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## HAVING CREATED INDIA'S OWN 4G / 5G STACK -



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C-DOT

# AMAZING TURNAROUND

## TO BECOME INDIA'S R&D POWERHOUSE (ONCE AGAIN)

# 5G SPECTRUM AUCTIONS, FINAL ANALYSIS.

18

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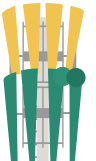
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Voice&Data is printed and published by Pradeep Gupta on behalf of  
Cyber Media (India) Ltd, D-74, Panchsheel Enclave, New Delhi - 110  
017, and printed by him at M/s Archna Printers, D-127, Okhla Industrial  
Area, Phase-1, New Delhi 110020. Editor: Gajendra Upadhyay

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All Payments Favoring: CYBER MEDIA (INDIA) LTD  
Distributors in India: IBH Books & Magazines Dist. Pvt. Ltd, Mumbai.  
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Corporate Website: [www.cybermedia.co.in](http://www.cybermedia.co.in)  
[www.ciol.com](http://www.ciol.com) (India's #1 IT Portal)

August 2022

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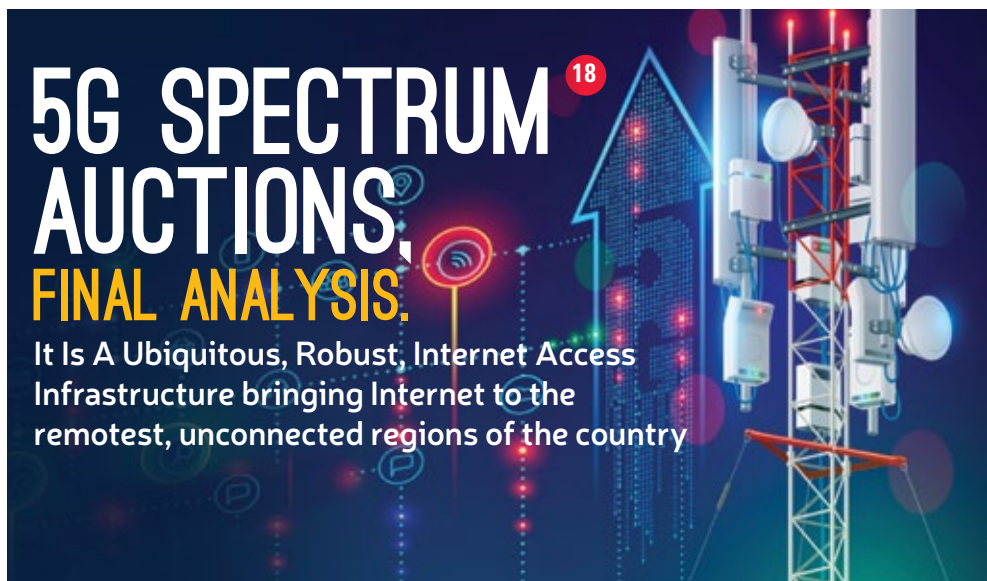
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## One year milestone — Telecom Reforms that rejuvenated the sector and infused LIFE into a 5G FUTURE



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**GAJENDRA  
UPADHYAY**

## [OPENING NOTE]

### C-DOT IS TRANSFORMING INTO A TELECOM R&D POWERHOUSE

With the 5G auctions now over, all eyes are on the race to launch the first commercial 5G network. Will it be a consumer market product or will it be a 5G private network?

There is immense hope from the Captive Non Private Networks (CNPN), segment, which the domestic 5G network equipment manufacturers are confident of enabling. Chances are private networks will dominate the first few years of 5G deployments. The behemoths of telecom, Jio, Airtel and Adani Networks will be the first off the blocks.

5G is expected to change the broadband game and lead the way into 6G networks, which is already on the horizon in a few years. Which is another dimension altogether.

A very important component of 5G networks will be the high speed carrying capacities of 5G traffic between towers.

It is a core infrastructure requirement. An amazing new startup is addressing this area with high capacity wireless radios. A small unknown company formed in Bangalore in 2015 goes on to make the world's first Multi Beam E-Band Radio, that provides high speed point to point capacity – capable of carrying massive amounts of data traffic from consumers to the mobile networks.

Astrome has created a revolutionary product, a beacon of Aatmanirbhar Bharat.

How revolutionary this is can be gauged by the fact that the Hon'ble Prime Minister, Shri Narendra Modi, himself considered it important enough to mention Astrome and their innovation in his Mann Ki Baat program recently. This is probably the highest recognition that any Startup would crave to have and Astrome deserves every bit of it.

We have the Astrome story and its product information in this issue.

The Astrome Microwave will revolutionise 5G roll out. It will enable fast aggregation of backhaul content without operators having to depend on high speed fibre connectivity. This is especially useful for towers in remote or distant terrains. Astrome is bound to grow at an unprecedented rate as the 5G networks roll out.

Of course our cover story on C-DOT chronicles the next frontiers being created by the country's only deep telecom R&D organisation. Having created a fully indigenous 4G Stack that will compete with the best in the world, it is now moving to a 5G infrastructure play which will drive India into the cutting edges of wireless infrastructure creation.

*gajendra@cybermedia.co.in*

[INTERVIEW]

C-DOT



**RajKumar Upadhyay**  
Executive Director, C-DOT



# “Accelerating Indigenous R&D and Intellectual Property (IP) – CDOT is taking Digital India into the Future”

*As the 15th Executive director of C-DoT, RajKumar Upadhyay took over the reigns of C-DoT which had already set the benchmark for indigenous manufacturing and IPR creation in the telecom sector India.*

*Dr Upadhyay took over C-DoT (2020) when the transition into a Digital India was already happening, driven by an entirely new generation of technologies in communications, as a natural progression of evolution. In an exclusive interview to Voice & Data, Dr Upadhyay shared his insights about his stint so far, the transformations that have happened, are underway and are in the making for the future. Excerpts from his chat with Editor, Gajendra Upadhyay.*

## **At what stage was the Indian Telecom Sector when you took over as Executive Director of C-DoT**

When I took over in, 2020, the sector was already reaping the benefits of high speed 4G networks.

Telecom has always been one of the fastest growing sectors of Indian economy. In 2020, India ranked second in terms of number of telecommunication subscriptions, internet subscribers and app downloads globally. Moreover, India is also one of the largest data consumers globally.

We have the highest data usage per smartphone, averaging 9.8GB per month.

Covid-19 dramatically increased the importance of communications the world over. We witnessed the challenges and adaptations in the way people were living and working.

Work from home became a new normal and the network during that period was heavily challenged to meet bandwidth requirements and Internet needs.

With exponential increase in internet usage telecom network security also became a concern. And a challenge.

Over 95% of India's telecom networks are built on equipment of foreign vendors. That too from a few select vendors. There is limited access to the security design of these vendors.

There have been many global reports on network breaches. This has resulted in bans being imposed on some vendors. There are also the geo political reasons and emerging scenarios that accentuated the security concerns. Telecom networks are highly prone to spyware/malwares emanating from the equipment itself or embedded in the software.

Keeping all of these in mind our government has aggressively pushed programs like 'Make in India' and 'Aatmanirbhar Bharat' in various sectors including

We are on the path of being self-reliant, and last financial year (2021-22) we also realized revenue of Rs 170 crores, which is the highest in history of C-DOT for any year. Given our success in 4G this is going to grow manifold.

Currently we have over 30 projects under development/ enhancement covering areas like telecom security, disaster management, Secured Quantum Communications, Artificial intelligence, computer vision and many more.

telecom. The govt announced multiple incentives for promoting R&D and manufacturing in India.

While there were opportunities there were challenges as well in developing technologies that are compliant to international standards. C-DOT accepted the challenge and aligned its R&D endeavors towards the mission of indigenously developing telecom technologies and providing an alternative.

To name a few, we have developed a secure Unified communication system, such as SAMVAD -- which is an alternative to popular chat platforms; there is C-DOT Video Conferencing tool, Covid Savdhan, quarantine alert system; disaster alert management system in multiple regional languages and a complete 4G solution in partnership with TCS and Tejas. We have also developed some robust solutions critical for managing security of telecom and IT networks.

**You have spent almost your entire career in the telecom sector. How did your past experiences help in taking over the current projects and defining a new path for R&D.**

I have spent almost 35 years in the government and yes most of it is in Telecom sector. I am fortunate to have worked in Department of Telecom dealing with policy and its implementation and in BSNL handling planning, operation, installation, IT, business development, material management and heading a business unit.

This equipped me with a good understanding in each part of the technology value chain. And its impact on business. I also worked in the TRAI for three years as Advisor handling Telecom and Broadcasting sectors.

This broadened my horizon for evaluating technology frontiers, impact of regulatory interventions on technology and gave me a multi-dimensional view of the sector. I was fortunate to have been associated with Indian Institute of Science (IISc) for almost 2 years handling security projects of department of telecom.

Here I came across various aspects of security required to be ensured in our networks from threat analysis to mitigation strategies.

And not to forget I started my career in DRDO as a scientist and worked there for four years. This gave me enormous exposure in R&D and managing of large projects encompassing multiple disciplines. I was also, additional DG of Prasar Bharti heading South India. This was another great learning to push technology for business and operational efficiency, revenue enhancements, aligning manpower to organizational goals. On the academic side I am trained both in technology and business from reputed institutes. Overall, I feel my varied professional, academic and R&D experiences have contributed and helped me chart a new path for CDOT and work together with our brilliant teams.

**Over the years how do you think the C-DoT focus on R&D has evolved – and where is it headed in future**

C-DOT has now evolved into a full-fledged telecom R&D institution. CDOT complies with level-5 maturity of the Capability Maturity Model Integration (CMMI Model). It has capabilities to undertake large-scale state-of-the-art telecom technology development programs.

C-DOT has done, and continues to do, tremendous work in the entire spectrum of telecommunications, right from conceptualizing a solution to its deployment in the network and in that process promoting manufacturing of telecom equipment in the country as well as generating local Intellectual Property Rights (IPR).

During the initial years of C-DOT it developed core switching solutions such as RAX (Rural Automatic Exchanges), which were later upgraded to MAX (Main Automatic Exchange). These products led to a telecom revolution in the country and telecom facilities reached the remotest parts of the country.

With the IP technology becoming cost effective and easy to operate, existing BSNL exchanges were



To accelerate development, we have changed our policy from developing alone to collaborative development with start-ups in the industry. We will jointly develop products/solutions and fund the startup/industry ecosystem wherever needed.

upgraded to next generation network called main automatic exchange (MAX-NG). Subsequently-DOT started focusing on Optical technologies and wireless technologies, and developed various commercial grade optical and Wi-Fi solutions like GPON (Gigabit Passive Optical Network) and Wi-Fi.

CDOT developed the ATM (Asynchronous Transfer Mode) technology to step in to the strategic needs of the country. It developed world class secured indigenous telecom solutions for multiple strategic agencies.

Along with the push of the Government towards Aatmanirbhar Bharat, C-DOT accelerated its efforts. We developed 4G technology for the country. Other strategic efforts have also been initiated in the cyber security of telecommunication networks. We have state of the art projects operational in this direction.

Currently we have over 30 projects under development/enhancement covering areas like telecom security, disaster management, Secured Quantum Communications, Artificial intelligence, computer vision, advanced switching and routing, Network Management, IoT- M2M ,5G etc.

With the solid support of the Government, and our success in 4G, we are now moving confidently towards 5G development. We will have our own home grown 5G soon. Initial work in the direction of 6G has also started. We are also developing routers, servers, switches, advanced Optical systems, AI applications, Security solutions, advanced applications etc.

To accelerate development, we have changed our policy from developing alone to collaborative development with start-ups in the industry. We will jointly develop products/solutions and fund the startup/industry ecosystem wherever needed.

**From the time you took over, what are some of the major projects you have steered which have the**

### **potential to reshape our country's communications landscape.**

Development of a completely indigenous 4G solution was a top priority for us. In this direction, we collaborated with the industry. C-DOT developed 4G core, Tejas developed Radio system and TCS as the lead consortium partner provided all other necessary software and integration knowhow.

We successfully completed the Proof of Concept (POC) in a live, field environment in BSNL's network. This is a historic achievement for us and soon this indigenously developed 4G network will be deployed by BSNL in its network Pan India.

While 4G POC was going on, our team also started work on 5G. We have developed 5G non stand alone (NSA) core so that BSNL is able to launch its 5G services very soon. We should have our first 5G RAN (Radio Access Network) by December, 2022 in collaboration with VVDN and a startup –WiSig.

Apart from 4G/5G we have developed and delivered critical projects like the ITU-CAP (Common Alert Protocol) based Early Warning and Disaster Alert Management system. This has helped save many lives during cyclones and other natural disasters over the past two years in our country.

CDOT has also worked on developing the PM WANI (Prime Minister – Wireless Access Network Interface) platform aimed at proliferation of Wi-Fi across rural India and Wi-Fi 6 solutions. CDOT has deployed multiple secure solutions for strategic agencies and have gained significant success in developing cutting edge secure quantum-communication based solutions.

Our unified NMS (Network Management System) was created for BBNL's BharatNet, that manages the entire network. It aggregates operational data from multiple technologies deployed in Bharatnet and provides real time information up to the village level on a single dashboard.

We will be deploying our secured routers/switches in various strategic networks and government networks. All these solutions have tremendous impact on our country's socio-economic growth and security of the nation's critical telecom infrastructure.

**How has your organization addressed the need for newer skill sets in emerging areas of technology - and which areas are likely to be dominant over the next decade.**

Telecommunication markets are highly growth-driven with new technologies emerging at a very fast pace. C-DOT takes it as a priority to update and address the need for newer skill sets of its employees on regular basis. C-DOT's Knowledge Management Group (KMG) conducts regular trainings and programs for development of multiple skill sets for all its employees on a regular basis.

As an organization we have also listed out technologies that will be the Future of Telecom (FoT).

We are in the process of setting up Centers of Excellence on these upcoming advanced telecom technologies. Besides these, C-DOT is associated with multiple telecom alliances and it routinely takes part in seminars and conferences.

We have also been collaborating with R&D Institutions, Industry and Academia in India and abroad and have formally signed MOUs with different institutions for sharing of knowledge and knowhow. We provide research scholarships in telecom and security to students of select institutes to develop R&D skills. We hope some of these students will join us.

**C-DoT has a strong presence in the roll out of Smart Cities. What is happening in this field now and which are the most promising technologies likely to be widely adopted.**

C-DOT's state-of-the-art oneM2M compliant C-DOT Common Service Platform (CCSP) is a horizontal IoT/M2M platform and can help in deployment of smart city solutions based on one M2M standards in the country.

This platform is built based on global and national standards.

This platform will provide a vendor lock in -free, standardized service layer for smart city solutions and products. We are encouraging device and application

providers to join hands with us in developing a standard integrated solution based on standards so that it can be deployed beyond borders too. C-DOT has made available its state-of-the-art IoT/M2M common service platform for integration, interoperability testing and conformance to global standards. For this we have formed a Centre of Innovation (COI) for IoT/M2M that assists startups/M2M providers in development, integration and testing of innovative smart solutions. The center is inviting industry partners to register for engagement and create end-to-end solution IoT/M2M solutions for smart cities. Around 30 startups have registered with us. We will support any startup in this area and provide funds wherever needed.

This will create synergies among the startups and M2M/IoT industry for capacity building in the area of oneM2M standards-based products and applications and will also bridge the gap between R&D and commercialization of M2M/IoT products based on oneM2M standards

**C-DoT has always worked closely with the industry across all verticals, what are the areas of partnership evolving now.**

C-DOT now aims to expand its R&D program through collaboration with Startups and industry. We are bringing more players under this umbrella for collaborative research and development of advanced telecom products and solutions.

The main role of C-DOT will be of a facilitator in development of products and solutions. To achieve this, CDOT has come up with a Collaborative Research Program for facilitating development of telecom and associated technologies by collaborating with Industry, Academia, startups etc.

Such partnerships will leverage the strengths and expertise of each party for developing telecom solutions that will reduce time to market and will pave way for advancement of telecommunication in the country.

A recent example of such collaboration is the successful POC trial of C-DOT's indigenous 4G solution in partnership with TCS and Tejas Networks in the BSNL network, that resulted in a commercial order.

A separate fund is being set aside, which shall be used for funding of telecom product development programs and handholding startups who are at least at TRL-3 to scale up their innovation through partnership with C-DOT.



Development of a completely indigenous 4G solution was a top priority for us. C-DOT developed the 4G core, with Tejas and TCS as lead consortium partner. This is a historic achievement for us and soon this indigenously developed 4G network will be deployed by BSNL.

**Startups seems to be a new area of focus for you. What is the framework for this.**

As I said earlier we have set up collaborative research program to work with startups. For early stage startups (below TRL-3), we are setting up incubation centers at C-DOT Delhi and Bangalore. C-DOT will provide necessary support including funding for promoting innovations in telecom technology. These centers will provide end-to-end support including infrastructure, mentoring, guidance on IPR, knowledge management and assist the startups in market access.

**Do you think C-DoT has lived up to its legacy or is there much more to be done.**

C-DOT has had an eventful journey in becoming the premier Telecom R&D Centre of the Government of India. Right from its inception, C-DOT has contributed in many technologies. C-DOT has indeed lived up to its legacy, and over the past few years we have developed and deployed many successful projects in multiple and key areas of Switching, Optical, Telecom security, Wireless Solutions, Network Management and Software Applications.

We are on the path of being self-reliant, and last financial year (2021-22) we also realized revenue of Rs 170 crores, which is the highest in history of C-DOT for any year. Given our success in 4G this is going to grow manifold. We will be drivers rather than followers in technology soon.

C-DOT's commitment to the cause of nation- building continues with products of national and strategic importance. As per the vision 2047, C-DOT aims to be a reputed global player in telecom R&D ecosystem. We are taking adequate steps in identifying upcoming key areas in telecom and are forming Centers of Excellence for R&D in these areas. Adopting the latest R&D trends and a well-researched methodology and partnership with industry would not only fill the research and development gaps in the country but give an impetus

to IPR generation and contribute to telecom standards, opening up export opportunities.

**Where are we as a Digital Nation today.**

The Digital India program of Government of India will transform India into a digitally empowered society -- focusing on digital literacy, digital resources, and collaborative digital platforms. Availability of digital services in local Indian languages and digital infrastructure is recognized as a core utility by every citizen. Telecommunications and digital presence has become the key indicator of nation's growing economy.

Currently, India is the world's second-largest telecommunications market with a billion plus subscriber base. A key pillar of India's current economic recovery is technology-led growth and government's innovation-friendly policies.

By 2025, India's digital sector value is targeted to cross USD 1 trillion. Today many critical sectors like health, education, power, agriculture, human capital development, governance etc. have been digitized and are offering e-services to the citizens of the country. For almost all our day-to-day tasks such as health, education, aadhar services, business and payments, banking, e-governance etc. we are dependent on handheld devices and Internet.

India's flagship digital platform Unified Payments Interface (UPI) clocked over 6 billion transactions in July. During Covid-19 pandemic Arogya setu and CoWIN portal to manage COVID were developed in a record time. CoWIN helped run Indian Covid-19 Vaccination program seamlessly and issued digital vaccine certificates.

In all of this, the security of our telecom network resources is of critical and paramount importance. 🙌

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# 5G - India's own 5G Stack - developed by CDOT - 5G RAN based on open standards

Collaboration with Indian startup companies on development of indigenous 5G endtoend solution is under finalization



BY ANURAG GUPTA

**5G**, the fifth generation of cellular networks, will bring a paradigm shift in the role of mobile technologies with a much broader role beyond connectivity.

5G and associated technologies will empower enterprises and other industry verticals which include agriculture, automotive, energy and utilities, financial services, healthcare, manufacturing, logistics, media and entertainment, public safety, public transport and retail to launch new innovative services.

5G networks support different data traffic profiles viz. high throughput (enhanced mobile broadband-eMBB), low latency (ultra-reliable low-latency communications-URLLC) and massive connections (massive machine-type communications-mMTC) and data traffic models.

The overall economic impact of the above is estimated to be of the order of 1 Trillion USD in India by 2035. 5G Trials currently underway in low band (700 MHz), mid-band (3300 MHz) and millimeter band (26 GHz) shall

be used to identify use cases and performance across different bands for large scale commercial rollouts.

Due to low frequency and with the ability to penetrate buildings efficiently, the 700MHz band shall help to provide connectivity (coverage) in congested regions. 3,300MHz band will be used for 5G communication service (capacity) while the 26GHz will be focused on providing super high-speed mobile broadband services (for hotspots).

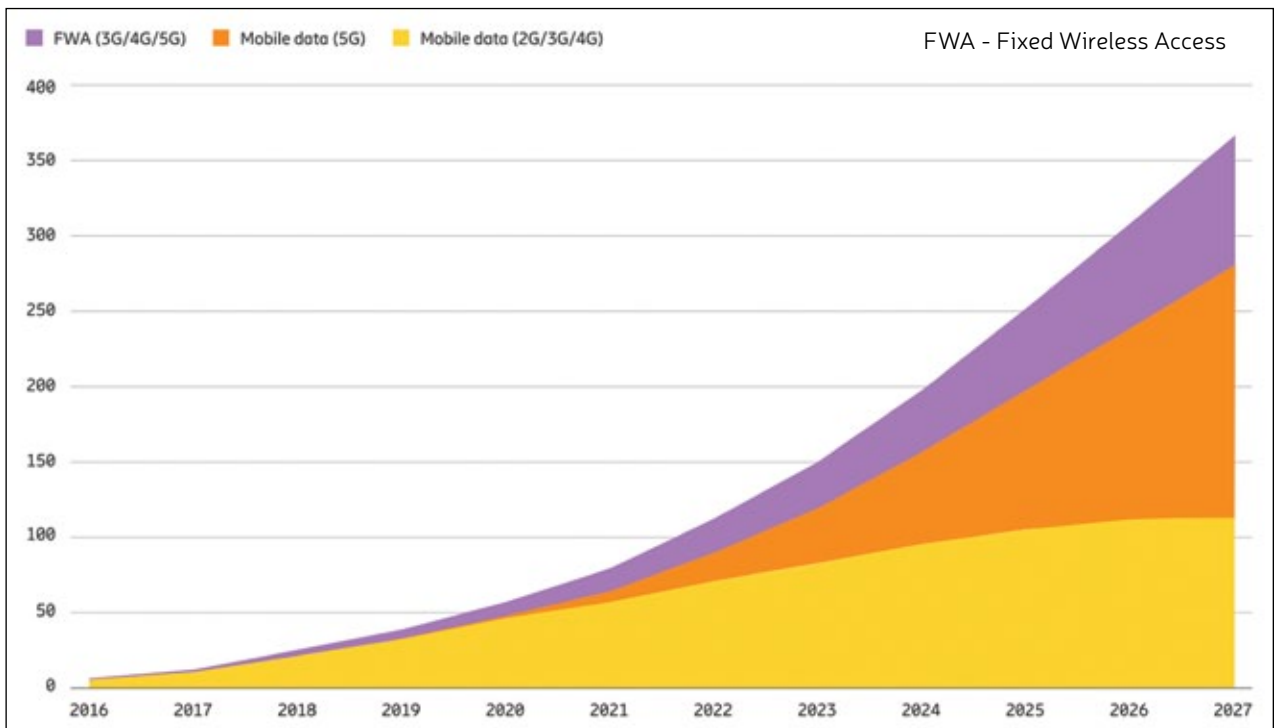
5G spectrum that has recently been auctioned include 600 MHz, 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300 MHz, and 26 GHz bands. Government is targeting to allocate spectrum by mid-August 2022. India is expected to see rollout of 5G services in certain pockets around September October 2022.

Global Mobile Suppliers Association (GSA) has catalogued 1,400 announced 5G devices, with over 809 devices announced with 5G standalone support. GSA has identified 735 announced 5G phones at the end of



5G networks support different data traffic profiles viz. high throughput (enhanced mobile broadband-eMBB), low latency (ultra-reliable low-latency communications-URLLC) and massive connections (massive machine-type communications-mMTC) and data traffic models.

### Global mobile network data traffic forecast (EB per month)<sup>2</sup>



2020. There are more than 1,050 commercially available 5G devices and 192 vendors producing or planning 5G devices.<sup>1</sup> (IGSA 5G Market Snapshot June 2022).

Mobile data traffic is forecasted to keep growing by 25 percent per year between 2020 and 2025. Video streaming is currently the main driver of increased data consumption.

In 2024, the first reduced capability (RedCap) devices should be available, which would allow expansion of the new radio, NR, device ecosystem to cater to use cases that are not currently best served by NR specifications.

This includes wearables, industrial wireless sensors and video surveillance.<sup>2</sup> (2Ericsson Mobility Report June 2022)

There are two main deployment strategies available to mobile operators for new 5G networks-

- Non-standalone (NSA), with 5G Radio Access Network (New Radio- NR) as an add-on to 4G
- Standalone (SA), having both 5G Core and 5G Radio Access Network (New Radio- NR)

To deliver mainly high-speed connectivity to consumers with 5G-enabled devices, non-standalone architecture (NSA) option can be used in early deployments. It enables operators to leverage their existing network investments in transport and mobile core networks rather than to deploy a completely new end-to-end 5G network.

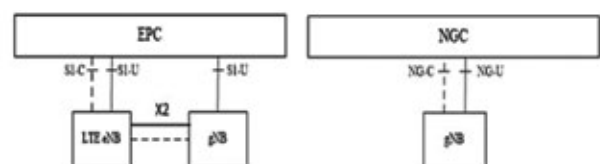


Figure 1: NSA Deployment

Figure 2: SA Deployment

Till the 4G devices get phased out, operators will require to continue to provide 4G services. NSA network can be used to provide 4G & 5G services. Majority of the current 5G launches so far have been of 5G NSA.

