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WHITE PAPER
ON THE OCCASION
OF
WORLD WIFI DAY
ON

PROLIFERATION OF BROADBAND THROUGH WIFI

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EXECUTIVE SUMMARY

Robust Broadband connectivity is the underlying backbone for Digital Connectivity. During the COVID-19 pandemic, as physical roads and highways went largely underutilized, the global broadband highway witnessed a surge in core traffic. Recent IP traffic measurements indicate that peak IP network traffic has stabilized at 25% to 30% above pre-COVID-19 pandemic levels[1]. In India, internet traffic surged by as much as 40% during the national lockdown[2]. The smooth functioning of public networks, especially in times of crises, is contingent upon the rollout of reliable, affordable & ubiquitous digital infrastructure. A strong optical fiber network, intelligently deployed towers, ample radio spectrum, commercial satellite access and the ubiquitous deployment of public wifi services are essential components of modern digital infrastructure.

Ubiquitous connectivity through modern telecommunications services is also a key engine of national economic success, and broadband services allow local economies to tap into unprecedented productivity gains that help catalyze inclusive and sustainable growth.

Broadband may be delivered via a variety of mediums. Cellular access is among the most mobile & ubiquitous forms of connectivity in India, and most of the nation's broadband subscribers use it as a primary medium to connect to the Internet. Fixed services provide high-speed & reliable broadband to homes and businesses, wherever physical infrastructure allows it, and satellite services have excellent potential to provide connectivity in hard to reach parts of the country, and can even act as a redundancy or backup network in times of need. WiFi, as a medium, combines the best of all of the above, i.e. offers reliable, high-speed mobile connectivity to the internet, and is extremely cost effective to deploy. Yet, there exists significant potential for public WiFi to grow as India embraces a digital lifestyle.

The far & wide deployment of commercial public WiFi is a key focus area for this whitepaper. The paper sets the context with a comprehensive accounting of the socio-economic effects of broadband, as well as what delays rollout to rural areas. The paper also adopts the use of the original WANI (WiFi Access Network Interface) architecture, facilitated by the TRAI through an elaborate consultative exercise, and perfected through a pilot deployment by industry experts from XiFi Networks, Cotyledon Technologies, Airjaldi Networks and others from all over the nation[3], to propose a commercial solution (JanWANI) that enables the deployment of community led and community deployed commercial public WiFi services in India.

The WANI architecture does for broadband connectivity what the India Aadhar stack and UPI have collectively achieved for financial inclusion in the country. Once fully realized, this architecture will not only enable the provision of cost effective public WiFi, but will also act as a powerful engine for rural skill development and generate significant employment opportunities.

[1] Robuck, M., 2020. Nokia Deepfield: Network traffic stabilizes to 25% more than pre-coronavirus pandemic levels. [Online] Available at: *https://www.fiercetelecom.com/telecom/nokia-deepfield-network-traffic-stabilizes-to-25-more-than-pre-covid-19-pandemic-levels*

[2] News18.com, 2020. Internet Traffic in India Sees 40% Spike in March Due to COVID-19 Lockdown: ACT Fibernet. [Online] Available at: *https://www.news18.com/news/tech/internet-traffic-in-india-sees-40-spike-in-march-due-to-covid-19-lockdown-act-fibernet-2612669.html*

[3] G, Arjun, 2018. India to have One million WANI compliant PDOs by 2019. [Online] Available at: *https://medium.com/redact/india-to-have-one-million-wani-compliant-pdos-by-2019-59ec83b3b712*

THE ECONOMIC IMPACT OF CONNECTIVITY

The socio-economic impact of broadband is significant and pervasive to a degree that supports the overall growth of an economy - regardless of its current level of development. A seminal study for the World Bank[4] showed that for every 10-percentage point increase in broadband penetration, developing nations would observe a corresponding and directly attributable increase of 1.38% to their Gross Domestic Product (GDP). In the time since, several studies have concluded with similar findings.

