etc.

5.3. Energy Consumption Rating (ECR) & Energy Passport (EP)

ECR and EP standard has been a hallmark study in delineating test methods and test procedures for all the conceivable telecom equipment and services at one place. This study was done in compliance to TRAI-DOT regulation on Green Telecommunication. Since it is a continuous nature of work following works are required to be done;

- To update Energy Consumption Ratings and Energy Passport standards as per requirements

- To prepare operational guidelines for Green/Energy Passport Certification process

- To carry out Carbon Emission saving calculation on account of Green Passport certification

- To carry out witness testing in manufacturer labs

5.4. Green Passport Lab

A very simple lab for energy measurement has been setup which would use control lab infrastructure for throughput measurements of non-radio devices and radio access lab for through measurements of radio devices. It would require strengthening and augmentation as testing proceeds to match with new requirements.

5.5. Voluntary Code of Practice (VCP)

Preparation of Voluntary Code of Practice document was another deliverable under TRAI-DOT 2017 regulation, which required industry commitment towards sustainable telecommunication goal. This document needs regular updation with changing requirements and availability of newer and more efficient products.

5.6. International engagement

Sustainable telecommunication goals can not be met in isolation, it requires knowledge and technologies sharing among the nations. TEC would represent India along with IR-DOT at Indo-US and other G2G joint working groups in the area of Green Telecommunication.

5.7. Subdivision: Next General Passive Optical Network (beyond 10G)

Passive Optical Networks (PONs) have become a popular fiber access network solution because of its service transparency, cost effectiveness, energy savings, and higher security over other access networks. PON utilizes passive components for signal distribution such as power splitter and or wavelength router which removes the need for power-feeding in the fiber distribution network.

PON Industry is ever striving to meet the humongous data consumption needs of the society, data centres and enterprises through Next Generation PON to be operating at 10Gbps to 100Gbps per interface. 10Gbps PON systems are being deployed in the

network after grand success of EPON and GPON systems. Standardisation of 25GEPON has completed in 2020 and rollout of 25GEPON may begin soon.

Demand for 25G interface for 5G mobile fronthaul is driving PON industry to accelerate standardisation of 25G WDMPON. To meet the demand for enterprise and data centre segment and standardisation for 50G interface is moving at a very fast pace and hopefully it would get completed in this year. With the completion of 50G PON interface standardisation, we can look forward to see 50G/100G PON system in the field soon.

In order to match with development taking place at international forums, there is a need to get actively involved in the study groups at ITU and IEEE. Following topics/technologies are under discussion and at various stages of development:

5.8. 25G WDM PON

To support eCPRI in 5G fronthaul application, 25G WDM is one of the key candidate technologies. It shall be able to meet full requirement in fronthaul on a single fibre. 25G WDMPON systems are already being deployed in China. Standardisation work is at the advance stage at ITU.

5.9. 50G/100G TDM/TWDM/WDM PON

The technologies projects mentioned from 6.1 to 6.2 are being studied together as a High Speed PON project at ITU for enterprise and data centre customers. Standards for different components are either approved or at advance stage. It is likely that most of the specification would get freeze this year.

5.10. Coherent PON

For higher throughput above 50Gbps per interface, current approach may not get the desired result. Coherent (Ultra dense) modulation would be needed. In Coherent PON, both OLT and ONT select the wavelengths according to the principal of coherent detection. OLT, ONT starts reception only when the locally oscillated light and signal meet the coherent conditions of frequency, phase and polarisation. The OLT and ONT select their wavelengths by dynamically changing their locally oscillated light frequencies

5.11. OFDM PON

Orthogonal Frequency division multiplexing (OFDM) is a method of encoding digital data on a large number of closely spaced orthogonal subcarrier signals. Each subcarrier is amplitude and phase modulated (I+Q). Each user uses one or more subcarriers. OFDM is another modulation technique to achieve a very high order PON. It offers high spectral efficiency. The high speed data stream is transmitted on a number of lower speed and orthogonal subcarriers in parallel. It is very mature and efficient algorithm of (I)FFT and has low computational complexity. It is future PON technology.

Most WDM/Coherent/OFDM-PONs require complex ONT with photonic integrated circuit, DSP processing, or fine wavelength tuning/reflecting and alignment. These type of ONTs are far from mature for mass production and are costly to implement. WDM/Coherent/OFDM-PONs will continue to be a hot topic of research and study.