5G NSA networks supports enhanced mobile broadband use case (higher broadband speeds) with 5G handsets, in networks having 3GPP Release 15 (or higher) compliant 4G eNodeB and 5G gNodeB. In 5G NSA architecture (Figure 1), the 5G Radio Access Network (5G RAN) is used in conjunction with the existing LTE infrastructure (eNodeB and Evolved Packet Core), thus making the technology available without 5G core network.

It combines 4G LTE coverage and 5G high speed benefits offered by the 5G New Radio, effectively allowing operators to take advantage of both network technologies simultaneously.

Till the 4G devices get phased out, operators will require to continue to provide 4G services. NSA network can be used to provide 4G & 5G services. Majority of the current 5G launches so far have been of 5G NSA.

In 5G SA architecture (Figure 2), the 5G RAN is

directly connected to 5G Core Network. 5GSA introduced Service-Based Architecture (SBA) and functional separation of various network functions in 5G Core as shown in Figure 3. Through use of Network Function Virtualization (NFV) / Software-Defined Networking (SDN) technology, 5G Core can be deployed in virtualised and cloudified manner.

5G SA network can perform 5G functions such as reducing latency, improving network performance and centrally managing network functions.

5G SA networks additionally support

- Low latency communications for industrial automation through real-time process control, teleoperation, drones control, live online entertainment, gaming, etc.
- Massive IoT for live monitoring and remote control in disaster recovery efforts, providing real-time data for emergency responders, gaming etc.

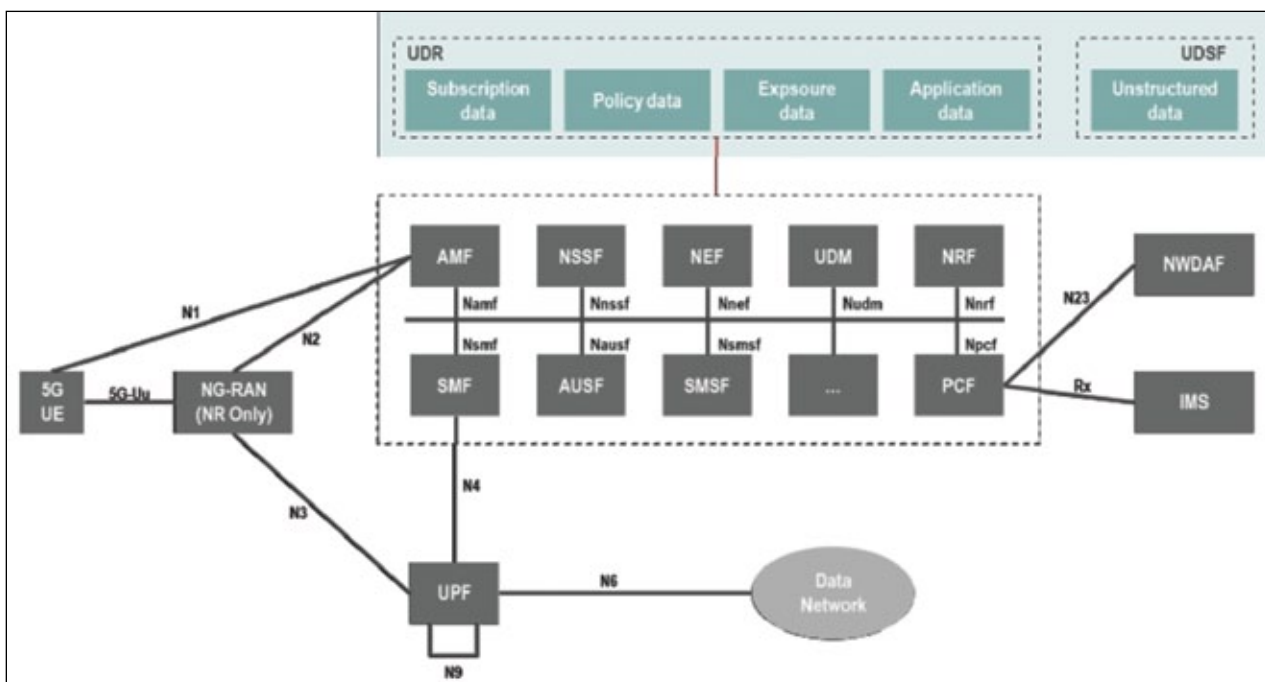


Figure 3: 5G SA Core Architecture<sup>3</sup>

The C-DOT 5G RAN is based on Open RAN architecture defined by O-RAN alliance as shown in Figure 4. Open RAN architecture is based on open interfaces and general-purpose hardware.

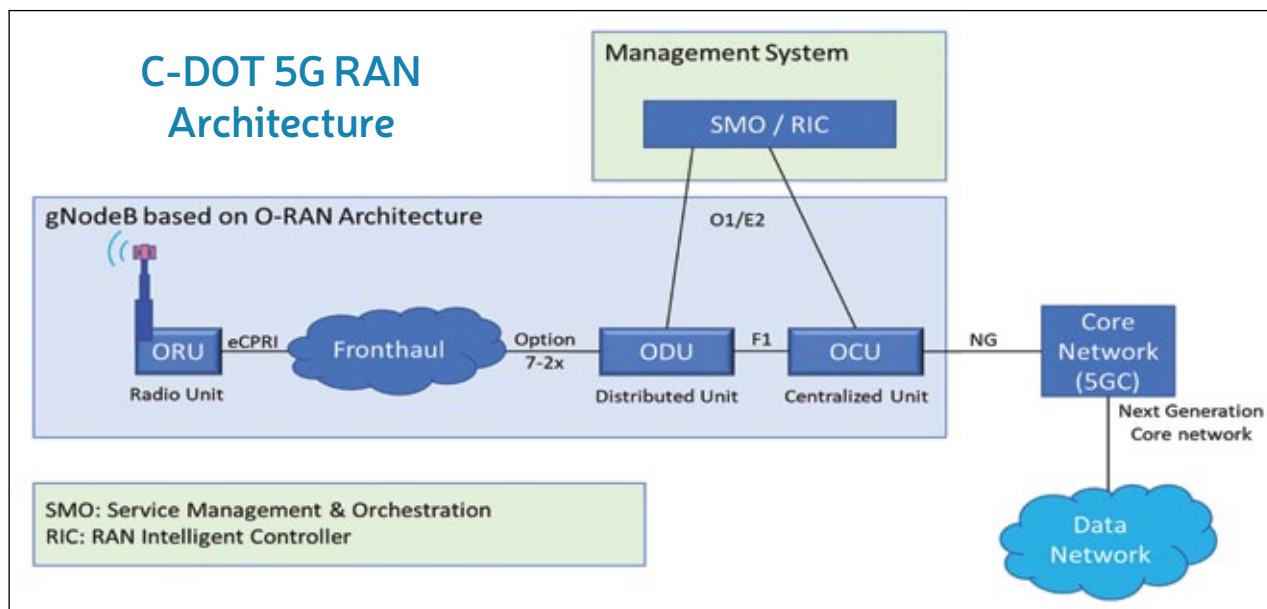


Figure 4: C-DOT 5G RAN Architecture

- Network slicing for sharing the same physical network infrastructure for simultaneously supporting high bandwidth applications, low latency applications and massive connectivity of IoT devices.

Current mobile network deployments are predominantly based on imported technology. 5G technology, with a significant focus on home grown technology development, will boost Digital India, Smart Cities and Smart Village missions thereby fulfilling the dream of becoming “Atmanirbhar Bharat”.

The C-DOT 5G RAN is based on Open RAN architecture defined by O-RAN alliance as shown in Figure 4. Open RAN architecture is based on open interfaces and general-purpose hardware. RAN is disaggregated into three different modules viz Centralized Unit (CU), Distributed Unit (DU) and Radio Unit (RU).

In line with the objectives of promoting indigenous development of 5G technologies under the Atmanirbhar Bharat program, C-DOT has launched a 5G India Alliance program to provide a common platform to Indian industry members for individually / collectively

developing 5G technologies in the country. C-DOT intends to facilitate the Indian industry in collaboratively designing and developing 5G technologies. Among other envisaged facilitation mechanisms, CDOT is in the process of setting up a sharable captive campus wide private 5G network infrastructure for conducting research & development, testing, pilot production and deployment of innovative 5G products and services.

The development of main functional components of C-DOT 5G RAN solution such as O-CU, ODU, O-RU and SMO is in progress. C-DOT has signed MoU with various industry / academia partners for the development of 5G solution.

In addition, collaboration with Indian startup companies on development of indigenous 5G endtoend solution is under finalization. C-DOT aims to play a key role in 5G deployments in the Indian market. 🙌

Anurag Gupta, CDOT

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# 5G Auctions – Accelerating India’s Digital Revolution

It Is A Ubiquitous, Robust, Internet Access Infrastructure bringing Internet to the remotest, unconnected regions of the country



BY JOSUN AND VOICE&DATA BUREAU

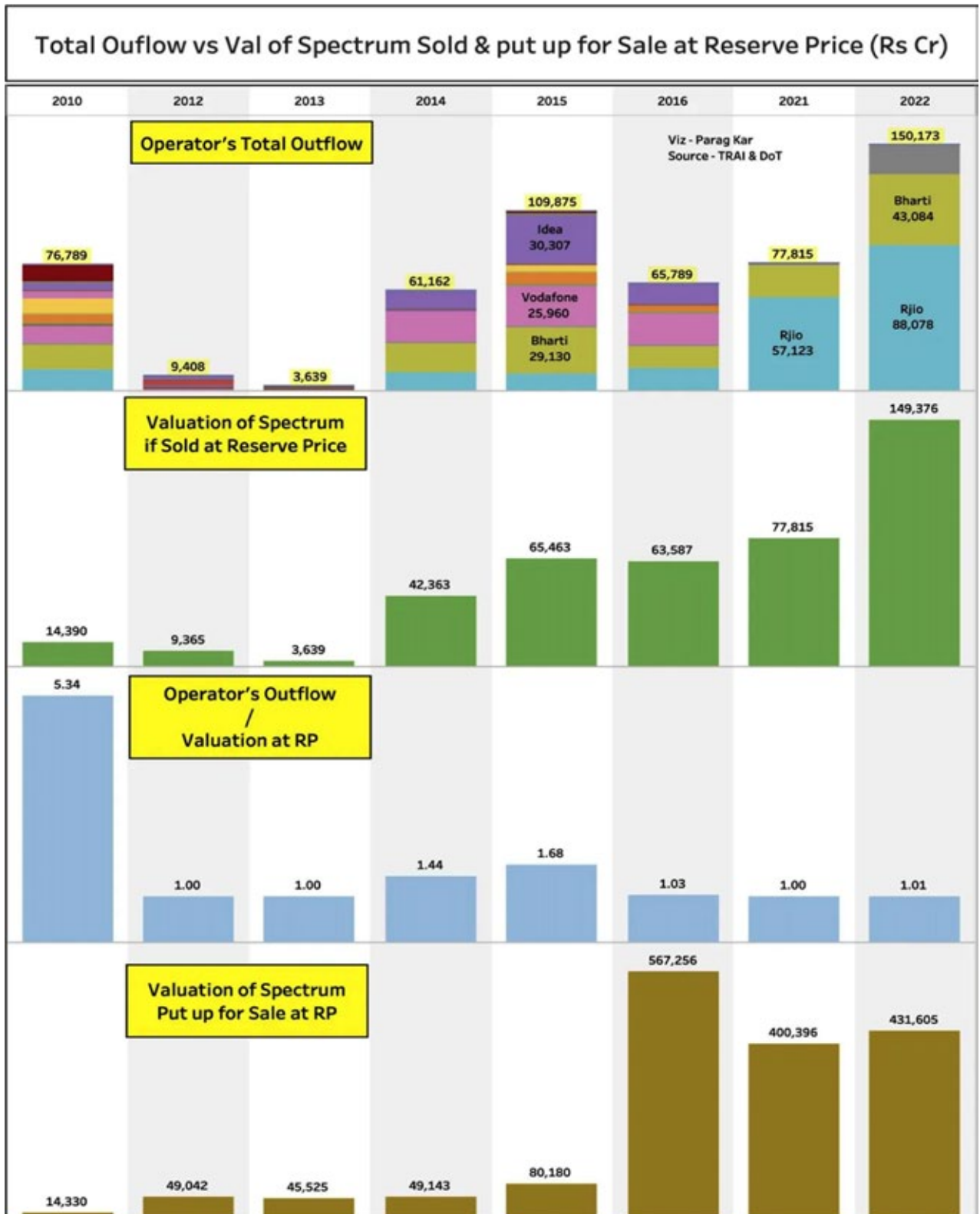
## The Auctions

July 26, 2022 kickstarted the Indian 5G spectrum auction among the country’s leading telcos with 40 rounds of bidding over 8 days. 71% of overall 5G airwaves were purchased by the four potential players – Reliance Jio, Bharti Airtel, Vodafone Idea, and new entrant in the telecom sector, Adani’s Telecommunications venture – filling government coffers with a approximately INR 1.5 lakh crore. This is the largest investment by the industry

in a spectrum auction even though the auction in general was not competitive.

“The auction itself was not competitive, with almost the entire spectrum being sold at the reserve price, but the quantum of investment was larger than we expected with Jio’s investment in 700Mhz and Vodafone Idea’s (VIL) meaningful participation in the 3,300Mhz band being the key surprises,” said a market analyst.

## Total Outflow & Valuation of Spectrum at Reserve Price for all past auctions



Courtesy: Paragkar.com



“We will celebrate ‘Azadi ka Amrit Mahotsav’ with a pan India 5G rollout. Jio is committed to offering world-class, affordable 5G and 5G-enabled services. We will provide services, platforms and solutions that will accelerate India’s digital revolution”

**Akash M. Ambani**, Chairman, Reliance Jio Infocomm

The 5G auction was held for the following categories of spectrum bands—low (600 MHz, 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz), mid (3300 MHz), and high (26 GHz). No bids were received by the government for 600 MHz, 800MHz, and 2,300 MHz bands.

transmitting a large set of data at very rapid speed. In comparison to earlier generations, 5G has a very low latency, which will enhance user experiences in various sectors. Low latency describes the efficiency to process a very high volume of data messages with a minimal delay. The 5G rollout is also expected to bring more development in remote data monitoring in sectors such as mining, warehousing, telemedicine, and manufacturing, among others.

5G is the fifth-generation mobile network capable of

### % of Spectrum Sold vs Offered, And 90% Outflow vs Validation at Reserve Price

Indian 5G Auction - Key Metrics											Viz - Parag Kar Source - DoT
	600	700	800	900	1800	2100	2300	2500	3500	26000	Grand Total
Total Spectrum Sold	0.0	220.0	20.0	12.8	88.4	35.0	0.0	20.0	5,490.0	45,350.0	51,236.2
Total Spectrum Offered	660.0	550.0	136.3	74.4	267.2	160.0	60.0	230.0	7,260.0	62,700.0	72,097.9
% of Total Spectrum Sold	0.00%	40.00%	14.68%	17.20%	33.08%	21.88%	0.00%	8.70%	75.62%	72.33%	71.06%
Total Outflow at Auction Price	0	39,270	1,050	349	10,376	3,180	0	650	80,590	14,709	150,173
Valuation at Reserve Price	117,810	98,175	22,351	11,085	27,697	14,585	4,430	10,940	104,610	19,922	431,605
% Outflow of Valuation at RP	0.0%	40.0%	4.7%	3.1%	37.5%	21.8%	0.0%	5.9%	77.0%	73.8%	34.8%

Courtesy: Paragkar.com



Over the years, Airtel has been very astute in its competitive spectrum acquisition approach. It has assiduously accumulated the largest pool of low and mid band spectrum.

Purchase of spectrum was as follows:

Operator	Airwave Purchased	Bands	Cost to Operator
Reliance JIO	24.7 GHz	4G & 5G spectrum 700 MHz, 800, 1800, 3300, 26 GHz	₹88,078 crores
Bharti Airtel	19.9 GHz	4G & 5G spectrum 900 MHz, 1800, 2100, 3300, 26 GHz	₹43,084 crores
Vodafone Idea	6.2 GHz	5G spectrum 3300 MHz and 26 GHz	₹18,799 crores
Adani	400 MHz	26 GHz	₹212 crores

### Rollout

5G mobile networks are expected to enhance the experience of Indian Internet consumers, with faster downloads, quicker response time. According to the Union Minister of Telecom, Ashwini Vaishnaw, 5G spectrum would be allocated by mid-August'22 and rollouts are expected to commence by October '22. "However, given the nascent 5G ecosystem (modest ~7% of the overall smartphone base is 5G enabled) and evolving use cases, we think 5G rollouts would likely be granular, starting with metros and larger cities," said analysts at Nomura.

Kotak Institutional Equities reports that "the exchequer is anticipated to accrue INR 133.7 billion on a yearly basis if all participants follow the 20 year Equated Annual Instalment (EAI) payment option, which is based on a 7.2% rate of interest. Bharti and Jio picked up a significant share of spectrum on offer across key bands in all 22

## Auction Bidder's Outflow (Pan India & Total)

Operator Outflow Summary (Rs Cr)											
Operators	600	700	800	900	1800	2100	2300	2500	3500	26000	Grand Total
RJIO	0	39,270	1,050	0	7,028	0	0	0	33,740	6,990	88,078
Bharti	0	0	0	349	2,764	2,680	0	0	31,700	5,592	43,084
VI	0	0	0	0	585	500	0	650	15,150	1,915	18,799
Adani	0	0	0	0	0	0	0	0	0	212	212
Grand Total	0	39,270	1,050	349	10,376	3,180	0	650	80,590	14,709	150,173

Courtesy: Paragkar.com



“This landmark deal reinforces our long-standing partnership with Bharti Airtel. Nokia’s best-in-class AirScale baseband and radio portfolio will help deliver superior 5G performance in one of the world’s largest networks.”

**Pekka Lundmark**, President and CEO, Nokia

circles. Some of it for bandwidth coming up for renewal in 2024; on the other hand, VIL added to its holdings in its target circles; Adani Data Networks took up spectrum only in the 26 GHz band across six circles focused on private networks/enterprise applications.”

### Operator-wise Overview

#### Aggressive Jio leads spectrum acquisition

According to a BNP Paribas report on the auctions, “Jio remains the most aggressive; 700Mhz can provide an edge in coverage: Jio acquired 100-130Ghz spectrum in the 3,300Mhz band and 1,000Mhz in the 26Ghz band besides its investment in 700Mhz. Jio will look to get an edge over competition through this investment as the benefits of 700Mhz spectrum include better indoor and rural coverage and lower operating cost. If 5G adoption accelerates and the next spectrum auction gets delayed, Jio can use this edge to improve its market share.”

The acquisition of the right to use this spectrum will enable Jio to build the world’s most advanced 5G network and further strengthen India’s global leadership in wireless broadband connectivity. Launched just six years ago, Jio has created multiple world records during its roll out of the largest 4G network in the shortest period of time. Jio’s 4G network provides the highest quality, most affordable digital services to over 400 million loyal and delighted customers. Jio will now raise the bar even further with its 5G services.

“Jio has been a front-runner in embracing technologies of the future and unlocking their full potential for the benefit of India, Indians and Indian businesses. Jio has demonstrated its visionary commitment yet again, as

India enters the 5G era. As with Jio 4G that blurred the line between Bharat and India and provided every Indian the best connectivity at the most affordable price globally, Jio 5G will ensure that every Indian gets to access the most transformative digital services and platforms offered anywhere in the world,” the company said in a statement.

Jio’s 5G solution is made in India, by Indians and to suit the need of every Indian. Jio is fully ready for 5G rollout in the shortest period of time because of its nationwide fibre presence, all-IP network with no legacy infrastructure, indigenous 5G stack and strong global partnerships across the technology ecosystem.

In a press statement Akash M. Ambani, Chairman, Reliance Jio Infocomm said, “We will celebrate ‘Azadi ka Amrit Mahotsav’ with a pan India 5G rollout. Jio is committed to offering world-class, affordable 5G and 5G-enabled services. We will provide services, platforms and solutions that will accelerate India’s digital revolution, especially in crucial sectors like Education, Healthcare, Agriculture, Manufacturing and e-Governance and make another proud contribution to Honourable Prime Minister’s digital India mission.”

Total cost of acquiring the right to use the above technology agnostic spectrum for a period of 20 years is INR 88,078 crore. As per terms of the spectrum auction, the spectrum payments have to be made over 20 equated annual instalments, with interest computed at 7.2% per annum.

Jio has acquired a unique combination of low-band, mid-band and mmWave spectrum, which coupled with its

Jio has acquired a unique combination of low-band, mid-band and mmWave spectrum, which coupled with its deep fibre network and indigenous technology platforms, will enable the company to provide 5G everywhere and 5G for all



“5G will have a powerful impact on India’s consumers and businesses – taking mobile experiences to a new level, introducing a gamut of enhanced capabilities and expanding what is possible.”

**Paul (Kyungwhoon) Cheun**, President and Head of Networks Business, Samsung Electronics

deep fibre network and indigenous technology platforms, will enable the company to provide 5G Everywhere and 5G For All (consumers and enterprises), the company said in its statement.

With its unmatched 700 MHz spectrum footprint, Jio will be the only operator providing pan-India true 5G services with faster speeds, lower latency and massive connectivity. Through this acquisition, Jio’s total owned spectrum footprint has increased significantly to 26,772 MHz (uplink + downlink), which is the highest in India.

Jio also has the highest amount of sub-GHz spectrum with at least 2X10 MHz contiguous spectrum in both 700 MHz and 800 MHz bands across each of the 22 circles. Jio is the only operator which has at least 2X10 MHz in 1800 MHz band (with 2X20 MHz in six key circles), 40 MHz in 2300 MHz band and 100 MHz in 3300 MHz band across all the 22 circles. In addition, Jio also has right to use 1,000 MHz in the millimetre wave band (26 GHz) in each of the 22 circles which will be crucial to enable enterprise use cases as well as provide high-quality streaming services.

Prior to the auction, Reliance Jio submitted the highest Earnest Money Deposit (EMD) amount of INR 14,000 crore, followed by Bharti Airtel which submitted EMD of INR 5,500 crore. Vodafone Idea Limited had deposited INR 2,200 crore as EMD, and Adani Data Networks submitted INR 100 crore.

### **Bharti Airtel follows expected lines**

As with Jio, Bharti Airtel too has built a pan-India 5G spectrum footprint. This could “further aid their market shares relative to Vodafone Idea, especially in the post-paid and high-end prepaid segment,” says a Goldman Sachs report.

BNP Paribas in its analysis notes: “Airtel has also added mid-band spectrum in 15 circles with the largest outlay in Mumbai, Delhi, Kolkata, Maharashtra and Gujarat. Depending on the traction Jio might receive,

we think Airtel might consider adding some more low-frequency spectrum in the future as there is still ample spectrum available in the 700MHz band.”

Kotak Institutional Equities Research on the other hand has made the following observations: “Bharti has acquired a total of 19,868 MHz of spectrum for ~Rs431 bn with an estimated EAI of Rs 41.3 bn. Bharti’s spectrum acquisition in the 3.3 GHz band is largely comparable to that of Jio’s and modestly lower than Jio in the 26GHz band... following the spectrum acquisition, Bharti’s spectrum holding now stands at ~22,000 MHz, in comparison to 26,772 MHz for Jio. Bharti may have to increase spectrum acquisition in future rounds in the sub-GHz bands if network quality lags that of Jio in the coming years.”

Airtel now has the widest mobile broadband footprint across the country making it well-positioned to usher in the 5G revolution in India. In the past year, Airtel led the industry and spearheaded 5G technology in India testing several use cases with multiple partners at many locations. From demonstrating India’s first 5G experience over a live 4G network in Hyderabad to India’s first rural 5G trial to the first cloud gaming experience on 5G to the successful deployment of India’s first captive private network on the trial spectrum, Airtel has created and nurtured a vibrant ecosystem of partners and start-ups to support faster adoption of next-generation technologies.

Over the years, Airtel has been very astute in its competitive spectrum acquisition approach. It has assiduously accumulated the largest pool of low and mid band spectrum (Sub ghz/1800/2100/2300 bands) which can be used to provide 5G coverage while massive capacities in the 3.5 GHz and 26 GHz bands will allow Airtel to create 100X capacities at the least cost.

This well thought out strategy for spectrum acquisition through auctions, M&A and trading has allowed Airtel to avoid the need for adding an expensive





“We look forward to supporting Bharti Airtel with its deployment of 5G in India. We will help Airtel deliver the full benefits of 5G to Indian consumers and enterprises, and seamlessly evolved from 4G to 5G.”

**Börje Ekholm**, President and CEO, Ericsson

sub GHz band. “This enables Airtel to meet all its objectives – the best 5G experience, 100x capacity enhancement and the most power-efficient solutions that will go towards meeting the ambitious ESG goals of the company. Even more importantly, this will provide Airtel an enduring competitive advantage for years to come in delivering the lowest total cost of ownership,” Airtel said in a press statement.

Airtel now plans to launch 5G services in every part of the country starting with key cities. The company is convinced that its higher-quality customer base will adopt 5G devices at a rapid pace in the country. In addition, Airtel’s strong presence in the Enterprise segment will allow for a slew of industrial use cases further strengthening Airtel’s leadership in the B2B market.