A recent report by ICRIER[5] reveals that in the case of India, a 10% increase in mobile penetration increases economic output by 1.9%. They also note that a 10% increase in internet subscribers, can increase state gross domestic products by as much as 3.2%. Their report also reveals significant positive effects associated with increases in internet traffic, as well as that a 10% increase in telecom investments would increase India's GDP by 3.3%.

In addition to economic impact studies that attempt to quantify effects on local & national domestic product, consumer surplus analyses are often employed for a more well-rounded understanding of how connectivity affects socio economic development. Such analyses are geared to estimate not only the economic value that accrues from the availability of connectivity, but also estimates of value added to the lives of consumers.

A consumer surplus study by WIK & BIF[6] in 2018 revealed that use of productive internet applications[7] *"saves on average 803.9 minutes per week for Indian consumers. Based on the average annual income in India (INR94,130), this translates into an annual consumer surplus of US$98 billion in 2017. Thus, each user of RIAs in India receives on average US$249 of consumer surplus annually. Applied to the entire population—not just RIA users—this results in US$74 per capita."*

The role of communications infrastructure in enabling overall socio-economic development is significant, making a strong case for the far & wide rollout of network infrastructure that can ensure universal connectivity to high-speed internet. India's National

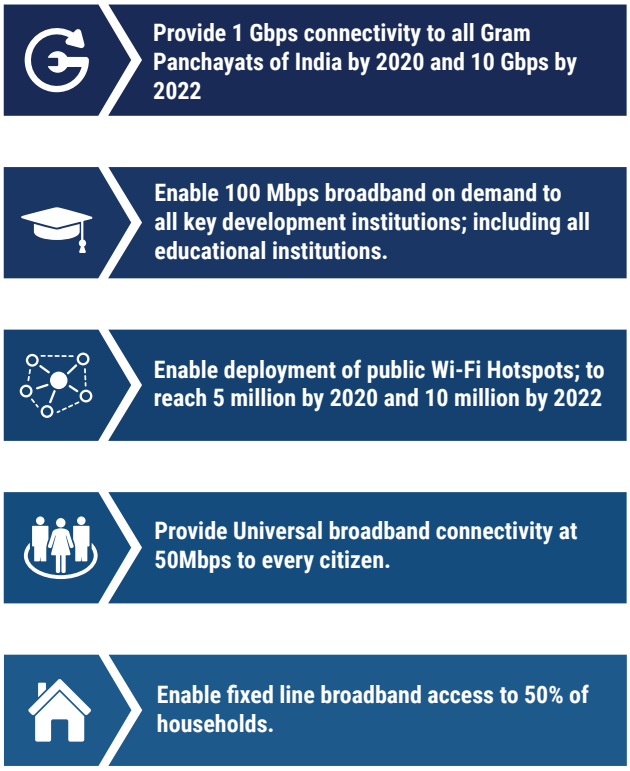


Figure 1: Connect India goals of the NDCP

Digital Communications Policy, 2018[8] highlights the importance of broadband and prescribes novel targets & milestones that must be achieved for India to become truly digital, which would in turn enable the development of a $5 trillion economy. It prescribes targets not only for universal connectivity, but also to ensure that it is affordable and of high quality (Figure 1). The Goals of Connect India in the NDCP talk of enabling the deployment of public Wi-Fi Hotspots; to reach 5 million by 2020 and 10 million by 2022, and further under Point 2.1.b.vi – *"Promoting Open Public Wi-Fi access through Wi-Fi / Public Data Office Aggregators and Public Data Offices."* The total count of WiFi hotspots in the nation currently stands at a little over 350,000 hotspots.

PREFERRED MEDIUMS FOR RURAL & COST-EFFECTIVE CONNECTIVITY

Over the years, cellular technologies have generally focused on providing services to urban areas, leaving rural areas unaddressed in terms of network coverage.

