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Telecom Regulatory Authority of India

Consultation Paper
on
Proliferation of Broadband
through
Public Wi-Fi Networks

New Delhi

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Written Comments on the Consultation Paper are invited from the stakeholders by 10/08/2016 and counter-comments by 24/08/2016 Comments and counter-comments will be posted on TRAI's website www.trai.gov.in. The comments and counter-comments may be sent, preferably in electronic form, on the email ID broadbandtrai@gmail.com

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Chapter I

Introduction

1.1 The growth of Internet penetration in India and realisation of its full potential is closely tied to the proliferation of broadband services. "Broadband" is currently defined to mean a data connection that is able to support interactive services, including Internet access, with the capability of a minimum download speed of 512 kbps. It therefore refers to a means of delivering high-speed Internet access services.

1.2 Broadband services can be delivered through a number of different access technologies, both wired and wireless, including Digital Subscriber Lines (DSL), optical fibre technology, cable TV networks and mobile broadband services like 2G/3G/4G. In addition to these, radio frequency signals (or spectrum) can also be used for the creation of "wireless local area networks" (WLANs), offering an effective mechanism for extending the "last-mile connectivity" of broadband connections to a wider segment of users.

1.3 The term Wi-Fi (an acronym for Wireless Fidelity) is commonly used to refer to the array of technical standards (802.11 standards and various amendments to it) developed by the Institute of Electrical and Electronics Engineers' (IEEE) that can be used to create WLANs. Strictly speaking, Wi-Fi is a certification provided by the Wireless Broadband Alliance[1] (WBA), which owns and controls the "Wi-Fi Certified" logo that can be applied to products that satisfy certain interoperability criteria. The certification is centred on the following tenets:

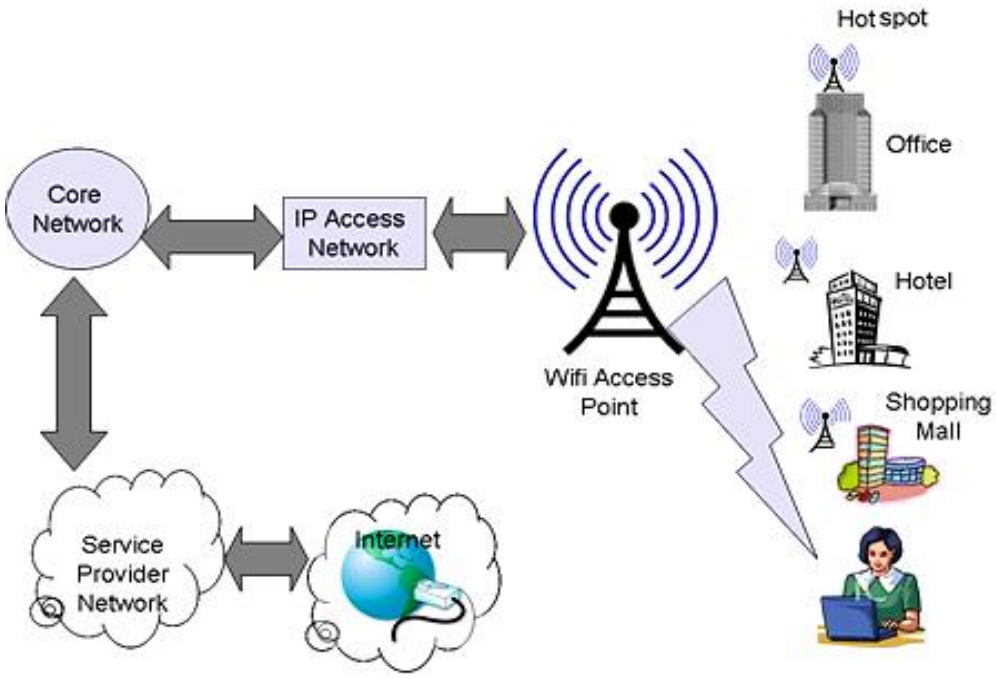
- *Interoperability* is the primary target of certification. Rigorous test cases are used to ensure that products from different equipment vendors are interoperable in a wide variety of configurations.

[1] WBA is a non-profit organization, formed in 1999, that promotes Wi-Fi technology and certifies Wi-Fi products if they conform to certain standards of interoperability.

- *Backward compatibility* has to be preserved to allow for new equipment to work with existing gear. Backward compatibility protects investments in legacy Wi-Fi products and enables users to gradually upgrade and expand their networks.