Gopal Vittal, M.D & CEO, Bharti Airtel said in a statement, “ We are confident that we will be able to deliver the best 5G experience in India in terms of coverage, speeds and latency. This will allow us to change a lot of established paradigms for both our B2C and B2B customers. 5G technology is the revolution that can alter India’s manufacturing, services and several other sectors. We remain fully committed to the Government’s Digital India vision and will continue to do what is needed to ensure that India becomes a beacon for the world in terms of technology.”

Airtel has signed 5G network agreements with Ericsson, Nokia and Samsung to commence 5G deployment in August 2022. Choice of multiple partners will enable Airtel to roll out 5G services spanning ultra-high-speeds, low latency and large data handling capabilities, which will enable a superior user experience

and allow the pursuit of new, innovative use cases with enterprise and industry customers.

Speaking about the agreement, Börje Ekholm, President and CEO, Ericsson, said: “We look forward to supporting Bharti Airtel with its deployment of 5G in India. With Ericsson’s unrivalled, global 5G deployment experience, we will help Bharti Airtel deliver the full benefits of 5G to Indian consumers and enterprises, while seamlessly evolving the Bharti network from 4G to 5G. 5G will enable India to realize its Digital India vision and foster inclusive development of the country.”

The multi-year deal will see Nokia provide equipment from its market-leading AirScale portfolio along with solutions and services for network management, deployment, planning and optimization services to ensure the best end-user experiences.

Speaking about the partnership, Pekka Lundmark, President and CEO of Nokia said, “This landmark deal reinforces our long-standing partnership with Bharti Airtel. We are delighted that they have chosen Nokia’s best-in-class AirScale baseband and radio portfolio to deliver superior 5G performance in one of the world’s largest networks. I look forward to our continued successful long-term collaboration in this vital and dynamic market.”

Airtel will also bring in South Korean Major Samsung as a network partner to deploy Airtel5G. This is the first time that both companies will work together.

Speaking about the partnership, Paul (Kyungwhoon) Cheun, President and Head of Networks Business at

Vodafone Idea said “We have successfully acquired mid band 5G spectrum (3300 MHz band) in our 17 priority circles and mmWave 5G spectrum (26 GHz band) in 16 circles, which will enable us to offer a superior 5G experience to our customers.

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Samsung Electronics said, “5G will have a powerful impact on India’s consumers and businesses—taking mobile experiences to a new level, introducing a gamut of enhanced capabilities and expanding what is possible. As a global leader in 5G, Samsung is excited to embark on this 5G journey with Airtel to deliver innovative solutions that will help advance India’s entrepreneurial spirit and open up a new paradigm for the country.”

### Vodafone India Limited – going slow

Vodafone India’s spectrum purchase was only for 16-17 of its priority circles. However the reading by analysts at Nomura is that “with the significant delays in fund-raising, capex constraint, existing gaps in 4G coverage and just ~12-15% share of spectrum in the 5G bands, we think Vi’s 5G rollouts would likely lag peers and could lead to further accelerated market share gains for Bharti and R-Jio.”

Bofa Securities adds that “Given VIL’s weaker balance sheet, we believe that in the medium term, VIL could be at a disadvantage compared to Bharti / Jio in the 5G space given lack of adequate spectrum. We also see risks of its 5G being viewed as more of a marketing gimmick, with investments largely done to prevent churn than create a better-quality network.

We view the company at maximum risk of losing its high-end subscribers over time if other telcos have better 5G networks.”

However, Vodafone Idea said “We have successfully acquired mid band 5G spectrum (3300 MHz band) in our 17 priority circles and mmWave 5G spectrum (26 GHz band) in 16 circles, which will enable us to offer a superior 5G experience to our customers as well as strengthen our enterprise offerings and provide new opportunities for business growth in the emerging 5G era. We actively participated in the spectrum auction to strengthen our pan-India 4G footprint and embark on our 5G roll-out journey in the country in line with our long term vision.”

“We believe that the above spectrum acquisition will enable us to strengthen our position in our key markets and it aligns well with our long term strategic intent. With this, we now have a solid portfolio of spectrum

across all bands in all our priority circles. We also have the advantage of leveraging the global experience of Vodafone Group which has proven expertise in deploying 5G in many markets. We will continue to invest in our future ready network to upgrade it for roll out of 5G services to our customers in future,” Vodafone Idea added.

### Significant Savings in Spectrum usage charges (SUC)

Operators will have to pay the first instalment of Rs 13,400 crore in August and the remaining Rs 1.36 lakh crore in similar instalments over the next 19 years. The high pay-out could force telecom operators to increase focus on monetization, potentially driving further tariff hikes over the next few months.

But with the removal of SUC, the savings are expected to offset additional spectrum pay-outs to a large extent (24-44%). Savings are expected to increase over the years as revenues rise. JP Morgan in its analysis says: “The annual spectrum payments for Jio will be INR 79 bn, Bharti INR 39 bn and Vi INR 17 bn. However, the telcos will save significantly on SUC as the additional spectrum comes at 0% SUC charge.

The weighted average SUC for the telcos now drops to 0.2-0.8% from 3.5% earlier resulting in significant cost savings. We estimate cost savings of INR 30-40 bn annually for Bharti and Jio over FY23-25 and INR 12-15bn for Vi.”

All in all, these spectrum auctions mark a turning point for India’s telecom market.

In addition to improving mobile broadband, 5G technology will enable the delivery of critical services such as telesurgery and the Internet of Things over a mobile network with unprecedented efficiency.

5G services will also be opening the floodgates for innovative applications that require a massive amount of high-speed bandwidth – Indian consumers are in for a treat. 🍷

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# CDOTmeet – Video Conferencing Solution by C-DOT

CDOTmeet’ is a browser-based clientless Video Conferencing solution to provide secure collaboration to enterprises

BY DHARMESH KUMAR CHAURASIYA

Video based conferencing has also added a new dimension to the work from home trend. However there has been a continuous concern about the security and localization of information during VCs using other applications.

Primarily these are:

- Location of VC server outside the organization
- No security of the content transmitted
- Data can be stolen by malware attack

In order to mitigate this concern, C-DOT developed an easy-to-use application in the form of ‘CDOTmeet’. C-DOT’s all encompassing Video Conferencing (VC) solution can be accessed on all devices like laptop, mobile, etc with access to Internet.

It obviates the need of a dedicated VC setup with a simple provision of opening a link like any other website on a web browser. The solution is ideally suited to cater to the office environment including the fast emerging “Work from Home” scenario that is here to stay. It offers various innovative features that create a highly interactive environment. In context of low speed connectivity in rural and semi-urban areas, the solution is optimised to render services in an efficient manner and enhancing the end user experience.

This feature rich solution with ease of access is effective tool for applications like e-learning and others. The basis for CDOTmeet stands on four verticals, namely:

- Inherent Security Features
- Moderator Control Features
- Unique Collaborative Features
- Generic Ease-Of-Use Features

‘CDOTmeet’ is a browser-based clientless Video Conferencing solution to provide secure collaboration to enterprises.

This will enable the enhancement of communication across boundaries for the employees of an organization. The users will benefit from the remote connectivity to other people anytime, anywhere, while still enjoying the privileges of a secure communication.

‘CDOTmeet’ is a holistic video conferencing solution which enables users to conduct meetings and presentations while providing different tools to enhance the experience of the same. The solution is secure and scalable. It may be hosted in the organization or may be accessed from a publicly hosted service.

‘CDOTmeet’ is a browser-based solution which can be invoked easily from Chrome browser and does not require the installation of any additional Apps, which may be used by organization personnel to conduct meetings, discussions and presentations in a closed user group or across such groups.

Unique ‘CDOTmeet’ features that enhance the productivity of your employees include Collaborative Whiteboard, Share External video, Schedule a meeting, real time Minutes of Meeting generation, waiting lobby, Breakout rooms etc.

CDOTmeet – Launched by Honorable MoC Sh. Ravi Shankar Prasad on 22/03/2022.

C-DOTmeet was launched for the public by Honorable MoC Sh. Ravi Shankar Prasad on 22/03/2022. During the launch, Honorable MoC conducted a two and a half hour long virtual meeting with 24 CPMGs across the country and praised C-DOT to deliver an indigenous videoconferencing solution in just 18 days. 🍀

Dharmesh Kumar Chaurasiya, COELI Group  
feedbackvnd@cybermedia.co.in





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# C-DoT's - 4G Success Story

4G networks are based on a pure data connection over an end-to-end Internet Protocol (IP) connection



BY SANDEEP KUMAR KHURANA

**B**harat Sanchar Nigam Limited (BSNL) had issued an e-tender for planning, testing, deployment and maintenance of its 4G network last year. After many trials, the final Proof of Concept (POC) of 4G services which were being conducted at Chandigarh and Ambala was completed successfully. The BSNL 4G network will use core technology developed by C-DoT and partner with TCS for the execution.

Mobile networks have evolved pretty fast over the last four decades. From first generation (1G) that supported

only voice, to second generation (2G) supporting voice and text (SMS services), and then to third generation (3G) supporting voice, text and low speed data (at least by today's standards) to finally the fourth generation (4G). True mobile broadband services entered our lives with 4G. It redefined mobile data.

4G networks are based on a pure data connection over an end-to-end Internet Protocol (IP) connection. All the traffic, be it voice, text, video or audio is transported in data packets on 4G networks. The concept of a "circuit" is redundant in 4G.

The C-DOT R&D team developed the 4G core, while Tejas Radio system and TCS provided the other necessary software and integration capabilities.

In a first of its kind for India, C-DoT has built India's completely indigenous 4G core and an end to end platform using commercial off the shelf (CoTS) hardware without any proprietary lock ins. This is nothing short of revolutionary for telecom R&D in our country.

While all private operators launched 4G on international vendor infrastructure, BSNL's 4G network plans were a little delayed. Now with the C-DoT technology we will witness the country's first 4G network, leading into a non stand alone 5G infrastructure that will eventually be a template for the rest of the world.

4G has changed our perception of high-speed mobile communications in India. For the first time since 1995 when the first 2G networks were launched in our country, it was possible to experience high speed mobile data services on a range of different handheld devices.

4G brought the Internet within reach to nearly every Indian. With over 700 million mobile broadband users today, mobile 4G has allowed access to digital platforms like social networks, streaming media, education, video calling and collaboration on the move.

At the same time other new technologies have flourished with 4G mobile networks. For example computing and telecommunications technologies have converted into a virtualized cloud environment to enable access to data and information. This has been the C-DoT strength.

### C-DoT and 4G

Since the beginning of its design-phase, the key focus was on making the C-DOT 4G Core virtualized and on the Cloud so as to achieve ease of deployment and ease of scalability along with low footprint and low power consumption.

Moreover, the cloud-based 4G Core reduces OPEX significantly by enabling expansion demands in terms of a pay-as-you-grow, virtualized infrastructure. This makes the solution highly cost effective. It further impacts another aspect – cost of future updates and upgrades. This is a major cost for all operators. The C-DoT open system which runs on freely available

commodity IT hardware, is capable of driving down this cost. One reason being the benefits that arise from better volume pricing of hardware, lower maintenance costs, broader knowledge and management skillsets of operations on readily available hardware, high scalability and – most importantly - freedom from proprietary vendor lock-ins.

As a pioneer in telecommunications networks, C-DOT has recognized the importance of deploying an indigenously developed 4G network and its impact on our country's socioeconomic growth. Our security especially where the nation's critical telecom infrastructure is involved.

It was with all these factors in mind that India's premier software and services company, TCS joined hands with C-DOT and Tejas Networks in June, 2020 to develop a completely indigenous 4G network solution.

The C-DOT R&D team developed the 4G core, while Tejas Radio system and TCS provided the other necessary software and integration capabilities. An end to end, complete 4G solution was developed and deployed in the BSNL network in July, 2021 for a Proof of Concept (POC) trial – which aimed at testing the robustness of the technology.

The PoC was conducted in a live field environment at BSNL's Ambala and Chandigarh networks. It went through a series of rigorous field tests.

Its most important value is: safety from any external threats. The entire solution is indigenous and no external vendors are involved. Further, the system allows low cost, regular updates and upgrades, long term support for service providers and protection of investments during further evolution to 5G.

The Core Network is a futuristic cloud-based software implementation running from a telco data center and is independent of any proprietary hardware implementation. Similarly, the access network is a software defined radio implementation which is expandable to new frequency bands and upgradable with newer features through software-only upgrades

BSNL is all set to launch its 4G services on a fully indigenous 4G core technology without being dependent on a specific hardware vendor as this will run on any off the shelf hardware. This is a game changer for technology R&D in the country – specifically in Telecom where C-DoT is leading this transformation to a creating a product nation.

## Technical highlights of C-DOT's Core solution

- 4G Evolved Packet Core Network providing mobile native VoLTE / VoIP / data services through seamless integration with IMS and legacy mobile services through interworking with 2G/3G networks.
- IP Multimedia Subsystem (IMS) for access independent and service independent delivery with provision for services/features portfolio expansion using 3rd party plugin servers.
- Wi-Fi Offloading & Services
- Flexible data center switch fabric
- Element Management System
- Security implementation through embedded Firewall, Security Gateway and CGNAT
- Seamless interworking with existing 2G/3G mobile networks
- Support for NBIoT and M2M
- Launch bed for 5G

With the PoC now complete, it is expected to see a full rollout and deployment of C-DoT 4G technology in BSNL network. While the world's biggest vendors

have annual R&D budgets of billions of dollars this development has been completed at a fraction of their R&D budgets.

### C-DOT 4G Core Network Entities

- Mobility Management Entity (MME)
- Serving Gateway (SGW)
- Packet Data Network Gateway (P-GW)
- Policy and Charging Rule Function (PCRF)
- Home Subscriber Server (HSS)
- Trusted/Untrusted Wi-Fi Offload Gateways

### Salient C-DOT 4G Core Features

- Simplified Network Topology
- Scalable Cloud based architecture
- Supports 3GPP defined interfaces
- Centralized Policy and Charging
- Virtualized Network Functions
- Interworks with 2G/3G Networks
- Separation of Control and User Plane
- Supports Non-3GPP Access Networks for Wi-Fi Offloading
- Supports Voice over LTE using IMS
- Supports 5G NSA deployment

### C-DOT 4G Core for 5G NSA Deployment

One of the key and crucial features of the C-DOT 4G Core solution is that it can be used to launch 5G in the Non-Stand Alone (NSA) mode during the initial deployment phase of the 5G network in the country.

This not only saves on the overall cost and expenditure for introducing the new technology but also speeds up the process of upgrading the network with minimal extra effort.

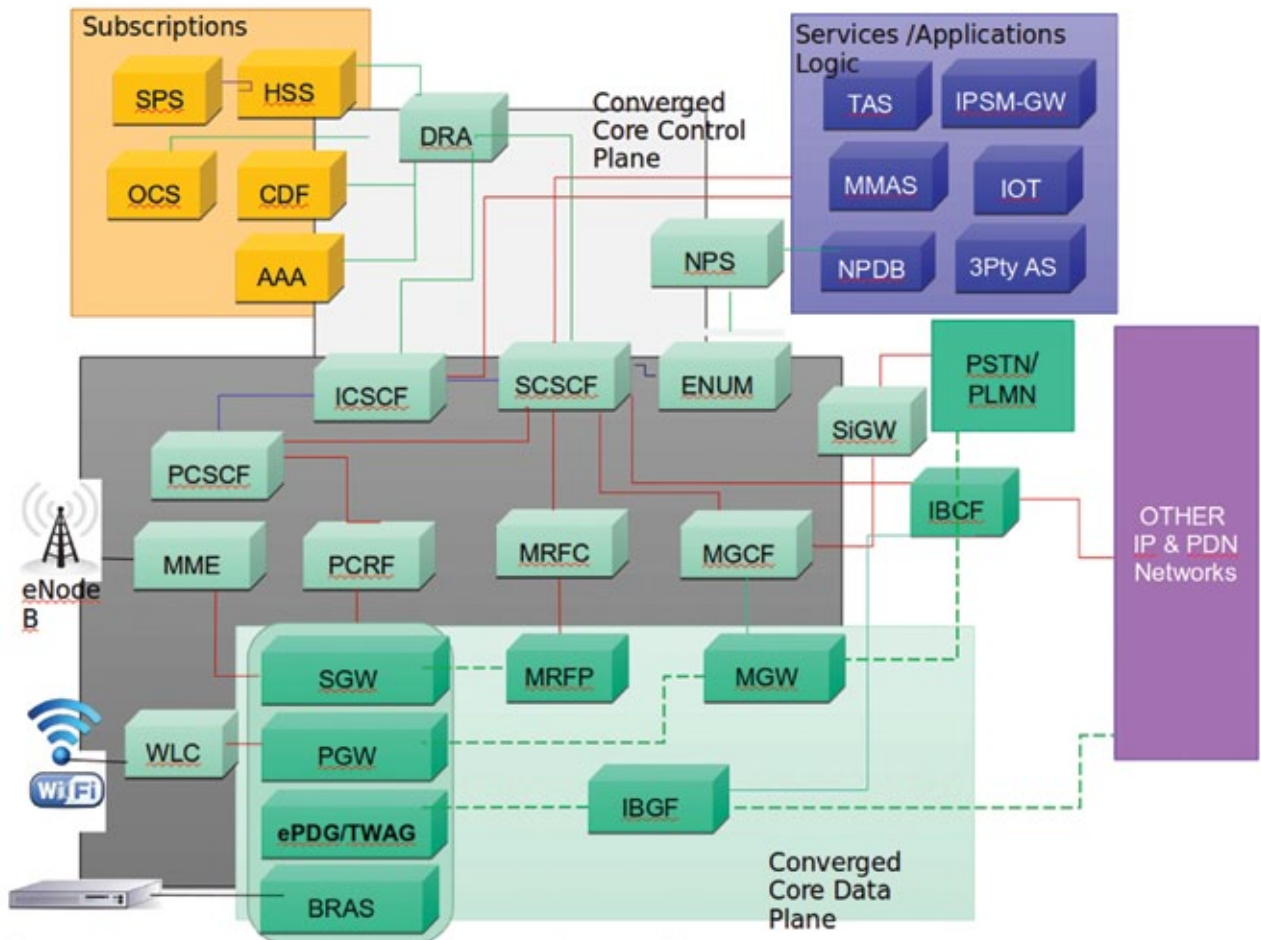
The architecture of the 5G NSA implementation in the C-DOT 4G Core is explained below.

### Architecture of the 5G NSA support as implemented in the C-DOT 4G Solution

C-DOT 4G solution can be effectively used for initial 5G deployments based on 5G NSA.

## C-DOT 4G Core Architecture

### Virtualized 4G Core



For this, C-DOT has implemented the option of splitting the User Plane Traffic from the APN at 5G gNodeB.

As can be seen, 5G gNodeB has only a user plane connection to the EPC Core.

There is no signalling plane connection between the two. All signalling to the UE (whether from the 4G eNodeB or from the 5G eNodeB) flow through the 4G eNodeB only which acts as the master node or signalling anchor to the UE. The UE in turn is required to support dual connectivity to both, the 4G eNodeB as well as the 5G gNodeB.

The 5G gNodeB is required to support dual connectivity to EPC over two separate data paths simultaneously (i.e., over S1-U to EPC as well as over X2-U to 4G gNodeB)

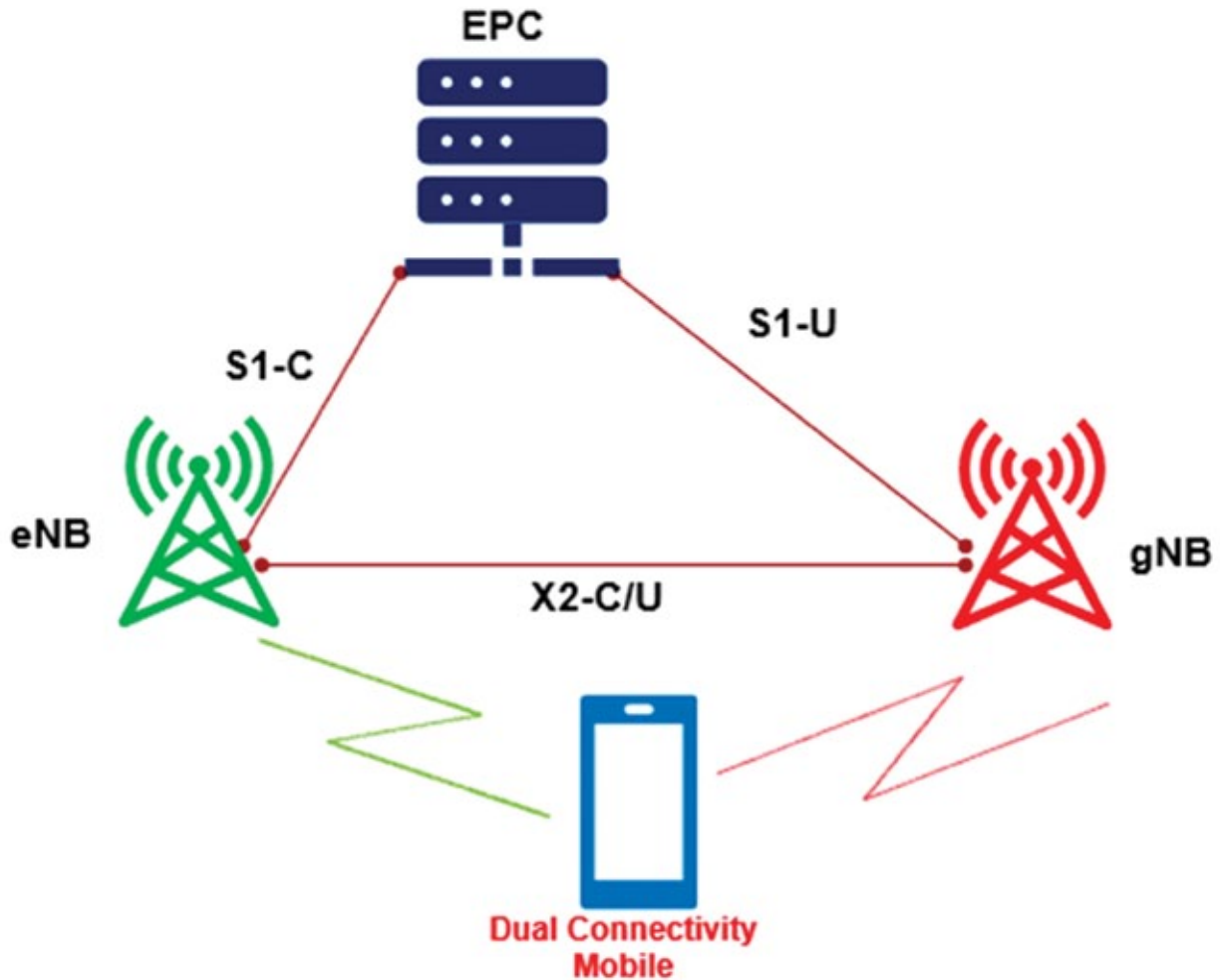
for the reason that in the event the UE goes out of 5G coverage, it will continue to receive services via the X2-U interface, although at lower speeds. The X2-C and X2-U interfaces (defined between two eNodeBs) are suitably modified in 3GPP standards to allow a 4G eNodeB to connect directly to a 5G gNodeB.

#### Benefits of C-DOT's Core solution

- Indigenously designed and developed solution from a trusted source, providing a long-desired boost to the country's critical telecommunications infrastructure.
- Telecom Import dependencies impinge the security of a country as there is always a risk of backdoors and gaps. C-DOT's homegrown solution does away with all such security risks.



# 5G NSA Option 3X



- Import substitution is now available for mass deployed vital telecom network technology acquired previously from foreign sources.
- Availability of locally designed technology will support the country's vision of self-reliant India "Atmanirbhar Bharat" by spurring domestic manufacturing, deployment and employment generation.
- Creation of a platform for the Indian industry to take further innovation in telecom technologies. Indian telecom industry will not only meet demands of the domestic market, but of other markets worldwide as well.
- Reduction in imports and growth in export of indigenously produced telecom gear will contribute favorably to bridging the trade deficit.
- In a country with low mobile tariffs (and consequently low ARPUs for operators), C-DOT's cost optimal 4G Converged Core Network solution will drastically reduce capital investments and operating expenses of the country's telecom network operators.
- C-DOT's 4G Core supports the launch 5G solution during the initial phases of deployment, thus reducing the cost of upgrading the mobile network of the country. 🌟

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# C-DoT's Artificial Intelligence (AI) and Machine Learning (ML) play

Developing a local SESH (sentiment, emotion, sarcasm, hate) for social media and chatbots

BY MEENU GUPTA

In January of 2022, a study published by The Brookings Institution, ranked India among the leaders in the world for both technology & research and funding in areas of Artificial Intelligence (AI) strategy, products and solutions.

According to an IDC forecast the Indian market for AI software, hardware and services, was worth \$3.1 billion in 2020 and would be worth 3 times by 2025.

Leading the research on the domestic development of AI technologies, C-DOT has created world class AI technologies that enhance Indian capabilities in AI products. These are aimed at deployment for businesses use and strategic sectors.

Some of the areas of AI focus for C-DOT are:

- Natural Language Processing
- Computer Vision
- AI enabled Drone Applications
- AI in Telecom Network Management and Security
- AI Application to Future Telecom Network (5G, 6G, M2M, Security)
- AI control systems
- Cyber Security

Artificial Intelligence is not an isolated technology. AI and Cognitive Sciences Initiatives are seen across industries, academia, R&D and application developers. It also has to negotiate the standards, policy and regulatory communities globally. AI promises historic transformations across every walk of life.