[4] Qiang, C. Z.-W., Rossotto, C. M. & Kimura, K., 2009. Economic Impacts of Broadband, s.l.: World Bank.
[5] Kathuria, R., Kedia, M., Sekhani, R. & Krishna, U., 2018. Growth Dividends of Digital Communications, New Delhi, India: ICRIER & Broadband India Forum.
[6] Arnold, R., Hildebrandt, C., Kroon, P. & Taş, P., 2017. The economic and societal value of Rich Internet Applications in India, New Delhi, India: WIK & BIF.
[7] Defined as applications used for a wide range of functions, allowing two or more parties to interact with each other in numerous ways. Rich mobile applications, rich communications services and rich internet applications classify as such productive internet applications
[8] Department of Telecommunications, Government of India, 2018. National Digital Communications Policy, New Delhi, India: s.n.

This is largely a result of an impaired business case, insofar as rolling out connectivity to remote & rural areas is concerned. High last mile rollout costs ultimately result in an increase in the digital divide among rural and urban areas.

Although WiFi (IEEE 802.11) had been evolved for providing a wireless alternative to local area networks, it has now developed to be a cost-effective option for long distance applications as well[9]. Due to its successful practical implementation over large distances, WiFi is fast emerging as a suitable medium for rolling out digital connectivity in far flung rural areas.

Last mile WiFi connectivity, unlike last mile cellular access, is relatively quicker & far more cost effective to rollout. It is in fact due to the way in which WiFi deployments are currently set up that prevents its wide scale adoption. The non-portable nature of WiFi (i.e. typically offered within a defined boundary) is among the most significant factors that render it unattractive to Indian consumers, especially as a service to be paid for. In the later sections of this whitepaper, we describe a public WiFi model that addresses this and other factors that prevent large city and national scale deployments.

WiFi is a suitable vehicle to take last mile broadband connectivity to rural areas. A vastly superior business case emerges when combining fundamental reforms to the regulatory regime, with the ongoing development of the technology.

THE IMPORTANCE OF LICENSE EXEMPT SPECTRUM IN 6GHZ BAND

With a mix of indoor low-power operations over the full 1,200 megahertz and standard-power devices in 850 megahertz out of the entire 6 GHz band, the FCC has unleashed a powerful alternative to accelerate broadband penetration across the rural and remote areas of the United States of America. An automated frequency coordination system prevents standard power access points from operating where they could cause interference with incumbent services. Combined with the ability to support low-power indoor access points that can drive high data rate applications such as AR & VR, the 6GHz band is uniquely suited to bring low-cost last mile connectivity to both rural & urban areas across the world.

With room for seven new 160MHz channels - and with no interference from previous-generation devices - the 6GHz band could potentially serve as a multilane superhighway for the latest Wi-Fi devices, all of them using Wi-Fi 6, the newest, fastest and most efficient version of Wi-Fi.

EVOLVING TO WIFI 6

The evolution of WiFi to WiFi 6 is as great a step forward technically as 5G is to LTE. Given significant improvements, the technology is no longer at threat of being rendered ineffective by cheap & reliable cellular access, but emerges as a strong complementary technology to 5G.

WiFi 6 also employs MIMO (multiple-input and multiple-output) to multiply the capacity of the radio link using multiple transmission and receiving antennas to exploit multipath propagation, and can use both multi-user MIMO and OFDMA simultaneously. Under thie new standard, 'nominal' data rates are significantly improved, and the standard doubles down on spectrum-sharing and re-use between devices. Due to its ability to enable high speed communications over separate streams, with disparate quality of service requirements, Wi-Fi 6 emerges as a prime candidate for 'peer-to-peer' integration with 5G (which sports similar capabilities).

Wi-Fi has many flavours and is designed to operate using non-contiguous blocks of spectrum. This is emblematic across many regulatory specifications. In the 802.11 ac version of Wifi, the sub-band size for high data rate applications is 80 MHz, which can be used either to create additional 160 MHz channels, to deliver gigabit service in a single 80 MHz, or be sub-channeled into four twenties for high density applications. Over the near future wider channels to support the new applications will be necessary. More contiguous 80 MHz and 160 MHz channels for .11ac and .11ax deployments will be key in delivering sustained throughputs in the 1 Gb/s range in dense enterprise and residential settings. The 6 GHz band, recently delicensed by FCC[10] provides access to greater bandwidth, enabling gigabit WiFi – the type of use that can support emerging applications and technologies. Similar reform is an urgent requirement for realizing the true potential of WiFI in India.