1.4 WLANs created using Wi-Fi technology can be used to connect personal computers, mobile phones, tablets and other appliances to a local network, which in turn provides connectivity to the Internet. These WLANs can be operated for private use, such as in the home, or to create short-range, public networks, known as "hotspots", which can be found in public places like airport lounges, coffee shops or neighbourhoods.[2]

Figure 1.1: Wi-Fi Access through a Wi-Fi Hotspot



1.5 At present, mobile network data usage in India is significantly higher than other forms of Internet usage. This can be attributed to a number of factors, including the cost and affordability of different broadband services, depth of fixedline coverage and lesser number of public Wi-Fi

[2] International Telecommunication Union, Global Market Trends, available at https://www.itu.int/osg/spu/spunews/2003/oct-dec/wi-fi.html

zones. In 2014, India ranked at 108th position globally in terms of affordability of fixedline broadband services and at 97th for mobile broadband services (postpaid, handset based).[3] This situation highlights the need for better proliferation of Wi-Fi networks that can offer a more affordable and flexible alternative for scaling up of Internet access.

1.6 In general, Internet Service Providers (ISPs) should incur substantially lesser costs in setting up Wi-Fi access infrastructure compared to mobile broadband networks like 2G/3G/4G. This is on account of the fact that Wi-Fi technology utilises unlicensed spectrum, the equipment is both cheaper and more readily available and maintenance and operational costs are significantly lower. It will of course need to take into account the need for backhaul connectivity to the Internet in order to provide Wi-Fi broadband services. The lower cost of Wi-Fi delivery should easily translate into lower prices per MB for the end-users, making it a more affordable service. Added to this is the fact that Wi-Fi networks can often offer faster speeds compared to mobile data, allowing users to access more data-intensive applications and content.

1.7 Wi-Fi networks therefore offer affordable, scalable and versatile technologies that can facilitate the spread of Internet access in rural and urban areas alike. Modern technology also makes it possible to integrate a server with high storage capacity with the Wi-Fi hotspot equipment. As the cost of such servers has come down significantly, along with the cost of storage, and the form factors of such devices are very small, it should be possible to cache or download content for easy browsing even when the backhaul connectivity is not available. Such an arrangement can find great application in storing children's study materials, educational data, agricultural and health related information, as well as movies and

[3] International Telecommunication Union, Measuring the Information Society Report – 2015, available at http://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2015/MISR2015-w5.pdf

entertainment content, for the benefit of Wi-Fi users in areas with irregular connectivity, such as rural areas.

1.8 For the access network, wireless data communication technologies can play a significant role in the penetration of broadband due to ease of deployment and faster roll out. Moreover, it also allows telecommunication service providers to offload their cellular data through Wi-Fi networks to reduce the traffic on their data networks by making use of unlicensed spectrum. While doing so, operators are in a position to offer a better user experience and higher access speeds to subscribers in the Wi-Fi zone, hence facilitating subscriber satisfaction and retention.

1.9 With this background, the objective of this Consultation Paper (CP) is to examine the need of encouraging public Wi-Fi networks in the country from a public policy point of view, discuss the issues in its proliferation and find out solutions for the same. In this paper, "public Wi-Fi networks" has broader meaning and not limited to the Wi-Fi hotspot created by licensed TSP/ISP at public places. There could be small entrepreneurs or even a very small entity which would like to participate in common and shared Wi-Fi network for larger public use. The CP is divided into four Chapters. This Chapter gives the background and introduction of Wi-Fi services. Chapter II provides an overview of the current state of public Wi-Fi services in terms of the advancements in Wi-Fi technology and current models of deployment. Chapter III analyses the issues being faced in proliferation of public Wi-Fi networks in the country and Chapter IV contains the issues for consultation.

Chapter II

Current State of Public Wi-Fi

A. Advancements in Wi-Fi technology

2.1 Wi-Fi uses radio waves that run at a specific frequency, generally 2.4GHz and 5GHz, to create wireless networks. The widespread adoption of Wi-Fi technology is attributable both to technological advancements in standards as well as the fact that most jurisdictions have fully or partially de-licensed the radio frequencies on which it operates, hence drastically bringing down the cost of delivering Wi-Fi services.

2.2 Wi-Fi technology has gone through significant advancements in the years since 1997, when the 802.11 standard was first adopted by the IEEE. These subsequent improvements to the technology have enabled better speed, reliability and security in the usage of Wi-Fi networks. Table 2.1 summarises the Wi-Fi generations currently in use.