C-DOT is working in collaboration with these institutions to arrive at world class AI products. C-DOT is already in collaboration with eminent academic institutions like IIT-Delhi, IIT-Patna etc. and is also planning to engage various startups and vendors to come out with world class and relevant AI products.

In future, majority of products and services in all vertical of life and business, shall have AI embedded in

them. As a result, AI technologies will have impact on all spheres of business and society world-wide. Therefore, it is very crucial to develop homegrown technologies that can compete in the domestic as well as the global markets so as to keep in line with Aatmanirbhar Bharat Mission.

C-DOT has developed algorithms and products in computer vision, image processing, text analytics and augmented reality (AR).

These include face recognition (FR), object detections, person tracking, intrusion detection, mask detection, gesture recognition, queue estimation, scenario summarization and anomaly detection in the area of computer vision.

SESH (sentiment, emotion, sarcasm, hate) for social media and chatbots in the areas of text-based analysis and SLAM based augmented reality for visual positioning system and indoor navigation.

The developed technologies have been embedded in various C-DoT products like

- Face Recognition technology has been incorporated in C-DoT attendance system, C-DOT secured phone, Face verification and matching system for criminals and fake identities, C-DoT Covid compliance system for detecting face mask and social distancing violations during pandemic time.
- Search Star for SESH Analysis (sentiment, emotion, sarcasm, hate) on social media posts. Trend Analysis App to show popular tweets, trend-timeline chart, sentiment, emotion and gender-distribution charts for trending topics on twitter.. Chatbot developed for C-DOT website.
- Wayfinder: With the ever-increasing need for enabling a user's handset with assistive technologies that help

Artificial Intelligence is not an isolated technology. AI and Cognitive Sciences Initiatives are seen across industries, academia, R&D and application developers.

Various AI domain in which C-DOT has a roadmap to research are as follows

Domain	Areas of Research	Products/Applications
Natural Language Processing (NLP)	<ul style="list-style-type: none"> <li>· Text Analytics</li> <li>· NLP Algorithms</li> <li>· Open Source Intelligence</li> <li>· Speech Analytics</li> <li>· Conversational AI</li> <li>· Fake News</li> </ul>	<ul style="list-style-type: none"> <li>· Chatbot Software</li> <li>· Automated Call Centre Software</li> <li>· Virtual Digital Assistants</li> <li>· Language transcriptions</li> <li>· SESH</li> <li>· Digital SpySystem</li> </ul>
Audio and Video Analytics	<ul style="list-style-type: none"> <li>· Image, audio and video processing</li> <li>· Algorithms for detection of Object, Animal, Person, Gesture, Moving Object, Depth Estimation etc.</li> </ul>	<ul style="list-style-type: none"> <li>· Scenario summarization Applications</li> <li>· Surveillance Applications</li> <li>· Compliance Applications</li> </ul>
AR/VR/XR	<ul style="list-style-type: none"> <li>· AR/VR technologies</li> <li>· Glasses</li> <li>· AR headsets</li> </ul>	<ol style="list-style-type: none"> <li>1. 3D Avatars</li> <li>2. Way finder</li> <li>3. Incorporation of AR features in Video conferencing</li> </ol>
AI enabled Drone Application	<ul style="list-style-type: none"> <li>· Victim Identification and Localization</li> <li>· Land mapping</li> </ul>	<ol style="list-style-type: none"> <li>1. Scenario Summarisation</li> <li>2. Computer Vision Applications</li> <li>3. Navigation Support</li> <li>4. Disaster Management</li> </ol>
AI based control systems		<ol style="list-style-type: none"> <li>1. Control of power grid</li> <li>2. Centralised control in various industries</li> </ol>
Network Security	SOAR	

them achieve their objectives efficiently and effectively, C-DOT has come up with a unique solution to help a visitor navigate inside a building. In order to enable a user with this technology, the users are only expected to install an app on their Android or iOS device. We also support a web based clientless solution with limited functionalities. There also exists an Admin Console for the administrator to upload floor plans and create or update routes and POIs.

A detailed list of various comprehensive features of the solution are:

- Highly optimized AI based Visual SLAM (Simultaneous Localization and Mapping) technology to run on user's hand held device
- Enhanced user experience through AR (Augmented Reality)
- No data pushed out from a User's device
- Real time routing provisions to regulate access to various areas within the premises
- Real time updating of functional elevators, staircase, escalators, passages etc.

- Efficient algorithms for crowd management using AI enabled dynamic routing
- App usage is secured by efficient geofencing based algorithms
- Disabled Friendly with support for Talk-Back for visually impaired
- Supports multiple indoor positioning algorithms using QR codes, BLE Beacons, Pinning on Map and Visual Positioning System
  - Virtual background, Background Blur and background noise reduction in CDOTMEET (CDOT video conferencing system)
- Intrusion detection and instant alarm through C-DoT Samvad chat and calling system .

C-DoT has trained and perfected its models with required domain data, e.g. for Indian scenarios, strategic domains and provides a very high level of accuracy as compared to other products available in market. 🙌

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# C-DOT's Collaborative Research Program 2022 (CCRP-2022)

Working with industry, start-ups and academia to bring greater levels of research and innovation into the country

BY GAGANDEEP ASIWAL

## **C**urrent Telecom Scenario.

The telecom industry is at the center of digital transformations across industries. Fueled by disruptive technologies like artificial intelligence, robotics, machine learning, advanced wireless communication, cloud and quantum computing, the sector is set to witness further rapid growth.

This sector will play a role as an enabler supporting other critical infrastructure and be pivotal for industries like health, education, power, agriculture, human capital development, governance.

Presently, almost 85 percent of the country's demand for telecom equipment is met through imports.

It is to reduce this dependency that the government of India has undertaken multiple initiatives and policy measures – example changing the import duty structure of telecom equipment, policies like Make in India, production linked incentives (PLI) and Design linked incentives (DLI). All of these will encourage a stronger telecom manufacturing and Research eco-system for nurturing innovation in the country and contribute to sustainable economic growth.

Aligning to the goal of Atmanirbhar Bharat (Self Reliant India), Union Budget 2022-23 has also announced allocation of five per cent of annual collections under the Universal Service Obligation Fund, for carrying out R&D to develop relevant products and solutions to enable development and proliferation of next generation telecom technologies in urban as well as rural and remote areas and promote indigenous manufacturing and R&D.

## **C-DOT and its Collaborative Research Program 2022 (CCRP-2022)**

C-DOT has more than three decades of R&D experience in the indigenous design, development and production

of telecom technologies especially suited to the Indian landscape.

It has been at the technology forefront and has significantly contributed to the digitization of the Indian Telecom Network. As part of its development process, C-DOT positioned a wide base of equipment manufacturers and component vendors for the Indian industry.

A well-researched methodology blended with newer technologies, would fill the Research and Development gaps in the country, and give an impetus to IPR generation contributing to telecom standards. It would open up export opportunities.

Thus, to meet the CDOT vision 2047 'to be a global player' in telecom technology development, apart from fulfilling strategic and rural telecom needs of the country, C-DOT is re-inventing its strategy by opening multiple channels of collaboration with Indian industry partners, academia, startups, MSMEs etc. for collaborative Research and Development of commercial grade indigenous telecom products.

Such collaboration will not only fill the research and development gaps in the country but also give an impetus to IPR generation and contribution to telecom standards, as well as open up export opportunities. It will also leverage the strengths and expertise of each party for developing telecom solutions that will reduce time to market.

The C-DOT Collaborative Research Program 2022 (CCRP-2022) initiative opens up collaboration with industry for joint R&D.

CCRP-2022 will act as a catalyst in creating an enabling environment for innovators and startups to flourish with

To meet the CDOT vision 2047 'to be a global player' in telecom technology development, and fulfilling strategic and rural telecom needs of the country, CDOT is re-inventing itself by opening multiple channels of collaboration with Indian industry partners, academia, startups, MSMEs.

C-DOT. The main role of C-DOT will be of a facilitator in development of products and solutions.

Through CCRP, C-DOT will co-create Indigenous products/solutions in ICT area through collaboration. C-DOT will provide funding for telecom product development programs and handhold startups to scale up their innovation together with C-DOT partnership.

A recent example of such collaboration is the successful POC trial of C-DOT's indigenous 4G solution in partnership with TCS and Tejas Networks in the BSNL network, that resulted in a commercial order.

CCRP will:

- **Facilitate rapid development of indigenous and innovative telecom technologies** for telecom needs of India in Strategic, Rural and Sectors of national importance with shorter timelines
- **Create a culture of synergetic innovation** with industry players, Academia, research institutions and startups, to encourage co-creation of technology development in ICT areas.
- **Empower a culture of technology co-creation and co-innovation** within the Indian telecom sectors that will have potential impact in increasing local manufacturing, value addition, capacity building and strengthening of the Indian telecom industry.

Through CCRP, C-DOT will invite applications in various technology areas such as Wireless mobile services (5G, 6G), Advanced optical (Transport and Access) technology, Quantum communications, telecom Security, Data Analytics, Artificial Intelligence, Machine learning, Wi-Fi, IoT & M2M, Intelligent and self-correcting networks, advanced switching and routing solutions etc.

These proposals can be at an ideation stage, or at advanced stage of product development life cycle. The proposals, after due diligence will be referred to Selection Committees for technical evaluations and conformities to RFPs etc. On approval of proposals, C-DOT will provide

due assistance in form of providing infrastructure & resources used for development, Tools-Testers, technical mentorship, financial assistance.

Funding and Revenue sharing will be done on FRAND (Fair, Reasonable, and Non-Discriminatory) terms to C-DOT and the proposal partners.

### Collaboration Areas under CCRP-2022

Collaborations with C-DOT under CCRP can be done through four major collaboration programs:

- 1) **5G development under C-DOT 'India 5G Alliance'** - 'India 5G Alliance', with C-DOT as facilitator, will undertake research programs in 5G under guidance from DOT. The purpose of this alliance is to facilitate design and development of indigenous 5G products through collaboration among various Indian companies and academic institutions that are working on 5G technologies. There are ten consortia under the alliance, each focusing on a particular key technology area in 5G.
- 2) **IoT & oneM2M development under Centre of Innovation (COI)** - The main objective of this center is to provide a platform for development of oneM2M standards compliant IoT/M2M solutions. This center will create an ecosystem of indigenous solution developers and will provide them an easy-to-use facility for testing the solutions developed by them and help making these solutions oneM2M compliant. C-DOT will make available its state-of-the-art IoT/M2M common service platform for integration, interoperability testing and conformance to global standards.
- 3) **Collaboration in telecom technologies (other than 5G/6G/IoT) under C-DOT research program** - Joint design and development of indigenous telecom solutions in key areas of telecom technology such as quantum communication, optical technologies, Wi-Fi, Routers, switches, applications, Telecom Security etc.

A recent example of such collaboration is the successful POC trial of C-DOT's indigenous 4G solution in partnership with TCS and Tejas Networks in the BSNL network.

**4) Entrepreneurship Cell at C-DOT Delhi and Bengaluru (for early-stage Startups)** - C-DOT is setting up incubation centers at C-DOT Delhi and Bangalore with an aim to build a strong ecosystem for promoting innovation through early-stage startups in key technology focus areas. C-DOT will provide necessary support including funding for promoting innovations and entrepreneurship.

C-DOT will also fund research scholars from IITs/ NITs working in the area of telecom and security. One scholarship each will be sanctioned to the selected institutes.

**Roles, Responsibilities and Functions of C-DOT in CCRP**

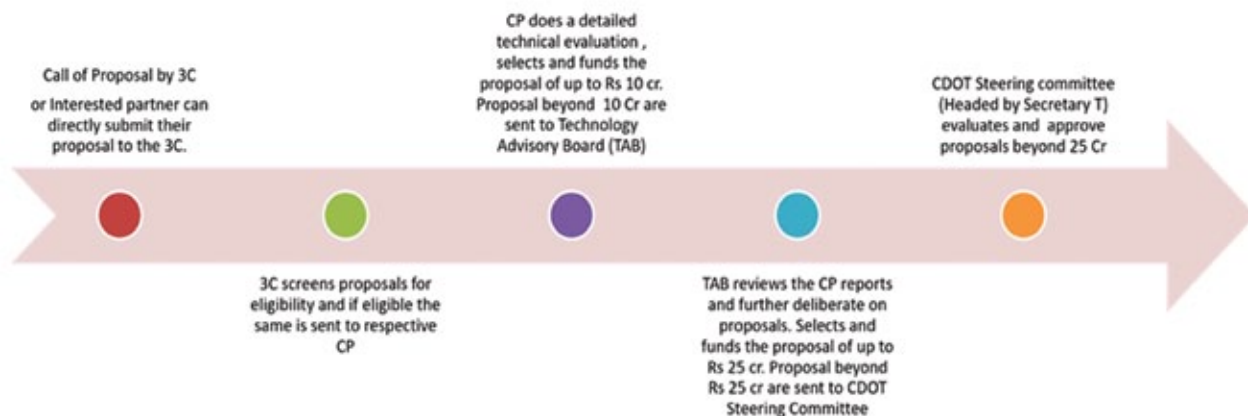
1. Inviting proposals from the industry, academia, startups etc. in different technology areas
2. Evaluation of proposal and upon approval: signing the agreement, finalization of milestones, defining clear milestones/targets that are easy to track, framing a budget and payment schedule
3. Periodic monitoring of the progress and review of project milestones collecting predefined periodic reports and utilization certificates in the prescribed format
5. Reviewing the technical and financial progress of the agreement and fund disbursement to the participating partner against the milestones or as per the technology readiness Level (TRL)

6. Facilitation in terms of technical support, testing, integration, field trial, Proof of Concept etc.
7. Specialized mentorship from C-DOT and other associated partners from Industries/ research institutes/ Govt. organizations for project-oriented consultation/ technology and business development issues.

**Broadly, the collaboration process is as follows:**

1. Both top-down and bottom-up approaches will be adopted. Projects of interest to national needs are put up by C-DOT on its website as call for proposal where universities / research institutions / industry / startups etc. can participate. In the bottom-up approach, any university / research institution / industry / startup etc., based on its current research activities and capability in the field of telecom and security, can also propose to undertake research activities which are of significant importance in the development of current or future technologies.
2. 3C (C-DOT collaboration Cell ) will check proposal for preliminary eligibility. Post successful checks the 3C will forward applications and the relevant documents to the concerned Consortium Panel (CP) for detailed technical evaluation of the proposals.
3. For proposals which need funding value beyond the powers of CP, the application will be forwarded to Technology Advisory Board (TAB) along with

## Broad Engagement Process through CCRP



3C (C-DOT collaboration Cell ) will check proposal for preliminary eligibility. Post successful checks the 3C will forward applications and the relevant documents to the concerned Consortium Panel (CP) for detailed technical evaluation of the proposals.

recommendations of CP. TAB will review the detailed evaluation report submitted by the panel and will further deliberate on proposal.

4. For proposal beyond the powers defined for TAB, the C-DOT Steering committee will discuss the TAB recommendations and consider the proposal for approval or otherwise.
5. Subsequent to the review and selection of the proposals as per this policy, 3C shall send a Letter of Approval (LOA) along with the agreement mentioning the terms and conditions of the collaboration, agreed milestones plan, fund disbursement plan, IPR sharing, etc. to the respective organization.

#### 6. Broad Evaluation Criteria of the proposals

Breakthrough potential	IP Potential
Technology Future	Financial Risk
Import Substitution Potential	Scalability of the Solution
Innovative Approach	Adherence to standards
Value Addition to existing products/technologies	Market Focus- Time to market and commercial viability.
Indigenous Content	Relevance of the application area

#### Funding Models

Research and product development may require financial support in the form of funding from C-DOT. The partners can submit information on quantum of funds required and the choice of funding method (equity, loan, grant). However, the model and payments terms of funding of proposals may vary on a case-to-case basis.

3C will periodically monitor the progress of collaborative projects through a PMU established for this purpose. The progress will be gauged on the agreed detailed monthly or quarterly plan of the expected milestones/activities. Fund disbursement will be based on milestones achieved measured in terms of TRL level.

Major Funding models are :

Funding Model	Description
Equity	Funding in this case will be treated as an investment in the venture (investment into technology) in the form of agreed equity in the participating company.
Soft Loan	C-DOT can provide funding to applicant or joint partners as soft loans. A nominal percentage of simple interest will be levied.
Grants	On the basis of merits of the proposal that are of national and strategic importance, C-DOT will provide funds to the partner as a grant. Any foreground technology developed and required for realization of the product will be shared on FRAND (fair, reasonable, and non-discriminatory) terms to all participating partners and the Indian eco-system.
Funding on Revenue sharing Model	In this model C-DOT will fund joint research programs and revenue generated through licensing and royalty from the product through Transfer of technology (TOT) will be shared among participating partners who contribute to the product. Revenue sharing will be decided on the basis of contribution from each participating partner as per the agreement.

#### IPR and Revenue Sharing

C-DOT will follow a very liberalized policy of IPR and revenue sharing primarily on FRAND ( fair, reasonable, and non-discriminatory) terms protecting interests of the collaborating partner(s) and C-DOT. C-DOT will protect its and the interest of its partners in terms of revenue and IPR sharing of the successful outcomes of the collaboration. The IPR and revenue sharing will vary from case to case basis depending on the model, quantum of funding etc. More details of the program are available on website C-DOT's website, [www.cdote.in](http://www.cdote.in), or any queries related to the proposals can be mailed at [ccrp@cdote.in](mailto:ccrp@cdote.in).

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# C-DoT's DWDM Transport solution — C-TERA- a necessity for our growing data demand

It is an enabler to bolster future needs of Transport Platform of the Nation addressing ever-growing demands of very high speed Data amidst tough climatic conditions and above all with a promise of quantum safe security



BY ASHOK GUPTA

**T**he ambitious Bharat Net, a flagship program of Government of India has endeavored to bridge the increasing digital divide between Urban and Rural India. This mission has been steered as an enabler towards digital inclusion as per the vision of Digital India program. 4G/5G and impending 6G networks have further triggered massive data consumption and proliferation of digital services making heavy implementations of technologies like Dense Wavelength Division Multiplexing DWDM an imperative.

The tsunami of data due to the popularity of the Internet has led to a paradigm shift in the telecommunication industry from voice-optimized circuit-switched services to data-optimized packet-switched services.

Transporting mammoth quantities of data reliably, at low cost, over very long distances require tough challenges to be met. Fiber cables that support unlimited bandwidth are the obvious choice for this, where the

C-DOT's home grown transport solution has been architected such that the operations may be planned and routine-handled without employing deep-skillset resources.

Data (digits) is converted to optical signals and pushed at high speed into these cables.

### DWDM

Optical transmission supports very high speeds. And it also allows simultaneous streams of data to run concurrently in the same fiber cable – using different colors. This is possible using the technique of Dense Wavelength Division Multiplexing (DWDM) technique, that allows the same optical fiber infrastructure to be augmented with multiple wavelengths.

Transporting very large volumes of data comes with a set of challenges in operations, administration and maintenance (OAM). It adds complexity to seamless interoperability between different operators and carriers, handling of route failures without disruption or service outage and above all maintaining the security of the payload (data) being transported.

Transport as a service (TaaS) needs to handle various kinds of data (typically called “clients”) to be transported,

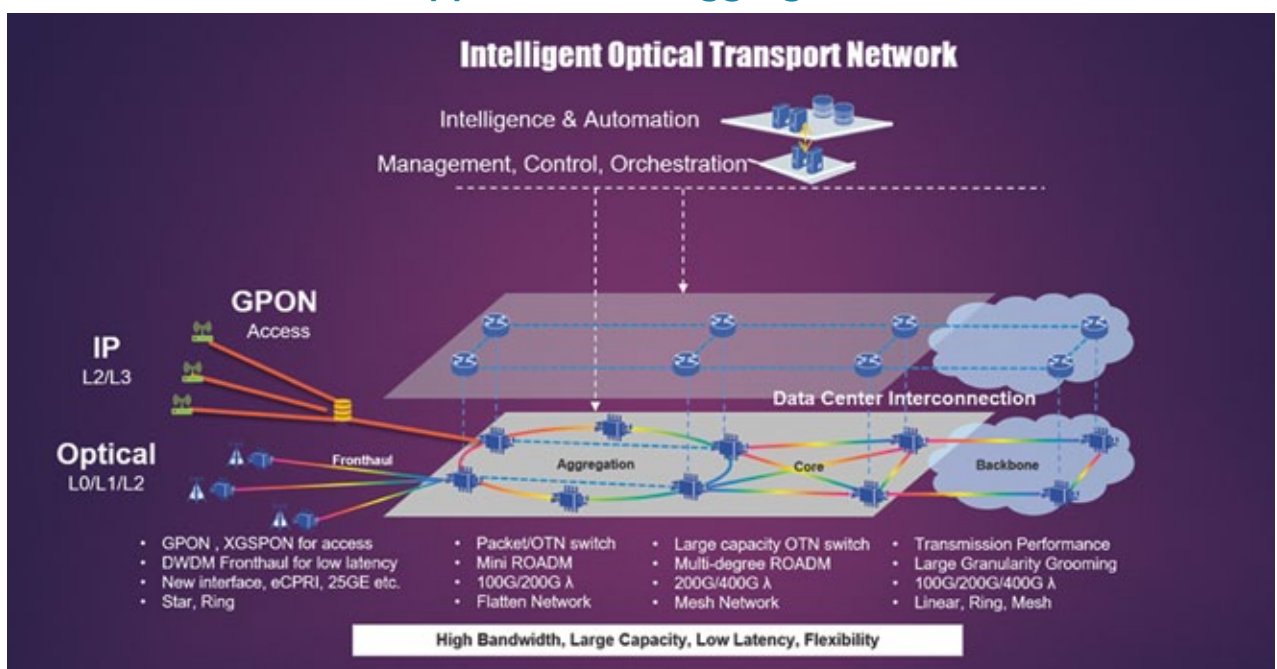
and each type may have different service level constraints. Clients may have different data-rates, size, and other attributes like latency and reliability constraints. The data volume need not be static in nature and may vary dynamically.

In order to cater to the above, OTN (Optical Transport Network) as a protocol has been standardized as a data wrapper enabling any-client protocol to be carried transparently within an OTN container without impacting the payload and the underlying service in a deterministic manner and without modifying its native characteristic, structure, timing and management information.

OTN provides an efficient and transparent way to transport, switch, multiplex and groom different Client services onto high-capacity wavelengths across the optical network with Forward Error Correction (FEC) for extended reach.

OTN is mainly known for its enhanced data-multiplexing capabilities which allows different traffic-

## DWDM and OTN applications in aggregation, metro and core



EDFAs (Erbium Doped Fiber Amplifiers) and alike amplification techniques allows bulk signal amplification within the optical domain. This is a leap ahead of the legacy approach – where signals were first converted to electrical, reconstructed and then all the individual signals were reconverted to optical. This has further fuelled DWDM acceptance in the network

types like Ethernet, SONET/SDH, OTU, fiber channel etc, to be packed in OTN container. The technology offers 6 levels of Tandem Connection Monitoring (TCM) for enabling efficient OAM and dynamic bandwidth allocation on demand across as many boundaries of different service operators. This is also a key reason for adoption of OTN as a favored mechanism for Optical Network Technologies.

DWDM technology is also a prudent choice for front-haul transport application to address various 5G distributed RAN use cases like Centralized Unit (CU) and Distributed Unit (DU). This technology enables transport of fundamental 5G use cases like uRLLC, eMBB and mMTC communication. This would enable delivery of high bandwidth and low latency services like E -Health, E-education, Smart Farming etc.

In line with the Prime Minister’s vision of Aatma-Nirbhar Bharat, C-DOT has developed state of the art 96-channels DWDM with each channel supporting 10G /

100G / 200G per wavelength to augment metro and core network applications. Undoubtedly, a robust and secure transport system is a necessity for national self-reliance.

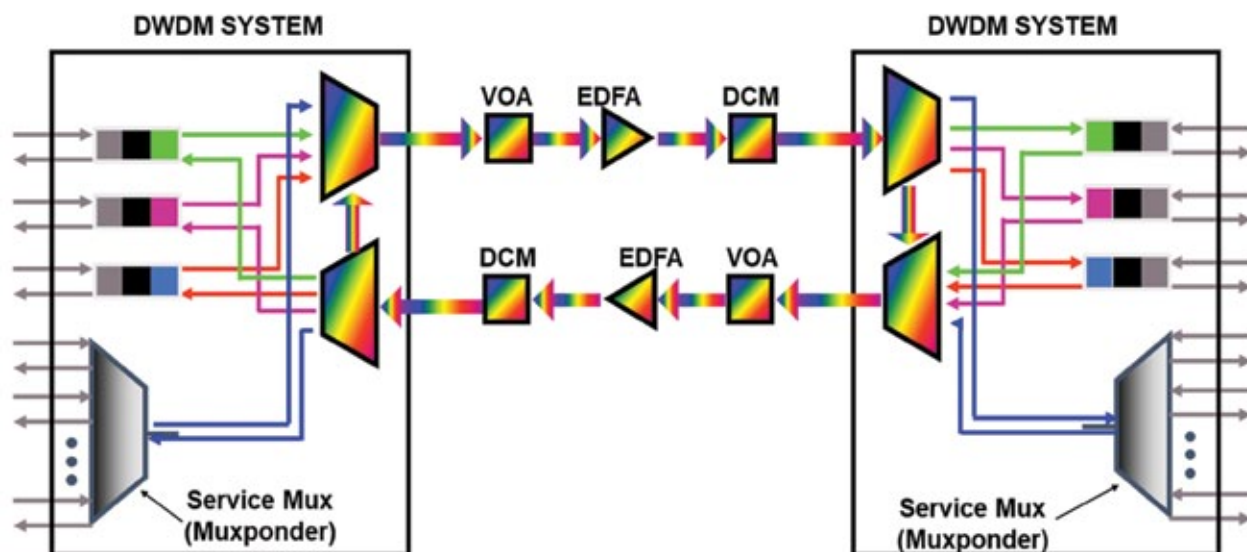
The technology is ruggedized to operate in harsh Indian environments with high reliability. The technology is architected in a way that it is modular, easy to operate and scalable as a true pay as you grow model to help operators manage their CAPEX.