With the latest 11ax standard, the capacity of an Access Point will hit 10Gbps (theoretically) requiring further opening up of more bands. Hotspots in 6GHz band will also support point to point and multipoint connections suitable for extending fiber POPs at Gram Panchayats to nearby villages without digging fiber. Due to low CAPEX and OPEX of operating in the ISM band, affordable last mile broadband to villagers in the form of grouping is

[9] S. Nandi, S. Thota, A. Nag, S. Divyasukhananda, P. Goswami, A. Aravindakshan, R. Rodriguez, and B. Mukherjee, "Computing for Rural Empowerment: Enabled by Last-mile Telecommunications," IEEE Communications Magazine, vol. 54, no. 6, pp. 102– 109, 2016.

[10] Federal Communications Commission, 2020. FCC Opens 6 GHz Band to Wi-Fi and Other Unlicensed Uses. [Online] Available at: *https://www.fcc.gov/document/fcc-opens-6-ghz-band-wi-fi-and-other-unlicensed-uses*

only possible using WiFi.

COMMUNITY NETWORKING AND VILLAGE LEVEL ENTREPRENEURS

At a community level, WiFi offers several rollout advantages over cellular and fixed last mile connectivity. First, WiFi utilizes unlicensed spectrum which is separate from licensed cellular bands, making its deployment economically viable for local entrepreneurs. Second, the latest WiFi technology can provide remarkably high data transfer rates, allowing for the provision of reliable high-speed connectivity to the internet. Third, WiFi and cellular technology are continuously converging with the development of mechanisms and protocols following the specifications of the latest 3GPP releases[11], and this integration is expected to be even higher in emerging 5G systems[12]. Therefore, it is not surprising that WiFi traffic is expected to exceed cellular traffic as over 50% of mobile data traffic is expected to soon be served by WiFi networks[13].

The spirit of community driven networks has also been enshrined in the National Digital Communications Policy 2018. Promoting Open Public Wi-Fi access through Wi-Fi / Public Data Office Aggregators and Public Data Offices has been specified as key reform required in the prevailing regulatory & licensing regime. The JanWiFi model envisioned in the policy takes due cognizance of the fundamental building blocks that are essential for the rollout of community networks that empower both the consumer as well as local entrepreneurs.

Despite concerns over the sustainability and scalability of community networks, they have flourished around the world as complementary models for enabling access to the Internet and its services. A study of the approach taken by community networks such as Guifi.net is valuable in this regard. As the largest community network in the world, Guifi.net has an annual turnover of millions of euros and has created many direct jobs. The success of well-designed community networks is a testament to the fact that when appropriately implemented, such constructs can drive socio-economic growth throughout local economies.

The WANI model described in the next section enables village level entrepreneurs (VLEs) to set up and monetize wifi hotspots. The model also offers the right kind of monetization incentives for village level entrepreneurs who would provide the services, as well as convenient ways to onboard and retain consumers. Using an aggregator approach, the model envisions the sale of bulk bandwidth to Public Data Office Aggregators that would in turn provide base connectivity to VLEs (individual Public Data Offices). VLEs would then be able to set up local hotspots and offer broadband services to consumers. The model also proposes simple payment mechanisms for users to pay for wifi services. Combined with the ability to offer seamless roaming between hotspots managed by different PDOs and PDOAs, the model inherently captures the kind of value that allows for the effective monetization of resources, renders the service highly attractive for potential customers, and establishes a strong business case for substantive supplemental income for local entrepreneurs. At a high level, the basic design of the model resembles the public call offices administered in India in the late 1970s. As recently as 2006, over 4.2 million Public Call Offices were run by small businesses for supplemental income in India[14].

THE WANI MODEL

A fit-for-purpose commercial public WiFi model for India must provide incentives for both providers to profitably expand the scope of their services, as well as offer substantive value for consumers to adopt the services with a high degree of confidence. An aggregator model compatible with the Public Data Office Aggregator model envisioned in the National Digital Communications Policy 2018 is described in this section.