5.12. Super PON

It is a google promoted PON technology. It uses both power splitter and wavelength router. It can reach 50km distance and serve upto 1024 ONT with 16 pairs of wavelengths and 1:64 splits with speed of 10Gbps. It could be most suitable for sparsely populated and rural application. It was taken up for study at both ITU-T and IEEE but not much progress has happened.

5.13. Flex MAC PON/Flex TRx PON

On the lines of OTN, flexibility at MAC layer and TRx level are next possibility to create further agility in the PON architecture.

5.14. Cloud based/ Distributed Architecture PON

Purpose built OLT/ONT may become a thing of past. Many small players are exploring possibility of using COT server and router based distributed architecture in PON or also exploring using cloud (IaaS) and overlaying PON application over the cloud. This field need to be studied.

5.15. Wireless Gigabit PON

This topic has cropped in the wake up of renewed interest in 60GHz band which is thought to be equivalent to fibre. It is being explored as one of the 6G technologies.

There may come more architecture but currently two are in forefront. First is GPON+ROF, the other is ROF+GPON. It would require a lot of developmental activities.

5.16. Passive 25G CWDM/MWDM/LWDM & Semi active WDM

5G fronthaul is very heavy on transport resources. Using passive WDM components can drastically reduce the number of fibre required. The following passive WDM are being deployed and 5G fronthaul. 25G low cost DWDM is also under study for 5G fronthaul. No activity is noticed in Indian industries in this regard. The following configuration may be explored to meet 5G and beyond fronthaul requirements.

5.17. Standardisation activities for Next Gen PON

- To prepare study papers

- To prepare Generique Requirement in Indian Context

- To prepare Essential Requirement to comply with Technology regulation of the country

- To prepare standard test schedules and test procedure for testing

- To prepare energy efficiency measurement metrics for different PON technologies and standard test schedules and test procedure for testing

5.18. Indigenization and Development of PON Ecosystem

- Help startups to test their product

- To help the startups in certification of the product

- To help the startups in IPR filling for their products

- To help startups to accelerate their product to the market

- To advocate the adoption of homemade products by TSP

5.19. Validation

- To carry out validation of PON and CWDM technologies developed by C-DOT and Universities/Institutions.

- To carry out witness testing in Type approvals

5.20. International Engagements

- To participate in IEEE803.xx taskforce and ITU-T SG15 studies on the above subjects.

- To participate in IETF and BF studies

21

6. Subdivision: General Administration

- Preparation of Annual Action Plan

- Monthly Management Information reports

- Inter and intra ministerial communication

- ISO Compliance

- Right to Information compliance

- Vigilance reports

- Parliament questions

- Public Grievances

- Promotion of Hindi in official use

7. Resource Requirements

To cement TEC position as technology policy advisor, technology enabler/regulator, and ecosystem builder, parallel studies would be needed in the aforesaid fields. It would require humongous efforts on our part to succeed in the efforts which we have taken upon ourselves. Based on the complexity of the studies that is required to be undertaken, following human resource would be required.

S.No.	Area	Designation	Nos.
1.	Division Head	Deputy Director General	1
2.	Sub-Divisions Head	Director	3
3.	Sections Head	Assistant Director General	11
4.	Cells Head	ADET	11
5.	Supporting staff • One ADT, one JTO, one SO with each cell • One PS with each with DDG & Directors • One MTS with each section and above • One RA with each ADG	ADT	11
		JTO	11
		SO	11
		PS	3
		MTS	11

As recruitment and regular posting would take its own time, immediate requirement could be met through hiring from technical manpower supplying agencies such as NISG. PA and MTS could be hired from MCSI.

Being a technical body, it is of an immense importance to collaborate with different standardisation bodies such as ETSI, 3GPP, BF, SCF, ORAN, IECTF, TGG etc. to exchange knowledge. Most of such bodies has membership requirement. To carry forward studies in nascent and niche areas, membership would also be required.

For Technology Development, Human Resource Development, Entrepreneurship Development and International collaborations funds would be needed. There would be need of extensive collaboration and partnerships to establish labs and R&D centers etc. For knowledge sharing, it would also require funds for organizing seminars and travels. Finer details may be worked out separately.

8. Organisation Chart