### C-TERA – A Transport Wizard

C-TERA© in its offering has all the subunits like TEs (Terminal Equipment), ILA (Inline Amplifier), 3R Optical Regenerators (OEO converter) and OADMs (Optical Add/Drop Multiplexers), to cater to various field deployment scenarios in different Network Topologies. Example, Point to Point, Ring (Hub-End and Closed) and Mesh Architecture.

OADMs are categorized on the basis of Wavelength reusability, path direction and grid flexibility. These

## Typical dwdm link diagram



are termed as Broadcast and select (B&S), Colorless and Directionless (CD) and Colorless, Directionless and Contentionless (CDC) and Colorless, Directionless, Contentionless and flex-grid aka CDC-F. With all these options networks deployments can be planned for hitless (handling disruptions/changes in the network without hitting the traffic services ) upgrades.

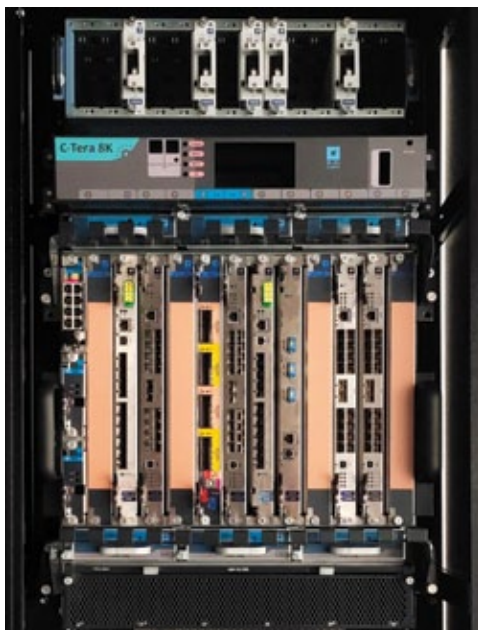
The network can be designed with or without OTN Switching. In case of no OTN Switching, it is a Muxponder/Transponder based solution with underlying optical layer which is best suited for predictable point-to-point cost optimized static connectivity. With OTN Switching, it is a central fabric-based switching solution which is best suited for architectures requiring any-to-any connectivity and flexibility, with the ability to adapt to changing traffic patterns.

Thus, OTN switching provides an alternative to the transponder and Muxponder approach providing efficient bandwidth utilization by way of grooming and consolidation of client traffic. CDOT has in its portfolio roadmap of delivering 8Tbps cascadable to support up to 16Tbps of Cross-connect capacity.

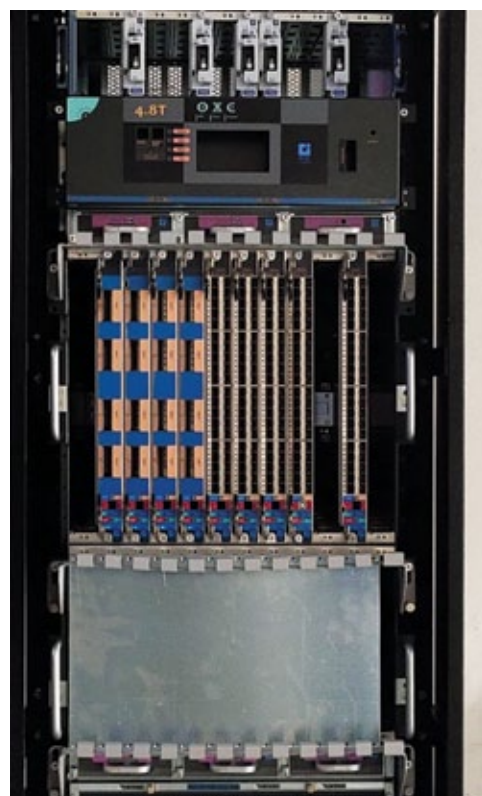
CDOT's technology supports non-coherent 10G Line services to co-exist with 100G/200G coherent technology. It is enabled by advanced adaptive dispersion compensation techniques as per links constraint. Clients of various types and data-rates are mapped into standard line rates of 10G/100G/200G via OTU2/OTU4/OTUC2 containers respectively.

For resilience against network faults, C-TERA© supports Various types of protection mechanisms to counter unforeseen network disruptions such as: Platinum Service (Permanent 1+1 path protection + GMPLS based restoration meaning there is a redundancy and a restoration facility built in), Gold Service (Permanent 1+1 path protection – with failover path / redundancy only), Silver Service (GMPLS based restoration only) and Bronze Service (No protection mechanism or failover provision)

C-DOT's home grown transport solution has been architected such that the operations may be planned and routine-handled without employing deep-skillset resources. The C-TERA© system empowered with Network planning tool (NPT), Software defined



**C-TERA 96s**



**C-TERA OTN DXC**



Transport as a service (TaaS) needs to handle various kinds of data (typically called “clients”) to be transported, and each type may have different service level constraints. Clients may have different data-rates, size, and other attributes like latency and reliability constraints. The data volume need not be static in nature and may vary dynamically.

networking and GMPLS enabling gives unique differentiated services to the service-provider. The Network Planning tool facilitates network operators to plan, deploy and automate network operations with GMPLS / ASON control plane.

The goal of the tool is to maximize both the quality of experience and optimization of the network resources.

NPT provides map view of the network topology, demand-aggregation, capacity-planning, fault analysis, customized report, chassis view, cabling diagram, inventory management, BOM generation, support of Traffic engineering and Restoration.

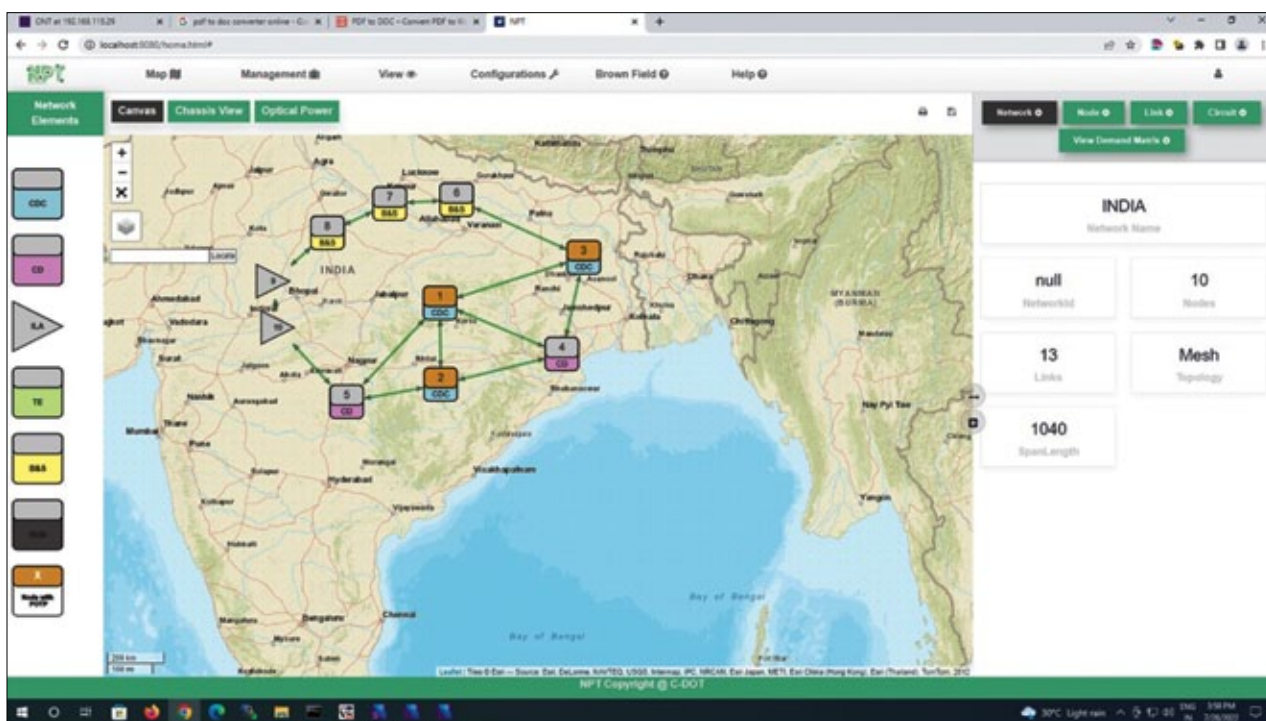
To eliminate tedious management activity and to automate the network configuration using Software

applications, the concept of Software Defined Networking (SDN) is introduced. SDN facilitates separation of control plane and data plane from the hardware. SDN places the control plane at the centralized controller and can orchestrate the Network Elements through a centralized control.

By enabling SDN we have achieved automation of the multilayer network provisioning and vendor neutrality, using orchestrator function over T-SDN. This lowers OPEX and CAPEX, enables swift service roll-outs and enables innovative third party application development on standard interface of the controller.

As network bandwidth grows, all layers of the network need to be intelligent and adaptable to manage traffic. Zero touch provisioning to ensure the network is up and

## C-DOT NPT graphical user interface



Transporting very large volumes of data comes with its own sets of challenges in operations, administration and maintenance (OAM). It adds complexity to seamless interoperability between different operators and carriers, handling of route failures without disruption or service outage and above all maintaining the security of the payload (data) being transported.

running with minimal operator supervision is the way forward. For end-to-end service configuration, Automatic bandwidth restoration, fast efficient re-routing, dynamic connection set up and tear-down is possible with the help of GMPLS. GMPLS enables users to dynamically and automatically allocate the resources and create end to end services. Thus C-TERA© is able to support the evolution of traditional network to an ASON capable network and complies with the ITU ASON standards.

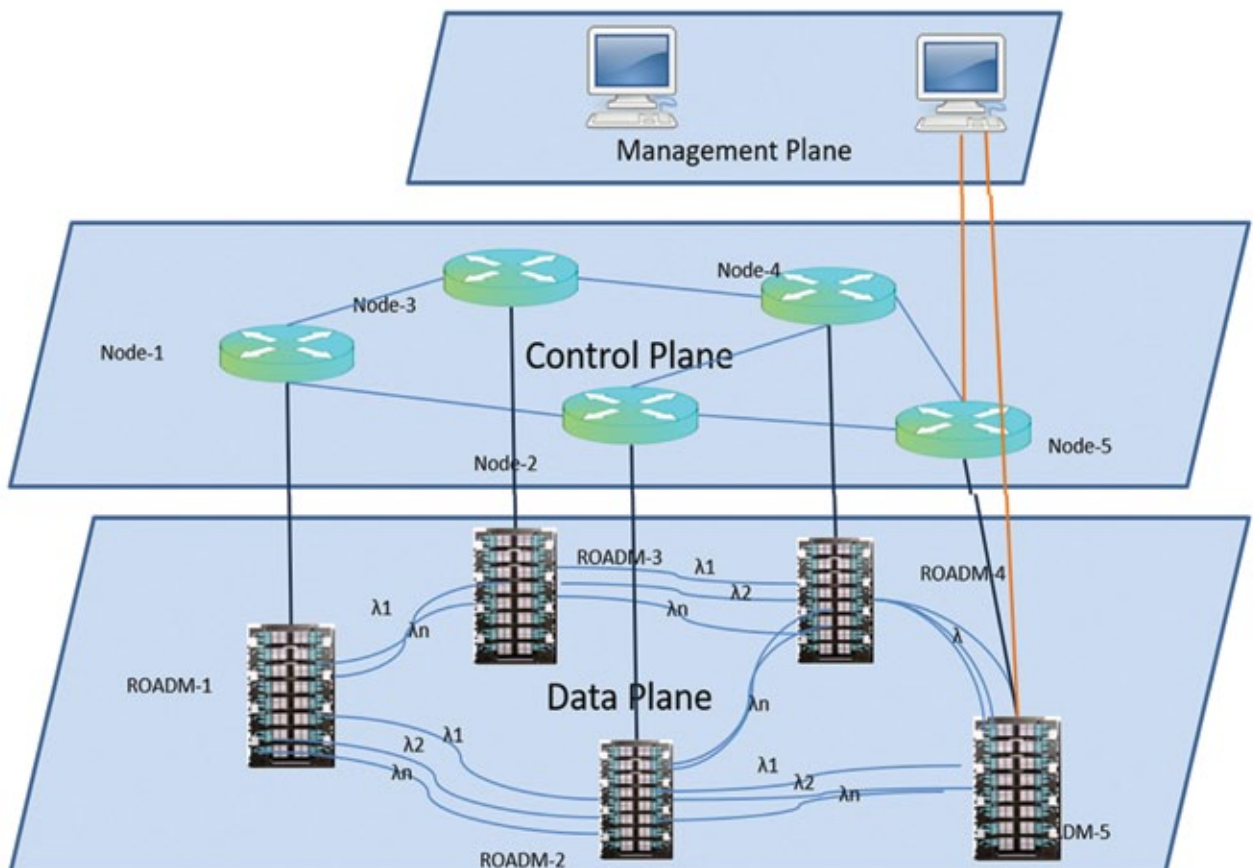
For remote management of DWDM Network and Network elements with ease, C-TERA is facilitated by

Management System (EMS / NMS). EMS/NMS allows user Authentication, Service-configuration, monitoring and reporting of Fault and Performance parameters. For local management of node Local craft terminal is provided.

The bouquet of C-TERA will remain incomplete without a discussion around data security.

The C-DOT product line is designed to support state of the art "in-flight" (that is, encrypting data on the fly without affecting its latency) AES256 encryption both at the client and the line end with traditional key generation

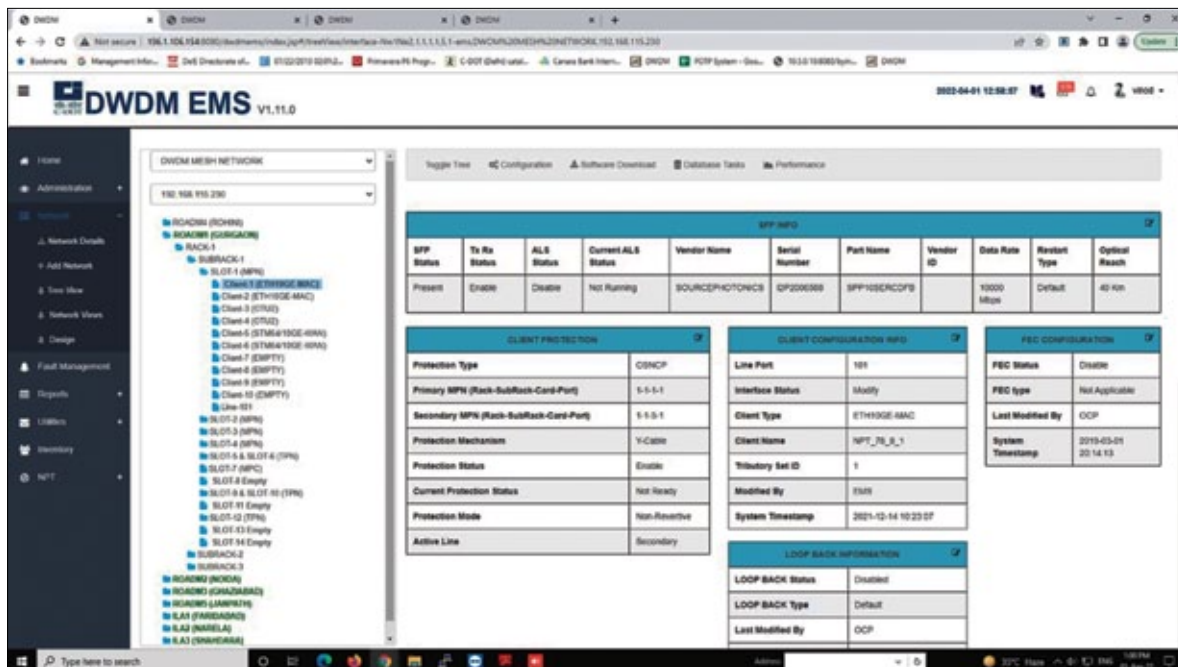
## Overview - ASON control plane



## C-TERA local craft terminal



## C-TERA element management system



methods like RSA and Elliptic Curve. This ensures no disruption while delivering high security.

However, with the impending arrival of quantum computers on the horizon, the level of security threats on the country's transport networks are likely to increase in complexity and severity.

It is here that C-DOT's C-TERA Qsafe® product line will come as a saviour. It is designed to combat

security threats posed by attacks implemented with Quantum safe methodologies. Qsafe uses optics based Quantum Key Distribution (QKD) and Code / Lattice based PQC algorithms. (see QKD story in this issue).

Ashok Gupta Group Head Optical Core Network  
 With contributions from: Guptaeswar Majhi,  
 Digamber Yadav, Sanjay Verma, Kashish Anand  
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## 5G WILL DISRUPT THE TRADITIONAL DIGITAL MOBILE MARKETS AND APPLICATIONS ACROSS SECTORS

Voice&Data is organising its 4th edition 5G conference under the flagship brand Telecom Leadership Forum. At this conference, policy makers, telecom ecosystem, technology companies, enterprise Users will meet and discuss on the latest challenges faced in the 5G deployments.

### KEY CONFERENCE HIGHLIGHTS



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LIVE SOCIAL FEEDS

TECHNOLOGY SHOWCASE

FIRE SIDE CHATS

### KEY DISCUSSION POINTS



5G, POLICY & REGULATIONS

5G STANDARDS

5G ROLL OUT

NETWORK PLANNING, OPEN RAN

5G FOR PRIVATE NETWORKS

SKILLING FOR 5G

5G INNOVATIONS FOR INDIGENOUS NETWORKS

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## HISTORY - C-DOT – The early days

CDoT came into existence with the mission to change the telecom landscape of the country through indigenously designed and developed technologies



BY RAVINDER AMBARDAR

**T**he eventful journey of the Centre for Development of Telematics (C-DOT), the premier Telecom R&D centre of the Government of India dates back to 25th August, 1984 when India was heavily reliant on imported Telecom technologies and equipment that could not meet the specific requirements of our villages which have been longing to hear the magical dial tone that could bridge the yawning gap between rural and urban landscapes.

The very idea of deploying telephone exchanges in the remote and inhospitable villages of India was far from reality. Not only did it seem impossible to realize this dream with the available infrastructure, manpower and technology solutions, it was financially non-viable given the exorbitant costs of the foreign equipment and their maintenance for smooth operation in extreme weather conditions.

C-DOT has been in the forefront of Telecom technology and innovation with its diverse product portfolio that has accelerated the digitalization of “New India” as envisaged by Shri Narendra Modi, Hon’ble Prime Minister of India.

C-DOT’s home-grown technologies have been instrumental in achieving digital literacy and digital empowerment owing to their easy adaptation for all sections of the society including illiterates and semi-literates.

C-DOT's indigenous Gigabit Passive Optical Network (GPON) technology is fueling the backbone of BharatNet, nationwide optical fiber network that aims to extend high speed connectivity to even the most inaccessible and inhospitable parts of India.

Today, when almost every Indian has access to a mobile phone powered by Internet, it seems quite unimaginable that people in India had to wait for three to four years in early eighties to get a telephone connection that too with great difficulty and influential contacts.

The lack of adequate connectivity and requisite Telecom infrastructure poorly impacted the global status of India as a preferred destination for international business and foreign investments. Newspapers were abuzz with headlines indicating the rapid shifting of business to other Asian countries due to non-availability of Telephone connections and leased lines.

India has been a pool of great talent producing top-notch academicians, scientists, doctors, artists and engineers who have made the entire nation proud with their unique innovations and targeted solutions that have benefitted the society at large across the globe. In continuation of this civilizational trend, Sam Pitroda, GB Meemamsi, DR Mahajan and MV Pitke laid the foundation of an ambitious project under the guidance and support from Shri Rajiv Gandhi, the then Prime Minister of India,

to illuminate our country on the global connectivity grid at a time when we unfortunately had a negative distinction for being one of the countries with a very low tele-density i.e. number of telephones per hundred people.

This was how C-DOT came into existence to fulfil the prestigious mission of reviving the connectivity landscape of the country with indigenously designed, developed and manufactured technologies. C-DOT embraced the revolutionary idea of conducting targeted R&D to achieve the desired output in a defined time-frame and result-oriented framework. It was the need of the hour to debunk the myth that the projects undertaken in India could never be completed in a timely manner owing to poor planning, non-availability of resources and other underlying issues & challenges. The founders of C-DOT were cognizant of the general temperament of people towards local industry and domestic capabilities. They took this challenge as an opportunity to restore the confidence and trust of Indians into Swadeshi i.e. home-grown. They wanted to prove that Indian workforce is well-equipped to execute complex technological projects



The team that brought the indigenous Demonstration of C-DOT Exchange at Bengaluru Telecom revolution

## [COVER STORY]

### HISTORY

The successful Proof of Concept (PoC) of the end-to-end indigenous 4G system that is powered by a 4G Core developed by C-DOT, Radio Access Network (RAN) from Tejas Networks led by TCS in consortium mode is a manifestation of the growing synergy between R&D and industry.

suited to diverse geographies and varied requirements of the country.

There was a saying that was very popular in the initial years after inception of C-DOT that C-DOT has been given the target of producing a state-of-the-art indigenous Telephone exchange/switch in 36 months with a fund of Rs 36 Crores. Sam Pitroda was very particular towards demonstrating the might of local R&D institutions in producing the world-class technologies within a specified timeframe provided they are given the opportunity, freedom, resources and autonomy at par with the global R&D technology houses.

The then Government extended all possible support and resources for setting up this R&D centre of Telematics or C-DOT. The Government gave this onerous task to the youth brigade of assiduous, inquisitive and creative engineers who were keen on unleashing their knowledge and skill to build indigenous Telecom technologies for connecting every nook and corner of our great nation.

The establishment of C-DOT as a Telecom R&D centre was indeed a herculean task. Given the constricted timelines for desired output, C-DOT did not wait for a new campus to be constructed afresh and rather started

functioning at Akbar Hotel in Chanakyapuri, Delhi.

This was a commendable initiative on part of C-DOT's founders as it saved a lot of time that could have gone into establishment of a permanent building. The highest priority was accorded to the accomplishment of the ambitious milestone of having a home-grown exchange that could propel the telephony engines across the length and breadth of the country.

The very idea of starting C-DOT from a five-star hotel was also criticized in the government quarters as there was a great deal of skepticism about the performance of C-DOT given the organizational workforce comprising of NRIs and young professionals who were thought to have joined C-DOT to just enjoy the five-star luxury and emerging MNC-like climate.

Since C-DOT was receiving grants from the Government to execute its projects, there were huge expectations from C-DOT in terms of financial gains and other advantages resulting from its indigenous technology endeavours. The senior officers in the Ministry were eagerly waiting for the visible results.

The founders were mindful of the consequences that would dent the confidence and image of all stakeholders if



Glimpse of Event marking completion of C-DOT Telephone Exchange 36 months of C-DOT





Sam Pitroda, GB Meemamsi, DR Mahajan and MV Pitke laid the foundation of an ambitious project to illuminate our country on the global connectivity grid at a time when we unfortunately had a negative distinction for being one of the countries with a very low tele-density i.e. number of telephones per hundred people.

they failed to deliver. They made sure that the workforce stays motivated to achieve its goals and successfully created a flexible work environment that was conducive to working late hours. The level of energy and enthusiasm was so high that engineers did not care about visiting their homes and worked day and night to fulfil their dream. The facilities including food and transport were made available to the engineers at any time. It was truly an ideal atmosphere replete with research-oriented outlook and relentless determination towards a focused mission.

Finally, the firm resolve and tireless efforts of C-DOT engineers fructified into a Rural Automated Exchange (RAX) that triggered the indigenous Telecom revolution in the country. The country's first indigenously developed digital rural electronic exchange (RAX) of 128 lines capacity was installed at Kittur in Karnataka on 22nd July 1986. This powerful innovation drastically transformed the proliferation of telephony across rural and urban areas. C-DOT was able to engineer this exchange at approximately one tenth of the cost that could have been incurred for production outside India.

A MoU was also signed with ITI for setting up model production plant for C-DOT switches. The Transfer of Technology (ToT) agreements were also inked with eight local manufacturers. C-DOT also adapted its indigenous technologies for deployment in other countries including Vietnam, Egypt, Iran and Bhutan.

There may not be a yardstick to statistically measure the financial gains and the advantages that accrued to India from the indigenously designed and developed C-DOT RAX. In comparison with the prices quoted by MNCs for telephone exchanges in those days, the savings that resulted from C-DOT RAX can be pegged to the tune of more than Rs. 10,000 Crores. Additionally, this led to the creation of a knowledge economy fueled by the skilled human capital that could have been worth a few billion dollars.

India scripted history in the area of Telecom with C-DOT's indigenous technological innovations. This revolution started with the RAX and continued to gain momentum with many more indigenous Telecom products and solutions that have played a key role in making India self-reliant and addressing diverse connectivity requirements.