Table 2.1: Generations of Wi-Fi Technology

Standard	Year of introduction	Frequency	Maximum connection speed
802.11a	1999	5GHz	54Mbit/s
802.11b	2000	2.4GHz	11Mbit/s
802.11g	2003	2.4GHz	54Mbit/s
802.11n	2007	2.4/5GHz	450Mbit/s
802.11ac	2014	5GHz	1.3Gbit/s

2.3 The original 802.11 standard supported 1 or 2 Mbps transmission in the 2.4 GHz band using either frequency hopping spread spectrum (FHSS) or direct sequence spread spectrum (DSSS). It was followed by the adoption

of the IEEE 802.11b standard, which operates on 2.4 GHz using DSSS and then the IEEE 802.11a standard, which operates on the 5GHz band and offers data speeds of up to 54 Mbps using an orthogonal frequency division multiplexing (OFDM) encoding scheme. These standards were however not inter-operable with each other and over time IEEE 802.11b became the more popular choice, mainly due to the cheaper cost of its adoption. The third modulation standard, 802.11g applied the frequency division techniques of 802.11a but using the 2.4GHz band radio frequencies of 802.11b. It was adopted rapidly due to reductions in manufacturing costs as well as the desire for better speed. The next iteration of the IEEE standard, 802.11n, operated on both 2.4 GHz and 5 GHz bands, which reduced the interference from other products operating in the 2.4 GHz band.

2.4 In early 2014 the IEEE ratified the 802.11ac standard, which brings gigabit speeds to Wi-Fi.[4] 802.11ac uses the 5GHz band and can reach a theoretical data transfer rate of up to 1.3Gbit/s. This speed is the result of three improvements. First, 802.11ac offers wider channels of 80/160MHz compared to 20/40MHz for 802.11n. Second, 802.11ac allows for up to eight simultaneous data streams between a Wi-Fi access point and a client device, whereas 802.11n can only accommodate four. Third, it uses more advanced beamforming technology to transmit data at denser modulations. Furthermore, it is anticipated that future iterations of 802.11ac will be able to achieve speeds up to 3.5Gbit/s. Another improvement is that 802.11ac reduces latency through multiple user MIMO technology, which enables the Wi-Fi transmitter to communicate with different client devices via multiple data streams simultaneously.[5]

[4] IEEE, *Official IEEE 802.11 Project Group Working Timelines*, 24 July 2013, available at http://grouper.ieee.org/groups/802/11/Reports/802.11_Timelines.htm.
[5] MIMO stands for multiple-inputs-multiple-outputs and refers to a Wi-Fi access point's ability to communicate with a client device via multiple independent yet simultaneous data streams.

2.5 In the Mobile World Congress of 2013, three organizations, namely GSMA, Wireless Broadband Alliance (WBA) and Wi-Fi Alliance jointly agreed to include "Trusted Wi-Fi" Network (cellular operator's own Wi-Fi network), as an integral part of LTE (4G) Core. This led to structured 3rd Generation Partnership Project (3GPP) standards getting defined for seamless session handovers from 4G to Wi-Fi and vice versa, thereby affecting mobile data offload. This not only resulted in Wi-Fi assuming greater significance and focus from cellular operators but also established that – "Wi-Fi is a complementary technology, not competing".

2.6 Pursuant to the above developments, Wi-Fi is now recognised as a part of the ecosystem of technologies which will form the 5G technology. Technologies like LWA (LTE Wi-Fi Link Aggregation) would enable LTE traffic to get offloaded to Wi-Fi and then get into main evolved packet core data stream right in the radio access network through a co-located small cell.

2.7 Globally, the past few years have also seen public Wi-Fi platforms evolving from supporting affordable broadband coverage and capacity for best effort access, to becoming truly carrier-grade. That process is still ongoing, but of late, rising uptake of some of the technologies is contributing towards making Wi-Fi carrier-grade. This includes technologies such as Passpoint and Next Generation Hotspot (NGH), the 802.11ac upgrade, and closer integration with other operator networks like cable and cellular networks. A carrier-grade Wi-Fi network has several key characteristics including high performance (more than 1Gbps for 802.11ac); handoff and seamless authentication across multiple Wi-Fi networks and to cellular networks; roaming capabilities; high levels of

security and quality of service; and the ability to be managed by a carrier's operator/business support systems.[6]

2.8 As seen from the above discussion, the recent standardisation work on Wi-Fi has focused on improved performance and the use of bands other than the 2.4GHz band, which is recognised as becoming increasingly crowded. While the pressure to designate additional bands for use by Wi-Fi devices, will remain, globally, there is also a move to consider expanding backhaul capacity by utilising other bands of spectrum that remain largely unused. For instance, by utilising TV White Spaces (TVWS) - spectrum in the Very High Frequency (VHF) and Ultra High Frequency (UHF) bandwidths, which is currently earmarked for TV broadcasting but remains unused.