WANI, in its original form and as recommended by TRAI, enables seamless authentication and roaming between different Wi-Fi networks, obfuscating the need for repeated authentication. With convenient one-time authentication, and the benefit of roaming, the model offers greater security & peace of mind to potential consumers. WANI effectively removes the need for One-Time Passwords that are typically required by public WiFi for egregiously short durations of time.

In addition to the above, WANI, once implemented can enable emerging communications technology in a seamless manner. Given the high throughput & low latency features of modern flavors of WiFi, zones

[11] 3GPP, "Technical Specification Group Services and System Aspects; Architecture enhancements for non-3GPP accesses (Release 13)", 3GPP TS 23.402 V13.3.0 (2015-09)

[12] Next Generation Mobile Networks (NGMN) Alliance, "5G White Paper", Feb. 2015, [Online]: www.ngmn.org

[13] Cisco, "Visual Networking Index Forecast", 2018

[14] "Quarterly performance indicators of telecom services for the financial year ending March 2006" (PDF) (Press release). Telecom Regulatory Authority of India.

served by WANI hotspots could even support local deployments of emerging IoT systems and platforms. Connecting operators via an exchange to a large scale WANI implementation would allow for large scale IoT deployment. In effect, WANI provides an effective short cut to enable true and ubiquitous muti vendor Internet of Things.

WANI CAN UNLEASH A WAVE OF LOCAL INNOVATION

Light regulatory requirements associated with UPI, where digital wallets co-exist with banks, vastly simplified the process to set up a payment banking business, allowing the creation of many valuable small and medium enterprises. The simple yet elegant regulatory structure proposed by TRAI for a WiFi Access Network Interface (WANI) would similarly aid many local entrepreneurs provide high quality commercial public WiFi services as well as provide significant opportunities for growth.

The WANI model, not unlike the administration of Public Call Offices, would also provide supplemental income for local entrepreneurs, as well as a much needed service demanded by consumers. It would additionally generate immense value for the entire community.

WANI CAN HELP BRING CUTTING EDGE EMERGING COMMUNICATIONS TECHNOLOGY TO MARKET

Interfacing upcoming Multi Vendor Internet of Things platforms with WANI would enable nation wide network connectivity across multiple devices. In a nation where networks lack ubiquity either in coverage or in quality, the ability to affordably provision as well as access a high quality network must be seized.

WANI would also provide a level of security on par with the kind available in private networks. With many nations engaged in a scramble to define a set of standards to conform to the market, WANI could potentially lead the earliest on-the-ground implementationsof large scale mvIoT, and in turn let the market define the standard. WANI's strength is its open standards approach, which can in this particular case allow a multitude of proprietary IoT networks to co-exist and function so long as they use WANI standards for inter-operations. Similar to how any payment technology or standard is allowed in India as long as it is capable of interfacing with UPI, WANI can secure India's technical sovereignty while ensuring that both the needs of the business and of consumers are met in as open and transparent a manner as possible.

WANI CAN BRING URGENT RELIEF AND OPERATIONAL EFFICIENCY TO A STRESSED ECOSYSTEM

WANI's design and specifications lend themselves to driving operational efficiencies for incumbent service provider. It would allow for the offloading of smartphone traffic to WiFi, to the benefit of consumers & service providers. The low costs associated with rolling out WANI compatible hotspots, combined with the benefits of seamlessly connecting to alternate networks like IoT would allow operators to save on significant duplication costs with significant, immediate & positive impacts to their bottom-line. Intuitively, WANI would also allow large service providers to quickly & affordably bring other emerging communications technologies (that rely on high throughput and low latency networks) to market.