### The Innovation continued in the Later Years

RAX was further revamped to a high-capacity Main Automatic Exchange (MAX) and MAX-XL (40000 Subscriber Lines) to meet the ever-increasing requirements. On 1st Jan, 2000, a total of 166 MAX – XL were serving 1 million subscriber lines all over the country.

C-DOT's indigenous Asynchronous Transfer Mode



Inauguration of RAX at Kittur, Karnataka



MAX-XL exchange was dedicated to the Nation by the then Prime Minister, H.D.Deve Gowda in 1997



The efforts of C-DOT engineers resulted in a Rural Automated Exchange (RAX) that triggered the indigenous Telecom revolution in the country. The country's first indigenously developed digital rural electronic exchange (RAX) of 128 lines capacity was installed at Kittur in Karnataka on 22nd July 1986.

(ATM) technology that is successfully deployed in defence establishments helped C-DOT secure its first US Patent.

C-DOT, over the years, has evolved into a full-fledged Telecom R&D institution that complies with level 5 maturity on CMMI model with capabilities to undertake large-scale state-of-the-art Telecom technologies development programs.

C-DOT has diversified its R&D focus on a multitude of Telecom technology areas spanning Optical Communication, Switching & Routing, Wireless Communication, Security, Network Management, 4G LTE, 5G & IoT/M2M solutions, Telecom software applications, etc. which have significantly contributed towards achieving self-reliance in the Telecom sector, nation-building and overall growth of Indian economy.

**Now**

Today, C-DOT has two research centres at Delhi and Bengaluru with a pilot production facility at its Bengaluru unit. C-DOT's current workforce of a little more than a thousand comprises of almost 90% meritorious researchers who have been recruited from the top technology institutes of the nation.

C-DOT has been in the forefront of Telecom technology and innovation with its diverse product portfolio that has accelerated the digitalization of "New India" as envisaged by Shri Narendra Modi, Hon'ble Prime Minister of India. C-DOT's home-grown technologies have been instrumental in achieving digital literacy and digital empowerment owing to their easy adaptation for all sections of the society including illiterates and semi-literates.

C-DOT's indigenous Gigabit Passive Optical Network (GPON) technology is fueling the backbone of BharatNet, nationwide optical fiber network that aims to extend high speed connectivity to even the most inaccessible and inhospitable parts of India.

With its wide array of Wi-Fi solutions including the latest Wi-Fi 6 and Solar, Long-Range & Satellite Wi-Fi, C-DOT is committed towards proliferation of public Wi-Fi hotspots and boosting village level entrepreneurship and MSMEs in the country as part of the prestigious PM-WANI initiative of the Government of India.

C-DOT has indigenously designed multiple variants of Digital Network Elements including Routers of Terabit & Multi-Terabit capacities and Layer 2/3 Switches that

have been deployed in national networks including those of defence and strategic importance. These technologies have been augmented for positioning in Data Centers and Cloud Networks as well.

C-DOT's Integrated Alert System for effective disaster management, based on ITU's Common Alerting Protocol (CAP) has been a path-breaking initiative saving millions of lives during natural disasters and Covid-pandemic.

C-DOT lays great emphasis on security in designing its technologies to cater to the dynamically changing cyber threat landscape. C-DOT has developed various innovative solutions for security-centric applications. These cover solutions for lawful interception, cyber health monitoring & analytics, advanced quantum communication, tracing of cloned & counterfeited mobile devices, secure chat & call platform and video-conferencing.

It has been a constant endeavor at C-DOT to design indigenous technologies for ease of manufacturing and deployment. C-DOT has dedicated teams for vendor development and transfer of technology to spur the creation of local Telecom manufacturing ecosystem as envisioned under the Hon'ble Prime Minister's mission of building "Atmanirbhar Bharat".

C-DOT is keen on collaborating with domestic industry, startups and academia to evolve a harmonious framework for design, development, manufacturing and deployment of home-grown technologies in an efficacious and expeditious manner.

The successful Proof of Concept (PoC) of the end-to-end indigenous 4G system that is powered by a 4G Core developed by C-DOT, Radio Access Network (RAN) from Tejas Networks led by TCS in consortium mode is a manifestation of the growing synergy between R&D and industry. C-DOT has been actively working in the area of 5G and inviting partners for its ambitious 5G India Alliance that will act as a catalyst for the indigenous development and deployment of 5G networks in the country.

C-DOT is continuously treading on the path of "Atmanirbharta" and is steadfast in its commitment towards indigenization of Telecom technologies driven by local skill and innovation. 🙌

Ravinder Ambardar, CDOT

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# National Integrated Alert System contribution towards disaster resilient India

Protecting lives by disseminating right information to right people at right time is the essence of an effective disaster early warning system.



BY SAURABH BASU

As per United Nations office for Disaster Risk Reduction, India is the third country with highest human and economic loss owing to natural disaster over the last 20 years (2000-2019). Around 79,732 people have lost their lives and 108 crore people were affected in 321 incidences of natural disasters (like cyclones, heat and cold wave, flood, Tsunamis etc.) in India in the same duration, according to the International Disaster Database (IDD). India has suffered nearly 80 billion USD in economic losses in the 20 years.

From a disaster management perspective, over the years India has built advanced forecasting mechanism of disaster events and created robust institutional mechanism through NDMA, SDMA, NDRF, SDRF for mitigation the damage and destruction caused disasters.

## Gaps in the System

However, in the existing early warning mechanism there are some gaps in disseminating the disaster alerts

C-DOT has created the Inter-Working Systems (IWS) for legacy technologies of radio, coastal sirens DTH and cable TV etc. in a cost-effective manner.

This indigenously designed and developed national level system supports the vision of Honourable Prime Minister of a self-reliant India and towards the PM's 10-point agenda for Disaster Risk Reduction.

to the citizens present in the targeted disaster impact area so that people can take necessary action to protect themselves from impact of disaster.

Some other challenges include addressing odd hours, warnings in vernacular languages, dissemination over multiple media to ensure reachability. Moreover, there are manual interventions required at different steps to send early warnings to common public precious time is lost in the manual process. There is need of adopting a coordinated and automatic approach between various stakeholders of disaster management for effective early warning dissemination.

### CDOT Solution

C-DOT is bridging these gaps by implementing pan India level Integrated Alert System known as सचेत (समकित चेतावनी तंत्र) for National Disaster Management Authority (NDMA).

The system will integrate and bring all the stakeholders under a common umbrella which will ensure a coordinated and automated approach to send location specific disaster alerts to the people of target areas for extreme events like Cyclone, Lightning, Tsunami, Flood over multiple dissemination media (SMS, Cell Broadcast, Radio, Television, social media, Coastal Sirens, Mobile App, RSS Feed etc.) in Indian vernacular languages.

The alert messages reach to the people over different media in such ways that grab attention and help them to take prompt action, for example mobile app produces distinctive tone upon receiving red alerts it has auto read aloud feature also, alert message comes as On-Screen Display (OSD) in TV.

C-DOT has created the Inter-Working Systems (IWS) for legacy technologies of radio, coastal sirens DTH and cable TV etc. in a cost-effective manner. This system equips the authorities to disseminate and communicate, timely, accurate and actionable warnings and associated information on likelihood and impact of disaster to common public.

This indigenously designed and developed national level system will support the vision of honourable Prime Minister of self-reliant India "Atmanirbhar Bharat" and also towards the in PM's 10-point agenda for Disaster Risk Reduction. This solution leverages technology for enhancement of disaster risk management. This will significantly contribute towards fulfilling country's goals to achieve the substantial reduction of disaster risk and losses in lives, livelihoods and health in line to UN's Sendai Framework guidelines. With the nation-wide roll out of this system India has become one of the few countries that have achieved deployment of automated multi-hazard multimedia early warning system.

The system has been successfully rolled-out across India and has been effectively used for sending over 4 billion alert messages during various disaster events like cyclone Asani, Assam, and Gujarat floods, Cyclone Nisarga and Amphan, Cyclone Tauktae and Yaas. Jammu and Kashmir Government has disseminated targeted weather alerts during Shri Amarnath ji Yatra. During COVID-19 pandemic situation, the service of this system (known as "COVID-19 Sāvdhān") is being rigorously used by 26 State & Union Territory authorities for sending targeted alerts to the citizens of India related to COVID-19 mitigation measures including alerts on quarantine centres, vaccination information, supply of essential commodities, law and order issues, etc.

The Integrated Alert System has generated Intellectual Property Rights (IPR) in terms of various patents, research papers in reputed journals and in form of ITU contribution. For enhancing the capacity of the system, C-DOT is focusing on using Artificial Intelligence (AI) in early warning by building the data-driven citizen-centric Decision Support System (DSS). This will help disaster managers by performing impact assessment of disaster events through configuration of decision models and evaluating disaster impact. 🌟

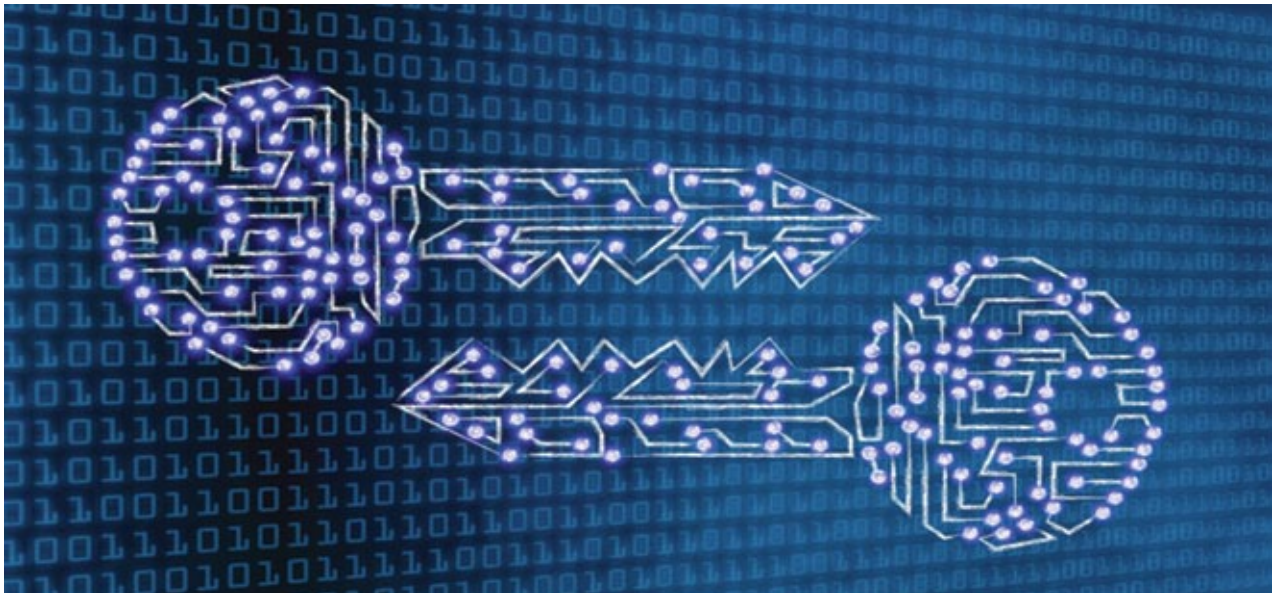
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# Post-Quantum Cryptography (PQC)

A low cost and time-effective solution for Quantum Safe Migration of legacy & Upcoming Communication Networks & Applications



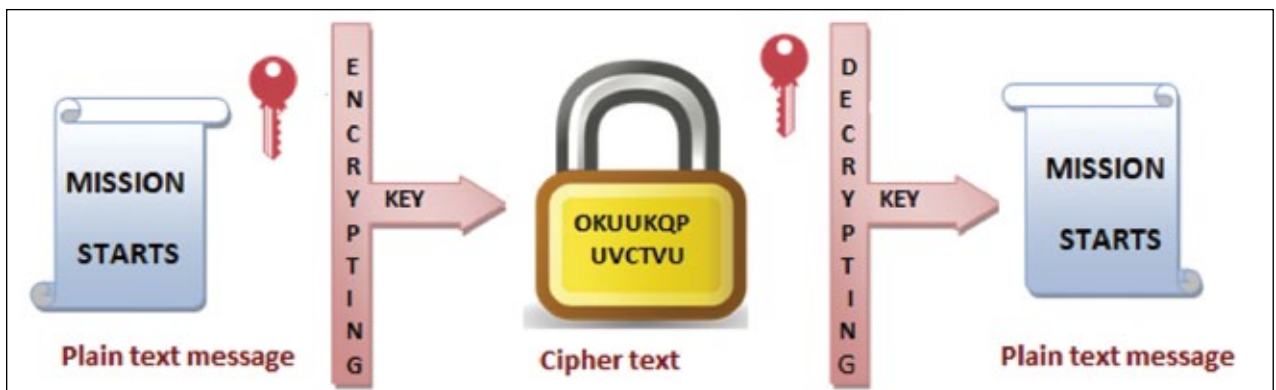
BY PRASHANT CHUGH & RAKESH SINGH RAWAT

Cryptography is used by security practitioners to protect anything that relies on electronic communication and data storage.

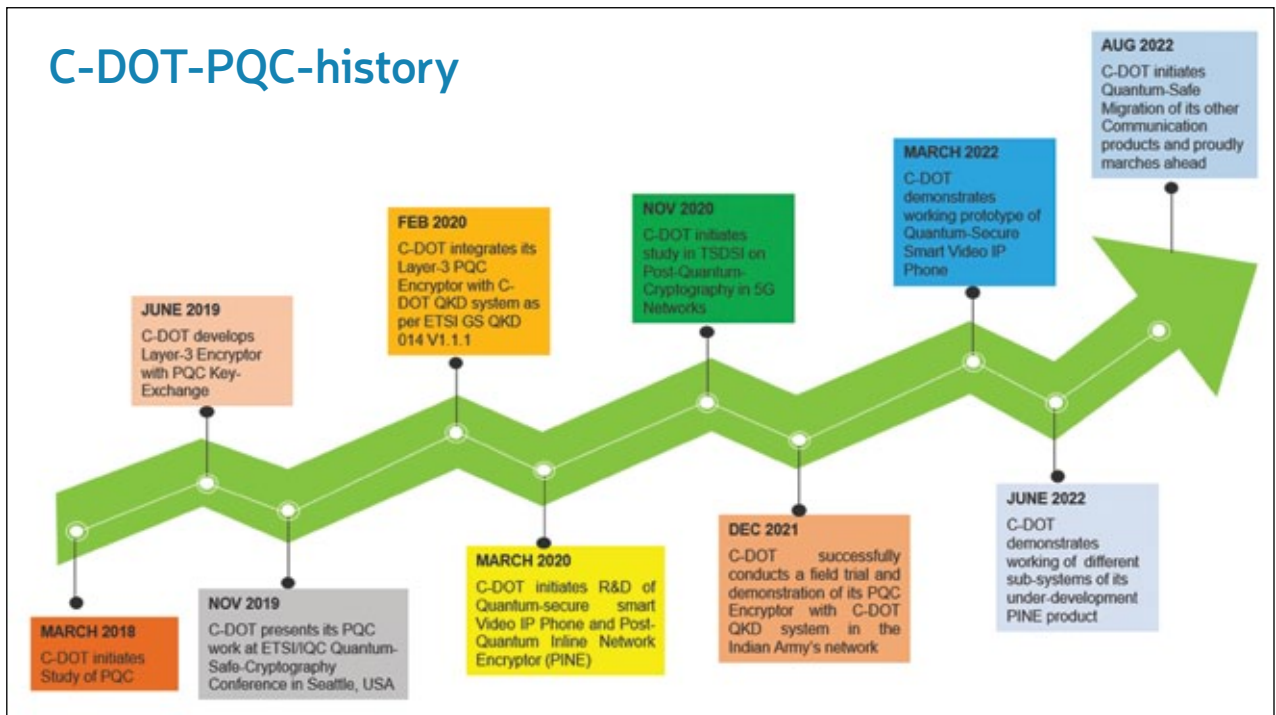
Cryptography uses computational hardness as a means to protect sensitive data. There are cryptographic problems that are difficult or impossible to solve using conventional computing.

Cryptographic algorithms can be broadly classified into two categories based on the keys used during the encryption and decryption processes:

- **Symmetric/Secret Key Cryptography:** In this scheme, encryption and decryption keys are same and it should be known to only the communicating parties.



The threat from Quantum computers on the current cryptographic functions is not only limited to data which is in-transit, but also to data-at-rest (for e.g. confidential data stored in databases).



- **Asymmetric/Public Key Cryptography:** In this scheme, two keys are used i.e. public key (for encryption) and private key (for decryption). Only private key needs to be kept secret as it is used for decryption. (See article on QKD in same issue for more details).

In most public communication networks, a combination of asymmetric as well as symmetric key cryptography schemes is used. Asymmetric/ Public Key Cryptography scheme is used for key distribution purpose while the data flow is secured using symmetric scheme because of its better performance in encryption/ decryption process.

### Quantum Computing and Quantum Algorithms

#### Quantum Computing

Quantum computing is the exploitation of collective properties of quantum states, such as superposition and entanglement, to perform computation.

It is a new branch of computing in which fundamental unit of storage is Qubits rather than bits in the

conventional computer. A Qubit can store both 0 and 1 at the same time. Quantum computers perform calculations based on the probability of an object's state before it is measured - instead of just 1s or 0s - which means they have the potential to process exponentially more data compared to classical computers. In short, we can say, Quantum computers can perform very rapid parallel computations as compared to classical computers.

#### Quantum Algorithms

There are two groundbreaking Quantum algorithms which have laid out a strong foundation towards breaking today's number theoretic based public key cryptosystems.

- In 1994, Shor proposed a polynomial-time (efficient) algorithm for solving integer factorization and discrete logarithm problems. The algorithm relies on the existence of quantum computers, and hence this type of algorithms is called quantum algorithms. Shor's quantum algorithm and its variants can be used for breaking most of the currently used public key crypto systems including those based on ECC.

“Store & Harvest” attacks happen where the encrypted data in communication can be stored now and attacks can be done on the stored data in future, once sufficient strong Quantum Computers are available for attack.

• In 1996, Grover proposed an  $O(\sqrt{N})$ -time quantum algorithm for functions with  $N$ -bit domains. This quantum algorithm once realized on quantum computers can be used for breaking symmetric key cryptosystems, and to defend against attacks based on Grover’s algorithm, we need to double the key sizes in order to achieve the similar level of security against conventional computers.

The threat from Quantum computers on the current cryptographic functions is not only limited to data which is in-transit, but also to data-at-rest (for e.g. confidential data stored in databases).

The digital information/ data having long life (like medical records, defense secrets etc.) are also vulnerable to Quantum attacks.

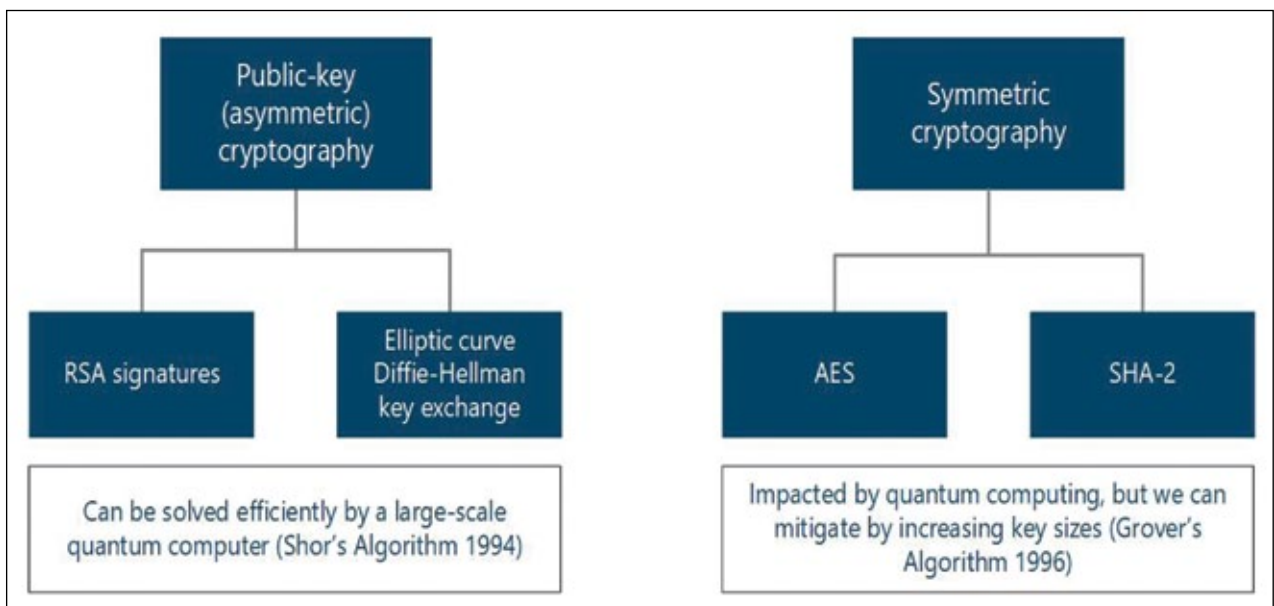
### Quantum threat to current Cryptosystems

Because of rapid advancement in Quantum computing, security experts world-wide have predicted that in a few years, these computers shall become a threat to the currently used cryptography techniques. In other words, with the help of strong Quantum computers, a security attacker can easily reverse calculate the secret cryptographic keys to get access to the secure data. Experts have predicted that in the coming years, asymmetric key encryption techniques shall be completely broken by Quantum Computers while the strength of symmetric encryption techniques shall be reduced by half. This is because the underlying mathematical techniques used in asymmetric key encryption- prime number factoring and discrete logarithms are predicted to be vulnerable to attack from Quantum algorithms running on Quantum Computers.

This kind of attack is called “Store & Harvest” attack, where the encrypted data in communication can be stored now and then attack can done on the stored data in future, once sufficient strong Quantum Computers are available for attack. Secure Communication protocols that are under threat from Quantum Computers include:

- IPsec
- SSH and TLS
- VPN
- S/MIME
- HTTPS

The above list of protocols practically include all the protocols used for Communications Security in the present times.



## PQC (Post Quantum Cryptography)

- PQC algorithms are based on hard problems of mathematics which are being discussed and evaluated in NIST & other international forums.
- Cryptographic algorithms usually require years of public review & scrutiny and the same is true for ongoing standardization in PQC
- Experts believe that PQC is usually a cost-effective Quantum-safe Migration solution for both legacy as well as greenfield Communication Networks

### Post-Quantum Cryptography (PQC)

Post-Quantum Cryptography (PQC) mainly refers to the development of new asymmetric cryptography techniques that shall use different class of underlying mathematical problems such as Lattice-based mathematics & Code-based mathematics, which are believed to be secure against both classical and quantum computers. A competition is being done by NIST (National Institute of Standards & Technologies), a U.S. standardization agency (which has standardized most of the cryptography algorithms in the past) to standardize new PQC techniques.

PQC is the field of cryptography whose objective is to develop cryptosystems that are expected to be secure against both Quantum as well as classical computers. PQC is implemented using today's classical computers but will be impervious to attack from tomorrow's quantum computers.

### Global Efforts and Standardization of PQC Algorithms

In Quantum Computing, progress has been swift. IBM has over 20 of the world's most powerful Quantum Computers, accessible for free on the IBM Cloud for experiments. Google is aiming to build a "useful, error-corrected quantum computer" by the end of the decade. ETSI's (European Telecommunications Standards Institute) whitepaper titled "Quantum Safe Cryptography and Security: An introduction, benefits, enablers and challenges" was the first important paper in this area. ETSI has thereafter worked a lot in this area under its Quantum-Safe-Cryptography (QSC) working group.

IETF has come up with many draft Request-for-Comments (RFCs) in this area such as the one on



extension of IKEv2 for incorporation of Post-Quantum Cryptography (PQC) algorithms.

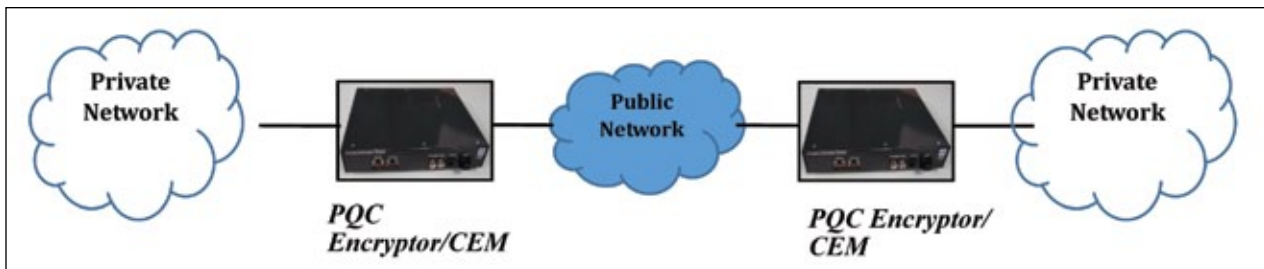
In 2016, NIST (National Institute of Standards and Technology), USA, had started PQC standardization program & competition. In this program, NIST has already completed the third round of the Post-Quantum Cryptography (PQC) standardization process, in which it selected public-key cryptographic algorithms to protect information through the advent of quantum computers.

A total of four candidate algorithms (One Key Exchange algorithm - CRYSTALS KYBER and Three Signature Algorithm- CRYSTALS DILITHIUM, FALCON & SPHINCS+) have been selected for standardization. Also, four additional algorithms (BIKE, Classic McEliece, HQC and SIKE) will continue into the fourth round and some of them may be chosen for standardization at the end of fourth round.

### C-DOT's work in PQC

C-DoT has developed a PQC IP encryptor called Compact





Encryption Module (CEM) supporting classical as well as future-proof Post Quantum Cryptographic algorithms for Quantum security. CEM supports Hybrid approach of Key Encapsulation Methods. In Hybrid approach, the Key exchange is performed by using a Post Quantum cryptography algorithm alongside a traditional, well trusted classical cryptography algorithm.

This approach ensures maintenance of current generation security standards as well as providing resistance against attacks from Quantum Computers. Hybrid Approach is the recommended approach for Quantum-Safe-Migration by NIST and ETSI.

C-DOT CEM can perform encryption and authentication operations, independent of application-level protocols, thus making it reliable & suitable for any application. A typical deployment scenario of a PQC encryptor or CEM is depicted in figure below:

The setup consists of two Compact Encryption Modules (CEMs) connected to each other over a public network with IPSEC tunnel established between them and running in Hybrid mode a classical algorithm and a Post Quantum Cryptography algorithm.

PQC activities were started in C-DoT, keeping in mind the objectives of providing future-proof cryptographic security in voice, data and video communication through C-DoT developed products and ensuring that C-DOT developed communication security products keep pace & comply with the evolving PQC standards at international SDOs (Standards Development Organizations) such as NIST & ETSI.

- C-DOT has successfully developed a PQC Encryptor called Compact Encryption Module (CEM) that supports PQC Key exchange & signature algorithms which are under standardization at NIST.
- C-DOT CEM has been successfully integrated with QKD (Quantum Key Distribution) System as per the ETSI standard for key interface. A combination of PQC and

QKD schemes offers the highest degree of future-proof security.

- C-DOT has successfully implemented PQC algorithms in its indigenously developed Quantum Secure Smart Video IP phone.
- C-DOT CEM has been successfully integrated in VoIP network for Post-Quantum security of signaling between C-DoT Quantum Secure Smart Video IP phone and Signaling server.
- In December 2021, C-DOT has successfully conducted a field trial and demonstration of its PQC Encryptor with C-DOT QKD system in the Indian Army's network between ChandiMandir (Haryana) and Kasauli (Himachal Pradesh)
- C-DOT is developing a higher capacity PQC enabled IP encryptor called Post-Quantum In-line Network Encryptor (PINE). The platform of this product is being designed to meet defense requirements.
- C-DOT is actively participating in development of PQC related standards with international SDOs like ETSI, 3GPP and also participating in forums and conferences by TSDSI (Telecom Standards Development Society of India)

C-DOT is actively pursuing introduction of PQC in many of its other communication security products so that Quantum-Safe Migration can be done for all the products as per evolving international standards. With C-DOT actively working & developing new innovative products in both PQC and QKD-based Quantum-safe technologies, C-DOT at this moment of time in history is in a special position to offer unique quantum-secure end-to-end communication solutions to the country in the years ahead. 🇮🇳

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# Quantum Key Distribution (QKD) For Secure Strategic Communications Networks

C-DoT has designed a new Quantum based security solution that will be an enhancement on current levels



BY ATUL KUMAR GUPTA & ARKA MUKHERJEE

In the last decade, we have witnessed a huge increase in Internet penetration – both wirelines and wireless. Growth in mobile data usage has seen a phenomenal growth and correspondingly the type and number of new devices in the system have also increased.

With the imminent rollout of 5G networks (spectrum auctions have just been concluded), a greater number of new devices are expected to come online. All of this will contribute significantly to the rising security challenges of the digital and mobile users.

One of the ways to address the security issues is by upgrading the existing communications infrastructure with quantum security and induction of quantum key distribution or QKD systems.

The Government of India in its budget 2020 had announced a National Mission on Quantum Technologies and Applications (NM-QTA) with a total budget outlay of Rs. 8,000 Crore (US \$ 1.2 billion approx.) over five years to be implemented by the Department of Science & Technology (DST).



Quantum Key Distribution (QKD) is a method of key exchange with security guaranteed by the fundamental rules of quantum mechanics that helps to detect any attempt of eavesdropping by changing the system irreversibly during any intrusion

The Centre for Development of Telematics (C-DOT), has already taken a technological leap in this highly exciting new area.

It has designed a fibre-based QKD system that is based on Differential Phase Shift (DPS) and Coherent One-Way (COW) protocols – to enable higher levels of security online.

C-DOT's legacy is of delivering cutting-edge indigenous technologies, both in hardware and software, and especially aimed to meet the requirements of the rural parts of our country thus reducing the digital divide.

In the area of QKD, which is the future of online data security, C-DOT has achieved many milestones already (See Contribution section below):

- With advancements in quantum computing, the security of existing cryptographic algorithms will slowly become obsolete and be at stake as networks and users shift to more secure standards.
- Quantum key distribution facilities mathematically secure “key exchange” as against the cryptographic method and any attempt at eavesdropping can be easily detected.

Cryptography is commonly used in communication networks to protect the data being transmitted over any media. Security of modern communication technologies mostly relies on state-of-the-art public key cryptographic algorithms like RSA and the Diffie-Hellman key exchange protocol. In any cryptographic algorithm, information security is critically dependent on the privacy of keys. The foundation of public key cryptographic algorithms is based on mathematically complex algorithms.

The security is ascertained from the assumption or belief that, even for the most powerful classical (existing) computer, it is practically impossible to perform certain mathematical operations like prime factorization of a very large integer even in a considerable amount of time.

In October 2019, Google confirmed achieving quantum supremacy. The ability to solve a problem that no classical computer can solve in any practical amount of time. In June 2022, Xanadu, a Canadian start-up, published an experiment in Nature using a quantum computer named 'Borealis' to generate one set of 216 numbers from a complicated statistical distribution in just 36 microseconds.

It is estimated that the most powerful supercomputer would take an average of 9,000 years to perform the



Secretary Telecom K. Rajaraman visits Centre for Development of Telematics (C-DOT); inaugurates the Quantum Communication Lab and unveils the indigenously developed Quantum Key Distribution (QKD) solution by C-DOT



C-DoT's fibre-based QKD system is based on Differential Phase Shift (DPS) and Coherent One-Way (COW) protocols – that enables higher levels of security over existing fiber infrastructure without having to use a separate dark fiber. It is a huge cost saving

same task. These discrete achievements in quantum computing show just the tip of an iceberg. If such immense computing power becomes accessible to bad actors, the security of existing cryptographic systems will become obsolete and compromised.

Quantum Key Distribution (QKD) overcomes this. It is a method of key exchange with security guaranteed by the fundamental rules of quantum mechanics that helps to detect any attempt of eavesdropping by changing the system irreversibly during any intrusion.

### Types of Cryptography:

In any encryption method, the information to be sent, also called plaintext message, is converted to a gibberish string, called "ciphertext", with the help of a random string, called a key.

No information regarding the plaintext message can be obtained from the ciphertext unless the key to decrypt is available.

Cryptographic algorithms can be broadly classified into two categories based on the keys used during encryption and decryption:

- **Symmetric Key Cryptography:** The same key is used for both encryption and decryption processes. The key lengths are relatively smaller (128-256 bits). Examples are Advanced Encryption System (AES) and Data Encryption Standard (DES).
- **Asymmetric/Public Key Cryptography:** In this case, a mathematically related key pair, public key and private key are used for encryption and decryption, respectively. It is not possible to derive the private key from the public key. Key lengths for asymmetric key cryptography are relatively longer (>2048 bits). Examples are RSA, DSA, ECC, and the Diffie-Hellman algorithm.

### Challenges with Existing Cryptographic Protocols:

The existing cryptographic algorithms have a number of pitfalls:

- There is no mechanism to detect intrusions in the system easily. Instances of huge financial and reputational losses have been reported multiple times in the past when intrusions went unnoticed for long.
- The security is belief-centric, which will no longer be valid once Quantum Computers mature.
- The low frequency of key updates is making the systems vulnerable to brute-force attacks.
- Asymmetric encryption is 2-3 times slower than its symmetric counterpart due to longer key lengths and the complexity of algorithms used in asymmetric encryption.

As per the report of IBM Security titled "Cost of a Data Breach Report 2020", the average total cost of a data breach is US \$ 3.86 million an approximately 10% increase since 2014.

In 2015, Michele Mosca (associated with University of Waterloo, Canada) provided a method to calculate the point in time where we need quantum-resistant systems through an equation, popularly known as Mosca's inequality:

$$D + T \geq Qc$$

Where:

D: The amount of time we need to keep our data secure;  
T: The time it will take our systems to transition from classical to post-quantum, and

Qc: The time it will take Quantum Processors to have reached a scale where they can breach existing encryption protocols.

There has been an informed consensus that this inequality has already been breached in the year 2017.

### The Architecture of QKD Systems

Quantum mechanics, formulated around 100 years back, is now maturing rapidly with its practical applications in four major domains: computing, communications, sensors, and devices.

QKD is based on the principles of quantum mechanics, i.e., Heisenberg's uncertainty principle and no-cloning principle, to generate a perfectly random key that is shared between two nodes, traditionally called Alice and Bob.

QKD is based on the principles of quantum mechanics, i.e., Heisenberg's uncertainty principle and no-cloning principle, to generate a perfectly random key that is shared between two nodes, traditionally called Alice and Bob.

This secure key is used to encrypt the messages which need to be sent by Alice and to extract the original messages from received signals by Bob (and vice-versa). Both Alice and Bob can detect the presence of an intruder trying to learn about the key, which inherently makes the generated keys highly secure from eavesdropping.

The sharing of secure keys between Alice and Bob requires a quantum channel and an authenticated classical channel. The quantum channel for this system is typically either single-mode fibre or free space,

whereas the classical channel can be a transmission over the Internet.

The Quantum channel and classical channel together form a QKD link. The architecture of a point-to-point (P2P) QKD link is shown in Figure 1. The P2P network topology can be easily extended to any network topology using key relays.

## QKD MARKET

QKD is expected to address a plethora of use cases and deployments for quantum-secure communications in the years to come. The global QKD market is expected to touch US \$ 3.4 billion by 2030 as per the Inside Quantum Technology (IQT) Reports, December 2021.

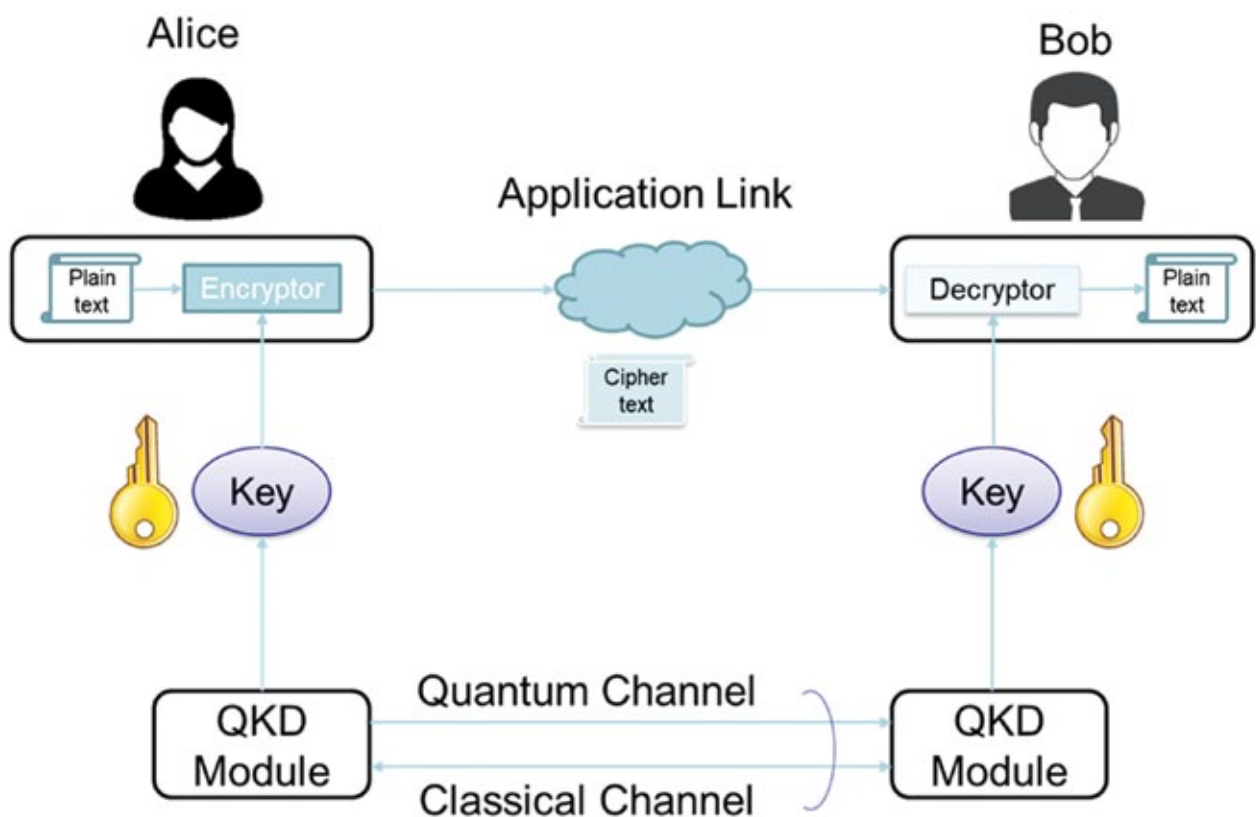


Figure 1: P2P QKD Link Architecture

# [COVER STORY]

## QKD

The generation of shared secret keys through QKD involves several steps (Figure 2).

During key sifting, Alice and Bob discard non-compatible qubits depending upon the protocol used. They calculate Quantum Bit Error Rate (QBER) to check for any attempt of eavesdropping and abort the key generation process if QBER is beyond a defined limit.

The generated keys are stored along with some metadata like key-id and delivered to the application on request. Keys generated in the QKD system can be

mathematically proved to be secure and it is not based on any belief.

Charles Bennett (associated with IBM Research, USA) and Gilles Brassard (associated with University of Montreal, Canada) proposed the first QKD protocol in 1984 at a conference in Bengaluru, India. This protocol is popularly known as BB84. Several other QKD protocols have been proposed later and proved to be Information Theoretically secure. Most of the existing implementations of QKD systems use dark fibre for the quantum channel. Undoubtedly this gives the best

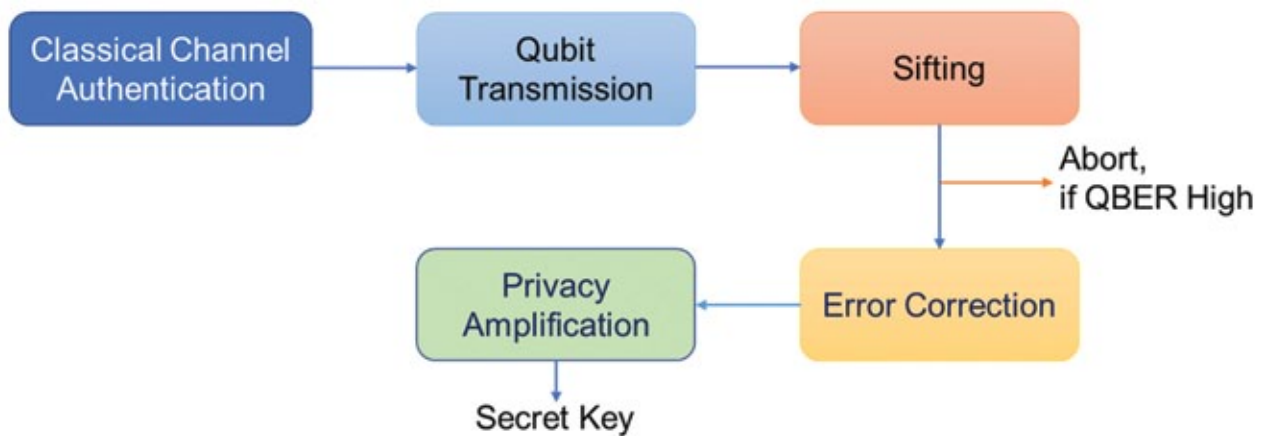


Figure 2: Key Generation Process in QKD

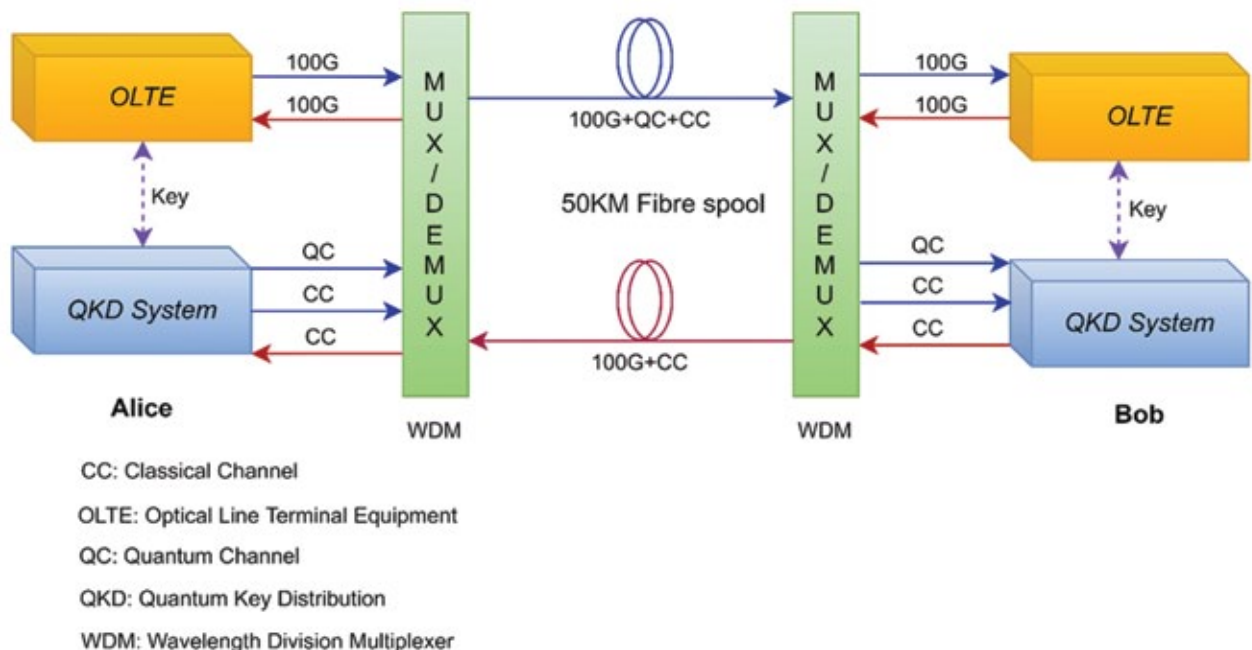


Figure 3: C-DOT QKD System: Deployment on Existing Data Carrying Fibres

performance in terms of secret key rate and distance between the nodes. However, dark fibre is not only scarce but also makes the system expensive.

C-DOT's R&D team has designed a fibre-based QKD systems based on Differential Phase Shift (DPS) and Coherent One-Way (COW) protocols.

In the C-DOT QKD system, the quantum channel and classical channel can also be multiplexed on the existing fibre carrying the network traffic, as shown in Figure 3. 100G traffic, quantum channel, and classical channel use C-band ITU-T grid wavelengths. The C-DOT QKD system also supports the common implementation of the quantum channel on the dark fibre.

### Global Standardization Activities

Different Standard Development Organizations (SDOs) like the European Telecommunication Standards Institute (ETSI), the International Telecommunication Union (ITU), and the International Standards Organization (ISO) are proposing standards for QKD.

In the long run, this will allow multi-vendor interoperability and open up new development opportunities. ITU has come up with a series of standards for the QKD network. Also, a few standards are under preparation. There is still a lot of scope for standardisation in terms of standard interfaces both vertically and horizontally in the QKD network stack.

### ITU-T Standards In-Force

- Y.3800: Overview of networks supporting quantum key distribution
- Y.3801: Functional requirements for quantum key distribution networks
- Y.3802: Quantum key distribution networks – Functional architecture
- Y.3803: Quantum key distribution networks – Key management
- Y.3804: Quantum key distribution networks – Control and management

### Contribution of C-DOT in QKD so far

- Indigenously developed complete hardware and software for both Alice and Bob nodes using both DPS and COW QKD protocols
- Achieved a secure key rate of greater than 1 Kbps over 100 km fibre with a Quantum Bit Error Rate (QBER) of less than 5%
- Successfully simulated Photon Number Splitting (PNS) attack

- Granted the Patent titled "An Efficient Method to Automatically Align Phase Modulator with Pulse Generator/Intensity Modulator in the Alice Node of DPS-QKD System" by the Indian Patent Office in July 2022.
- Two Patents have been filed with Indian Patent Office:
  - Device and Method of Synchronization in Quantum Key Distribution (QKD) System
  - Methods and System for Fast Synchronization in Long Range Quantum Key Distribution
- Integrated the QKD system with C-DOT Router as well as Post-Quantum Cryptography (PQC) system as per ETSI standard
- In December 2021, C-DOT has successfully conducted a field trial and demonstration of its QKD solution along with the C-DOT PQC Encryptor and Router in the Indian Army's network between Chandimandir (Haryana) and Kasauli (Himachal Pradesh)
- Successfully demonstrated multiplexing of the quantum channel and classical channel on the existing data-carrying fibre. The solution can be further optimised for longer distances and can be customized for already existing data carrying fibre links.

### Applications

QKD systems have relevance in all telecommunications networks that carry confidential, sensitive, financially important or strategic data.

The potential users for QKD technology are:

- Networks encompassing government offices spread across geographies or across different parts of the country
- Banking, Financial Services and Insurance (BFSI) sectors
- Healthcare and pharmaceutical industries
- Military and defence networks
- Telecommunications and the IT industries
- Blockchain applications

With its vast range of indigenously developed communications products and solutions, C-DOT is pre-eminently placed as a trusted source of quantum secure end-to-end communication infrastructure.

C-DOT's active role in pursuing QKD development aims at taking a leading role within the country and globally, in fulfilling the ambitious goals of NM-QTA under the "Quantum Communications" vertical. 🌟

Atul Kumar Gupta & Arka Mukherjee, CDOT  
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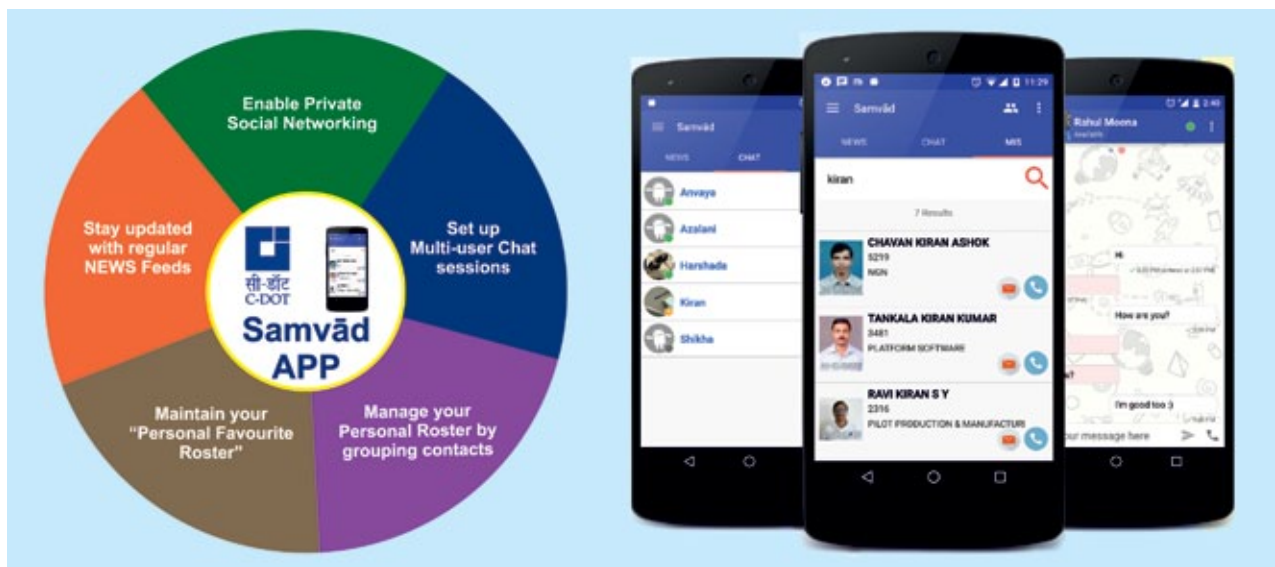
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# SAMVAD – A Secure Unified Communication Solution for Collaborative Working around the Globe

Samvad supports both Call & Chat for sharing of text, image, audio and video files



BY ANVAYA RAI

The lockdown and the post Covid era, has brought an ever-increasing demand for solutions to ensure secure communications between employees (who work from home) and their offices, while ensuring a seamless exchange of confidential corporate data.

This exchange of data has to be facilitated over a user's device through open public internet services. The available applications in this regard, had some major security concerns, such as:

- Location of chat server outside the organization
- No security of the messages transmitted
- Data can be stolen by malware attack

In order to mitigate this concern, C-DOT started work on developed an easy-to-use application in the form of 'SAMVAD', an Android and iOS App which provides a secure environment for a healthy collaborative workspace distributed across the globe.