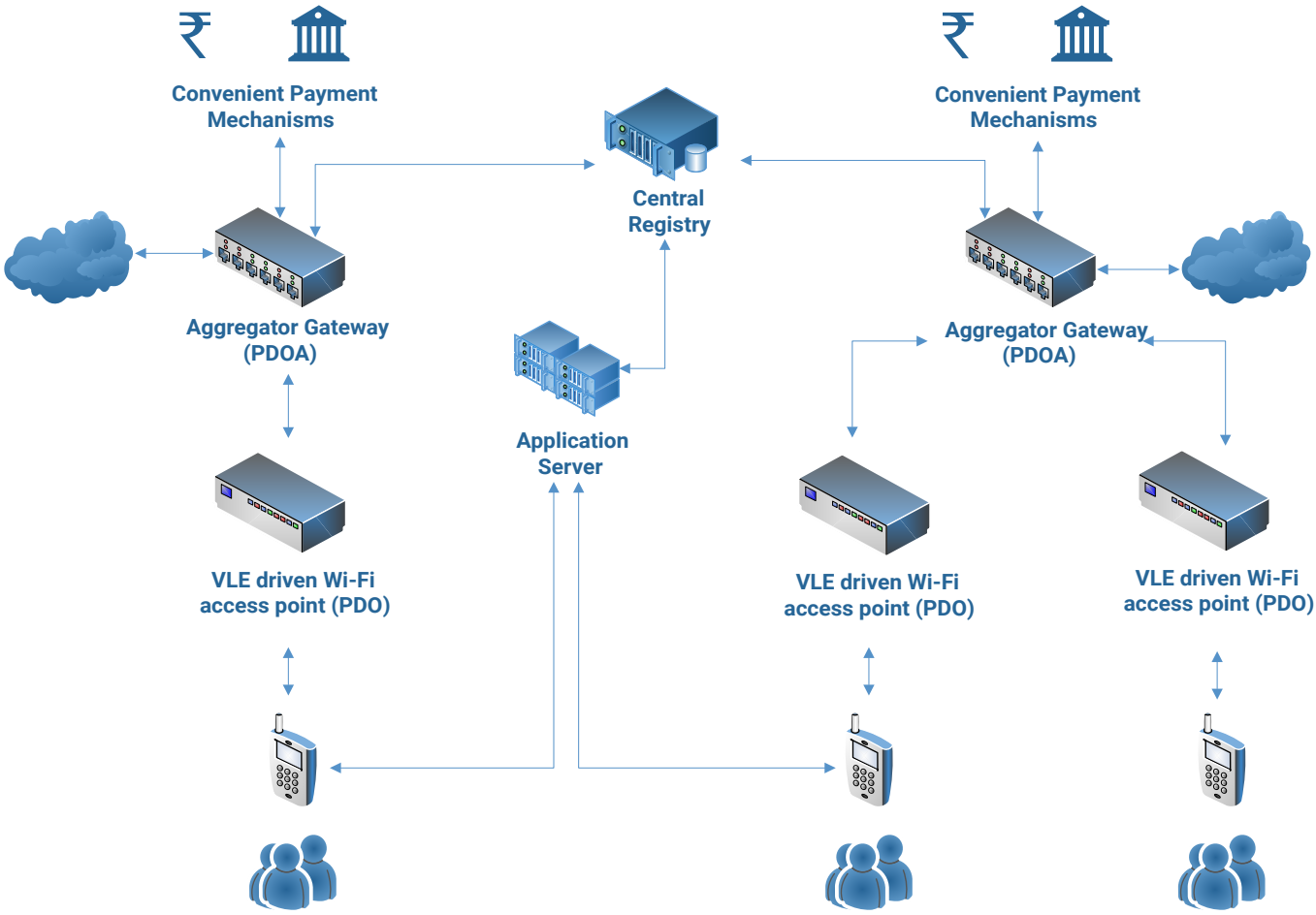
FROM WANI TO JANWANI

The following conception of an aggregated model based on the open WANI architecture (JanWANI) (Figure 3) is geared to help local entrepreneurs deploy wifi networks, increase their customer base, significantly improve the utilization of the network, as well as organically build lasting customer loyalty. At an operational level, the platform offers the ability to enable roaming between participating hotspots, accept multiple forms of payment, consolidate billing, and add new revenue streams through the provision of value-added services.