In order to facilitate the collaborative working and seamless connectivity of employees for smooth data exchange, Samvad supports both Call & Chat for sharing of text, image, audio and video files. The basic underlying theme for Samvad revolve around four verticals:

- Security Features
- Organizational Features
- Unique Chat Features
- Generic Ease-Of-Use Features

The entire ecosystem focuses on "Securing the communications made through VoIP Calls, Chat Messages and File Sharing, both On User's Device (Data At Rest) and Over TSP / ISP Network (Data In Transit)".

This motive is served through the following methods:

- TLS v1.3 / TLS v1.2 based End2End encryption
- Built-in Keystore and Certificates (SSL Pinning)
- Login/ Password and AppLock based App access

- Encrypted On Device Storage of Data and Messages
- Data storage in a Private Directory
- Message Tracking & Traceability
- Simultaneous Information/ NEWS dissemination

The other key enablers towards the successful mitigation of the above objective are:

- **In App File Viewers:** All the Files, Images, Videos and other Data shared through Samvad are visible only within Samvad and are inaccessible to other apps in the device. The In-App File Viewers support Images, Videos, Audio, PDF (including Password Protected), Text, Doc etc.
- **Tagged Messaging:** Messages and Files can be tagged as “Confidential” or “Non-Forwardable” to sensitize the receiver and regulate the further spread of the information shared with him/ her. “Forwarded” Tag helps in Traceability & Track-ability.
  - A Sender can tag a message or file as “Confidential” to mark the information as sensitive and the Receiver will always see this tag associated with the message and can judiciously share the information further.
  - A Sender can tag a message or file as “Non-Forwardable” to restrict the further dissemination of the information shared in the message or file and the Receiver will not be able to forward these to others.
  - When a message or file is forwarded by any user, the Receiver will see that message with a “Forwarded” tag. This can be used by the Receiver to report the message to the System Administrator and the communication can then be “Traced” and “Tracked”.
- **Off The Record (OTR):** Samvad enables a user to ensure an additional End-to-End Session based encryption of messages between Peers and verify the other Peer through a Shared Secret before initiating any communication. For this mode to be active, both the Peers need to be online. This channel gets disrupted if either of the Peers goes offline or is disconnected during the communication.
- **Cross-Compatibility between Android & iOS:** User Data can be seamlessly migrated between Android and iOS devices, without any need for a Third-Party Tool. Users can take back up of their data at regular intervals and can restore it on new devices later.

- The Chat-Backup is cross compatible between Android and iOS, i.e. a backup taken on the Android version of Samvad App can be seamlessly restored on the iOS version of Samvad App. All the Backed-Up User Data is stored securely on the Samvad Server in the User’s Private Storage and is encrypted by User specific random keys.

- **Vapor Messaging:** To ensure highest level of Data Security and Integrity, Samvad supports the functionality of Self-Destructive Messages. Under this, the messages get deleted from the both the devices (sender and receiver) after being read.

In addition to ensuring secured Peer to Peer communication, Samvad also enables its users to setup Team Meetings using the C-DOT Video Conferencing Solution. Users can setup a live conference and add other team members or they can schedule a conference for a later time and invite the other team members to join the same. This feature of the solution enables the participants to exploit the possibilities of Screen Sharing, Presentation Views, Multi-User Whiteboard, Break-out Rooms, Live recoding for Minutes of Meeting, Room Recordings etc.

### Samvad – use case / practical deployment

C-DOT Samvad solution has been successfully deployed in various departments of the Government of India including the Defence establishments and Strategic agencies.

One of the strengths of the solution is centered on the high degree of customizations that it offers to cater to the diverse deployment scenarios and specific requirements. The solution has significantly evolved and matured because of the active feedback from the customers. As a result of active engagement in the field, Samvad has translated into a rich bouquet of wide-ranging features and services.

Security has become paramount in the view of spate in cyber-attacks having far-reaching implications to data protection and integrity. C-DOT Samvad has been exclusively ruggedized with premium security features to meet the requirements of strategic communication. 🌟

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# Wi-Fi BY CDOT

C-DOT has built the expertise to design and develop Wi-Fi access points to meet the country's needs



BY JAYANTA MANDAL & P. CHARUMATI

The Wi-Fi interface is now a global standard for high speed Internet access and is available on all client devices be it smartphone, laptop, tablet etc. Wi-Fi is a part of the 3GPP standards as one of the dominant radio technologies which recognizes the benefits of Wi-Fi.

Over the last 20 years, the worldwide standard, IEEE 802.11 has evolved – it has gone from enabling Internet access at 2 Mbps to over 10 Gigabit speeds today.

IEEE 802.11 is the technical name for WiFi that provides wireless communications within a wireless local area network (LAN), to an access point (AP) or wireless router which is also known as a hotspot. The broader IEEE 802 set of LAN technical standards, specify a set of media access control (MAC) and physical layer (PHY) protocols for implementing wireless local area network

(WLAN) computer communication.

The evolution of WiFi has happened in the following key attributes:

- Greater Speed offered to devices through
  - Support for higher order of modulation schemes
  - Transmission of multiple streams
  - Support of higher bandwidths
- Improvement in network efficiency and capacity
  - Introduction of MU-MIMO(Multiple User-Multiple Input Multiple Output)
  - OFDMA (Orthogonal Frequency Division Multiple Access)

Wi-Fi 6 is the next-generation wireless standard that's faster than the current 802.11ac. More than speed, it will provide better performance in congested areas, be it large open areas like stadiums or a personal device-packed

Apart from the traditional use of Wi-Fi as a hotspot, C-DOT has also deployed in multiple locations such as Meerut in UP and Akola in Maharashtra, Point-to-Point Links over Wi-Fi.

## Evolution of Wi-Fi

IEEE 802.11 Protocol	Release Date	Frequency Band(s)	Bandwidth (in MHz)	Max Throughput
802.11-1997	1997	2.4	22	2 Mbps
802.11b	1999	2.4	22	11 Mbps
802.11a	1999	5	20	54 Mbps
802.11g	2003	2.4	20	54 Mbps
802.11n(Wi-Fi 4)	2009	2.4/5	20/40	600 Mbps
802.11ac(Wi-Fi 5)	2013	5	20/40/80/160	6.8 Gbps
802.11ax(Wi-Fi 6)	2019	2.4/5	20/40/80/160	10 Gbps
802.11be(Wi-Fi 7)*	2024	2.4/5/6	20/40/80/160/320	160 Gbps

\*(Work In Progress)

home. Wi-Fi 6 was officially introduced in late 2019, and Wi-Fi 6-enabled hardware was released throughout 2020.

The 802.11ax standard will replace 802.11ac as the de facto wireless standard over time. Wi-Fi 6 offers upto 10 Gbps speeds, uses less power and is more reliable in congested environments with better security.

### Wi-Fi Journey in C-DOT

With Wi-Fi deployments to cover the entire country, it is immensely important to strengthen the indigenous manufacturing ecosystem. And to provide an impetus to indigenous manufacturing ecosystem, C-DOT has built the expertise to design and develop Wi-Fi access points to meet the country's needs.

## C-DOT Wi-Fi Portfolio

S. No.	Wi-Fi Technology	C-DOT Product Name	USP of C-DoT Product
a)	Wi-Fi 4	CRB	3-radio support
b)	Wi-Fi 5	Solar Wi-Fi High Speed Access Point Enterprise Access Point	3-radio Support, Support for Multiple backhaul interfaces such as Optical and Electrical Interface Support for LTE Interface Supports both hotspot and Point-to-Point configuration
c)	Wi-Fi Access Points for PM-WANI	Indoor Variants WAYU (Wi-Fi 4 based) WGR (WiFi5 based) Outdoor Variants WAP DOA	PM-WANI Compliant Access Point
d)	Wi-Fi 6	Tej 3600	Supports both hotspot and Point-to-Point configuration Support for LTE Interface

IEEE 802.11 is the technical name for WiFi that provides wireless communications within a wireless local area network (LAN), to an access point (AP) or wireless router.

As the Wi-Fi standards have evolved, C-DOT has walked hand in hand with the technology and provided the access points as per the latest standards.

**Wi-Fi to fulfill the Need for faster Broadband**

Broadband has become a necessity. It has an impact on social and economic development. There are various means to carry this broadband data – Wi-Fi being one such.

It enables transmission in license free band, is very economical and quick to deploy. Public Wi-Fi networks should be future proof, scalable, maintainable and open standards based to provide controlled, unhindered and unbiased bandwidth shared among the TSPs, ISP and Government usage on need basis at any location of the island.

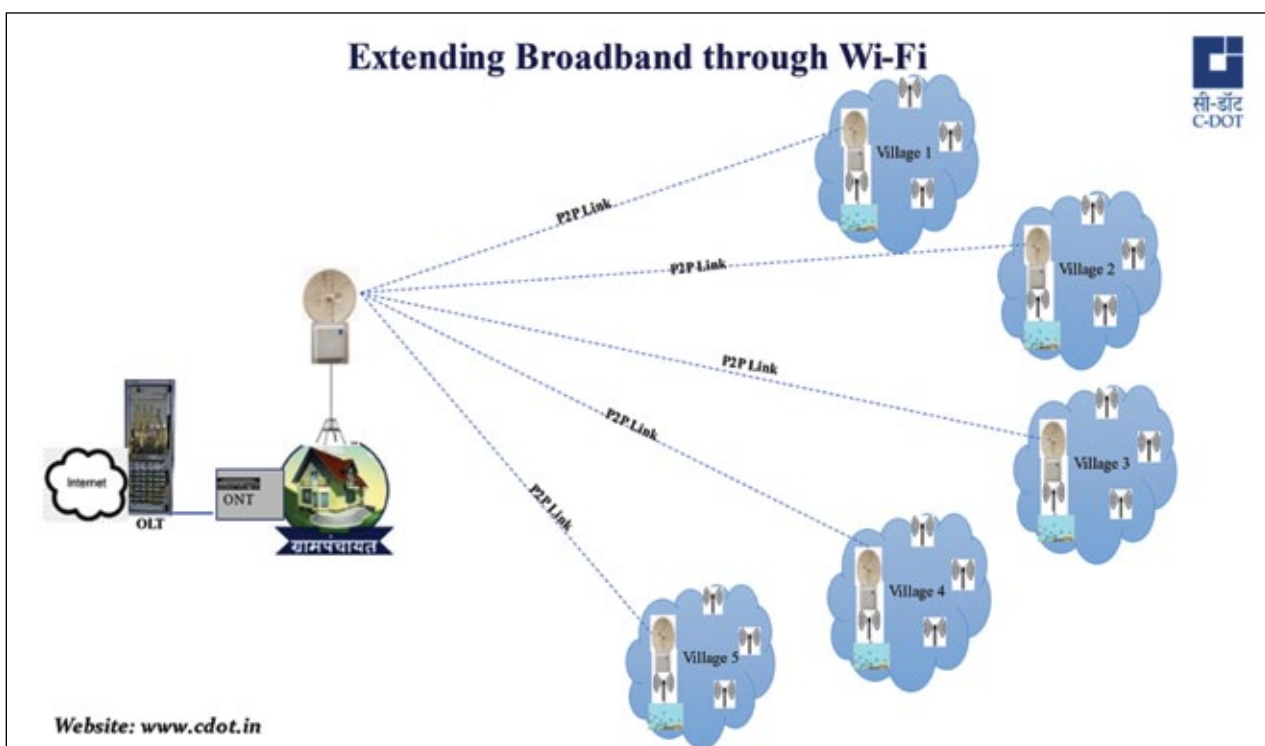
The network architecture should be cost effective and built with minimum capex, shelter, solar-powered equipment's and bandwidth on commercial term and conditions.

It should require less space, easy to install and operate. Communication technologies for rural and urban need to meet the following requirements:

- Provide high speed broadband connectivity for community services.
- Be reliable and rugged to work in Indian environments
- Require low power and be operational on alternative sources of energy like solar powered
- Have an attractive price/performance ratio
- Works with easily available, low-cost end user equipment such as low-cost smart phones etc.
- Preferably be maintenance free or at most require low skill maintenance
- Be easily and locally repairable
- Not demand of special operating environments like air-conditioning.

**C-DOT BBWT (Broadband Wireless Terminal) Wi-Fi solution addresses all these requirements of urban, semi-urban and rural population.**

C-DOT Wi-Fi equipment (in 2.4 and 5 Ghz ISM band) has



The PM-WANI scheme is completely a technical scheme and does not provide any commercial framework for the PDOA's and APP Providers to operate. This provides the flexibility to the PDOA's and the APP Providers to define their internet plans and tariffs based on the business case.

the capability of for extending connectivity from GP to Village over 5 GHz Wi-Fi Point to Point (P2P) link.

It was proposed as a low-cost, faster-to-deploy solution for connecting villages under the Bharat Net program.

A Pilot was proposed by CDOT in a few villages for demonstrating the capability of P2P link for connectivity as well as for providing village level Internet coverage using Wi-Fi hotspots.

C-DOT has always ensured that the access points designed are rugged for outdoor use in rural environments as well as defense requirement. Apart from the traditional use of Wi-Fi as a hotspot, C-DOT has also deployed the P2P link in multiple locations such as Meerut in UP and Akola in Maharashtra, Point-to-Point Links over Wi-Fi.

### Further Proliferation of Wi-Fi in India

Broadband proliferation in a vast country like India where there are significant differences in demography, depends on a large number of WiFi service providers. Most of them have to come forward to meet the NDCP 2020 goals of hotspot deployment.

It is recognizing the impact and reach that can be offered by Wi-Fi, the Govt. of India launched the PM-WANI scheme in December 2020. Under this scheme, the complete Wi-Fi network which was earlier installed and maintained by one entity has been unbundled based on functions within the architecture and been distributed to different sub-categories of service providers, like:

- **PDO** – Public Data Office who offer last mile internet service to the user and is responsible for maintaining the Wi-Fi Access Point.
- **PDOA** – Public Data Office Aggregator who offers the functions of Authorization and Accounting to the PDO's.
- **APP Provider** – Responsible for Authentication of the end user and offers a user friendly APP for the user to discover and select the PM-WANI hotspots.

Under this framework, any PDOA will be able to work with any APP Provider. Inter-operability of the PDOA and the APP Provider is ensured, through the presence of Central Registry.

The Central registry is responsible for certification of the PDOA and the APP Provider and has the database of the PDOA, the underlying hotspots of the PDOA and the APP Provider.

New unlicensed players such as Public Data office Aggregators and APP Providers have been introduced under this scheme to offer safe, secure internet access to the end users.

The scheme not only aims to improve broadband proliferation in the country, but also offer employment opportunities to Village Level Entrepreneurs to act as PDOs and Software startups to either become the technology providers for PDOA Stack and APP Provider solution or become PDOA/APP Provider themselves.

The PM-WANI scheme is completely a technical scheme and does not provide any commercial framework for the PDOAs and APP Providers to operate. This provides flexibility to PDOAs and APP Providers to define their internet plans and tariffs based on the business case.

PDOAs are currently experimenting with the scheme to identify various financial models which will be profitable for them. Unavailability of internet backhaul, difficulty in getting access to locations in public places such as bus-stops, railway stations etc, have dampened the growth of PM-WANI. DoT is now closely working with all the Ministries to facilitate the roll-out of the PM-WANI network. DoT is engaging with all the PM-WANI stakeholders also for the opportunities.

### Innovations in Wi-Fi by C-DOT

- **Local Content Server Integration:** C-DOT has integrated the Wi-Fi solutions with Local Content Server, so that even without internet access, users can access education and information content hosted on the Local Content Server.



## [COVER STORY]

### Wi-Fi

Till date, C-DOT has facilitated 51 PDOAs and 45 APP providers with the PM-WANI India Stack. It makes the PM-WANI technology seamless, so that service providers can focus on the network operations and on building a successful business model.

#### Testimony of Rural Deployment of C-DOT Wi-Fi



C-DOT Wi-Fi Installation at Rohta Block



C-DOT Wi-Fi Installation at Akola Maharashtra



- DVB-T2/S2 Integration: C-DOT has also integrated the Wi-Fi solution with DVB-T2/S2 to provide access to the terrestrial and satellite channels over Wi-Fi. This would help in reducing the load on 4G backhaul when multiple subscribers are streaming Live channel content on their phones and also providing access to educational channels in villages.

#### Role of C-DOT in PM-WANI

C-DOT has played a key role in PM-WANI. Be it the design and development of PM-WANI Central Registry within one month or the Central Registry for onboarding PDOAs and APP Providers.

After the scheme was launched, C-DOT observed a lacuna in the space of PDOA and APP Provider technology providers. C-DOT then started the development of the PDOA and the APP solutions. Till date, C-DOT has facilitated 51 PDOAs and 45 APP providers with the PM-WANI India Stack. It makes the PM-WANI technology seamless, so that service providers can focus on the network operations and on building a successful business model. 🙌

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# Revolutionising the 5G Backhaul – The world's first multi beam, E-band radio for Multiple-Point-to-Point (Multi-P2P) communication

GigaMesh provides multi-Gbps mesh connectivity to 5G sites at a fraction of cost of fibre



BY NEHA SATAK

It is a revolutionary new concept that the Hon'ble Prime Minister himself referred to in one of his Mann Ki Baat programs.

In the last decade, there has been an impetus to move to higher frequency spectrum (millimeter wave or mmWave) so that higher data rates can be achieved

in wireless communication to cater to the increasing data demand.

Among millimeter wave frequencies, the E-band frequencies (71-76GHz and 81-86GHz) have gained much traction due to their fibre-like data performance with very small unit size.

With the roll out of 5G networks in our country, the number of cell towers will increase at an exponential rate. It will become more and more difficult to connect every tower with fibre.

Point-to-Point communication means that one equipment at one site can communicate with only one other equipment at another site.

Some of the major telecom OEMs have also come up with products in the E-band but they are too expensive to be considered for rural deployment in developing countries. The main reason for the high cost is the Point-to-Point nature of the current state-of-the-art technology. Point-to-Point communication means that one equipment at one site can communicate with only one other equipment at another site.

The objective was to make E-band a more viable alternative to fibre for local needs of India. Astrome was founded in Bangalore India, in 2015, and incubated by the Indian Institute of Science. It is pioneering the future of millimeter wave wireless communication – be it on earth or in space.

Astrome developed GigaMesh - the world's first E-band radio that features Multiple-Point-to-Point (Multi-P2P) communication which offers low CapEx and OpEx costs as compared to current solutions.

The major differences between GigaMesh and existing E-band radios are:

- GigaMesh device can simultaneously communicate to multiple surrounding GigaMesh radios while maintaining the full data throughput to each surrounding radio.
- GigaMesh automatically aligns antenna during initial deployment
- Realignment of link when a fault occurs is also automated
- The formation of links to new towers is made easy through just a Software command.
- GigaMesh also has inbuilt intelligence to support dynamic power allocation to maintain optimum SLAs

GigaMesh provides multi-Gbps mesh connectivity to 5G sites at a fraction of cost of fibre.

It reduces time-to-market for deployment of 5G services and fits as fronthaul, midhaul and backhaul.

In its Fronthaul configuration, GigaMesh interfaces with an radio unit, RU, and transports the data from multiple RU sites to the DU location. As midhaul, GigaMesh can interface with DU on one side and CU on the other side. GigaMesh is also compatible to work as 4G and 5G backhaul.

In most developed countries, at least 80% of the 4G infrastructure and towers are connected with fibre compared to only 30% that are connected in developing countries.

With the roll out of 5G, the number of cell towers will increase at an exponential rate. It will become more and more difficult to connect every tower with fibre.

There is a need for wireless technologies that can deliver fibre-like data speeds at lower cost than fibre. Such a solution can also help distribute fibre capacity from cities to nearby towns and villages, especially in the emerging markets where most population reside in towns and villages.



See link to video of Hon'ble Prime Minister mentioning Astrome: [shorturl.at/BFGMV](https://shorturl.at/BFGMV) 🙌

Gneha Satak, CEO, Astrome  
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## PROFILE: Indian origin, Vijay Sankaran, is the global Vice President and CTO of Johnson Controls, the world's largest technology and software company for making buildings smarter.

In our urban environments, buildings account for almost 40% of global greenhouse gases



BY AANCHAL GHATAK

**W**e know there are Intelligent, healthy, living, breathing and responsive humans. We also know of green, unpolluted environments mostly in reference to our land, forests, fauna and the planet as a whole.

But rarely, if at all, do we think of these adjectives when we look at those massive steel, concrete, glass and iron buildings dotting our landscape, that are now part of our daily lives – from office to home, we are in and out of these structures daily.

But for Vijay Sankaran, vice president and chief technology officer for Johnson Controls (JC), there is no other way to look at buildings. Across 150 countries in

the world, Vijay looks at millions of buildings and sees in them living, breathing, wide open spaces – filled with humans and other living creatures – where people spend large chunks of their lives.

Be it offices, homes, shopping complexes, hospitals, schools, industrial complexes or plain old warehouses, Johnson Controls is spearheading new solutions to make these structures smarter, more efficient and sustainable through technologies and software solutions deployed in buildings across over 2000 locations in the world.

And in his current role, Vijay Sankaran, heads the entire technology, software and platforms development that power these buildings. Whether it is the security

Be it offices, homes, shopping complexes, hospitals, schools, industrial complexes or plain old warehouses, Johnson Controls is spearheading new solutions to make these structures smarter, more efficient and sustainable through technologies and software solutions deployed in buildings across over 2000 locations in the world.

and access systems for entering these spaces, or the cleanliness of the air inside, or the hundreds of devices that enable life inside buildings, (air conditioners, thermostats, cooling / heating controllers, electrical gadgets) Vijay's job is to ensure these are running seamlessly, smoothly and delivering comfort to inhabitants.

Till recently Vijay was the Chief Information Officer and Head of Innovation at TD Ameritrade, a financial services firm dealing in stocks, trading, mutual funds and cash management services. Some of Vijay's responsibilities here were taking care of the digital strategy, software engineering, technology operations, cybersecurity and data analytics. Prior this he held senior executive roles in the automobile industry – at Ford Motor Co. where he was the IT CTO and leader of applications development. Thus,

the smart building transition, though a bit unexpected, was easy given his multi dimensional career.

He is clearly excited about his role in creating the smart buildings of the future. "For one these smarter spaces will help sustainability on a variety of parameters," he said.

For example, the Gurgaon office of JC brings a feeling of wide open spaces, pleasant ambient lighting (close to natural light) and a buzzing, energetic team moving around their daily work.

In our urban environments, buildings account for almost 40% of global greenhouse gases. Enabling them with better energy management and efficiency reduces the operating costs for owners. It also significantly



We've taken a very distinctly outside-in view, which is: what aspiration and challenges our customers have and how we can solve them through data analytics, AI, digital experiences and digital solutions in an overall software platform.

minimizes the carbon footprint. As the human race continues to build more, managing the impact of carbon emissions is a major goal for JC. And also for Vijay.

"This will play a very significant part in managing global warming and climate change," he says, speaking to Voice&Data during one of his recent trips to meet the JC India Team, which is expanding fast across multiple cities and working out of amazingly smart buildings.

Smart buildings will not only be better for tenants, but also for owners and the global environment. "We now need more people to think about making buildings sustainable," says Vijay.

Healthy buildings have become an obsession for everyone post Covid-19. JC technologies are ensuring that buildings manage their environments autonomously, and respond to changes. Vijay explains this: "Intelligent Buildings – are all about data. How to use the data from inside the building, from the edge devices in use, and the external data, with AI and ML, to drive customisations for better outcomes."

"We often think of how autonomous vehicles could change our lives in the future. But, how often do we consider the impact an autonomous building could have?"

How is this achieved?

It is part of his portfolio. Vijay is heading an initiative inside of JC that brings cutting edge solutions to handle the challenges of smart buildings. To bring data from the many sources – security equipment, fire detectors, automations like lifts and escalators, the chillers and HVAC units that keep buildings at a steady temperature and many more – onto a platform called the Open Blue Bridge. It connects all the diverse devices inside a building on a single platform and aggregates information, data points and inputs to derive greater intelligence and thereby manage the system better.

"We've taken a very distinctly outside-in view, which is: what aspiration and challenges our customers have and how we can solve them through data analytics, AI,

digital experiences and digital solutions in an overall software platform."

Johnson Controls and the technologies being overseen by Vijay are comprehensive engineering solutions that use remote diagnostics for effective responses to day to day operational management of equipment and facilities.

For Vijay Sankaran who holds a bachelor's degree in mathematics and computer science from the Massachusetts Institute of Technology, these are exciting areas to apply his expertise.

He is also clearly excited to be able to oversee the creation of such cutting-edge solutions in India and deployed here. The roots are deep. Vijay was born in the US, where his parents had migrated. But after decades in the American corporate sector, he is thrilled to work with Indian companies again and be a part of where the country is headed as a leader in technology and as a nation.

"India's digital revolution started some years back, and we have seen great improvement in sectors like e-commerce, digital payments, Internet connectivity and more data centers," he says. "India is poised to be a global technology leader in years to come," he adds. Some of this technology will include solutions for smart buildings of the future from JCI development centers in Pune, Bangalore and Gurgaon.

This will also allow Sankaran to travel to India more often and witness other changes in like in the area of sports, where India is beginning to make a mark in nearly every discipline in all global events. Vijay is himself a sports enthusiast, a keen follower of football and basketball in the US and a fan of the Michigan University teams. Both his sons are also competitive Tennis players.

In his spare time, Vijay enjoys watching fantasy movies and television shows – which perhaps serve to transport him into the future and to new frontiers of technology that may be relevant for our buildings and the planet. Because this is the only Planet we have. 🌍

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