The WANI model enables entrepreneurship at the village level by embracing the public data office aggregator approach. The JanWANI model described above embodies these WANI principles by allowing public data offices, or village level entrepreneurs to roll out WiFi services affordably, as well as offer mechanisms to better monetize their deployed infrastructure. Aggregator hubs (PDOAs) can use the platform to deploy applications and improve the business case for deployment by layering on a wide range of value-added services that take advantage of the APIs provided by the platform. The aggregation model allows providers to ensure their customers stay connected to a WiFi hotspot as they move over large distances. This unique, but certainly not the only benefit of the aggregator model makes a compelling case for commercial WiFi services customers are actually willing to pay for.

For consumers, gaining access to services has been designed to be as simple as downloading an application, followed by a one-time registration that makes available to them a wide variety of partnered hotspots. A single authentication process then enables seamless connectivity as the user moves from one zone to another. Smart billing features built into the platform also allow users the flexibility to pay as they go. At the same time, the design of the network allows for an equally fair apportioning of costs and revenues for participating service providers.

JANWANI Open Architecture



Flexible & Secure User Authentication

Seamless roaming between WiFi Providers

Industry Standard Security & Billing Protocols

Multiple user friendly payment mechanisms

New User enters parent network

A new user can log into a hotspot through the WANI Application.

Registration: Users register with a Mobile Number and Email Id

After the user has chosen the desired payment options & data pack, the status is updated in the Central Registry & data usage is monitored & updated on a regular basis.

Existing User enters partner network

Every user who enters a partner network is authenticated & verified. Once verified, users are given access to the internet or asked to recharge using a number of convenient digital payment mechanisms. New users would be given an option to register

User authentication & data usage are validated by the Central Registry prior to enabling access.

Existing User is low on Data when roaming in a partner network

A Users data allowance is constantly monitored & if below a threshold, triggers a warning, followed by an option to purchase a new/top-up data pack.

Users can renew the service at the same cost, or can recharge with the data plans provided by the partner network, and avail a seamless WiFi roaming service wherever partner hotspots exist.

Figure 3: WANI Open Architecture & Key Benefits

CONCLUSION

WiFi is incredibly versatile - offering the mobility of cellular, the reliability of fixed connectivity and affordability unlike any other. This makes WiFi a suitable vehicle for taking last mile connectivity to rural and other areas deemed commercially unviable for cellular or fixed connectivity. The catalytic effects of connectivity make for a compelling case to do as much as is possible to connect the least connected parts of India. The productivity premiums associated with the rollout and adoption of affordable, reliable and high-quality connectivity are numerous & significant; and must be pursued if India is to ever become a truly digital economy.

The opening up of spectrum bands critical for the implementation of large scale deployments of the technology is a fundamental reform that must be undertaken. As the technology matures to WiFi 6 & beyond, fresh capacity would be required to cater to many applications that would emerge along with the evolution of the technology. Given the roadmap defined by international standards development bodies, WiFi is quickly transforming into a highly complementary technology to 5G. This further reinforces the business case for large scale WiFi deployments over the near future.

The WANI architecture championed by TRAI has been used in the preceding sections of this paper to present a commercial public WiFi solution (JanWANI) that drives entrepreneurship at the village level. Aggregator hubs, also known as Public Data Office Aggregators (PDOAs) enable individual village level Public Data Offices (PDOs) with connectivity to the internet under this model. Under such a construct, local entrepreneurs can affordably set up local WiFi hotspots and offer commercial services to consumers. The model also envisions seamless roaming between participating hotspots and providers across multiple aggregator hubs located all over the nation. In its fully realized form, JanWANI would drive skill development and enable local entrepreneurs to quickly begin offering an affordable & high quality service to consumers.

In addition to enabling the cost effective rollout of high quality commercial public WiFi services, JanWANI would also be well equipped to quickly and effectively deploy large scale IoT. Other emerging communications technologies that rely on the availability of high-speed and low latency networks would also be easier to roll out in areas covered by JanWANI hotspots. Combined with the support for seamless roaming through and across partner zones, truly mobile and multi vendor applications could be deployed with ease. The design of this architecture not only enables the provision of a better ccommercial grade WiFi service, but also drives innovation in a manner that is empowering for local entrepreneurs, customers and entire communities.