B. Status of adoption of Wi-Fi networks

2.9 Globally, Wi-Fi has captured many peoples' imagination because it enables multiple users to share the same Internet connection — all of them without cables — allowing full portability using laptop, PCs or other devices. Wi-Fi's popularity has also been fuelled by the fact that the equipment needed to create a Wi-Fi hotspot is relatively inexpensive. Moreover; Wi-Fi operates in the industrial, scientific and medical (ISM) spectrum, which is unlicensed in many countries. Very few regulations apply to its use, also contributing to Wi-Fi's low cost.[7]

2.10 The global outreach of Wi-Fi technology is evidenced by the fact that at present more than 450 million households worldwide and over 47 million

[6] Wireless Broadband Alliance, Towards 2020: Emerging Opportunities for Wi-Fi Services, May, 2015, available at http://www.wballiance.com/resource/towards-2020-emerging-opportunities-for-wi-fi-services/.

[7] International Telecommunication Union, Trends in Telecommunication Reform, 2003, available at www.ictregulationtoolkit.org/Documents/Document/Document/3540.

global public hotspots are estimated to be connected by Wi-Fi.[8] As per data published by iPass and Maravedis Rethink, India had 29,205 Wi-Fi hotspots in 2014 (31,518 in 2016; see Table 2.2 for details). In comparison, top ranking countries like France, United States, and United Kingdom had significantly higher numbers at 13 million, 9.8 million and 5.6 million hotspots, respectively. The situation of Wi-Fi hotspots is not encouraging in India as we represent one sixth of the world population whereas our share in Wi-Fi hotspots is less than 1/1000. The study also estimated that the global number of hotspots would grow to over 340 million, nearly one Wi-Fi hotspot for every twenty people on earth by 2018, as compared to one Wi-Fi hotspot for every 150 people today. Globally the increase in number of Wi-Fi hotspots from 2013 to 2016 has been 568% whereas India has an increase of 12% only. For India to reach a goal of one hotspot for every 150 people, 8 lakh additional hotspots will have to be installed.

Table 2.2: Wi-Fi Hotspots in India (2016)

Location	**Number of Hotspots**
Hotels	12,856
Retail	4,435
Cafes	13,967
Municipalities	150
Airport	108
Flights	2
Total	**31,518**

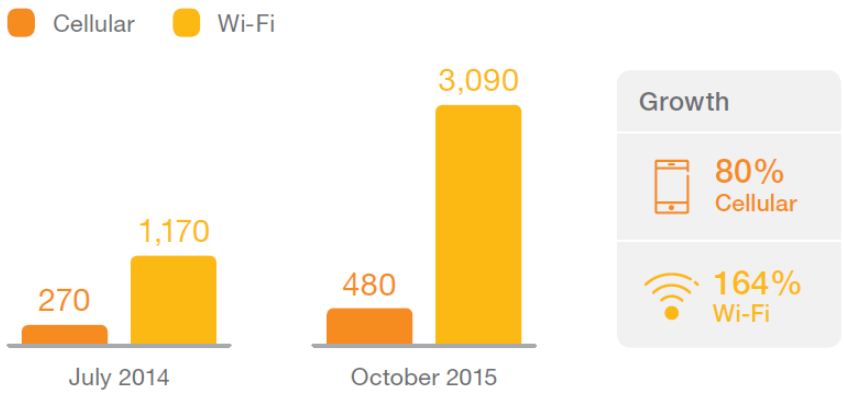
(Source: iPass Wi-Fi Growth Map[9])

2.11 According to the Ericsson Mobility Report of June 2016, over 85 per cent of data traffic generated by the use of smart phone video apps goes over

[8] Wi-Fi Alliance, 2016, available at http://www.wi-fi.org/beacon/wi-fi-alliance/wi-fi-alliance-6-for-16-wi-fi-predictions.
[9] Available at https://www.ipass.com/wifi-growth-map/.

Wi-Fi. The study notes that although cellular data usage on smart phones is growing, Wi-Fi data growth is dramatically outpacing it. As shown in Figure 2.1, an analysis of smart phone on-device measurements in the USA, Japan and South Korea indicates an 80 per cent growth in cellular data usage between July 2014 and October 2015 for smart phone video streaming apps; but corresponding Wi-Fi data growth is more than double of cellular data usage. This indicates that the use of Wi-Fi for internet access is exploding as more mobile devices are Wi-Fi enabled, the number of public hotspots expand and user acceptance grows. Until recently most technologists and mobile industry executives viewed it as the "poor cousin" to licensed mobile communications and therefore they most certainly never viewed any role for Wi-Fi in mobile networks or in their business.

Figure 2.1: Average Monthly Cellular/Wi-Fi Video Data Use (MB)



(Source: Ericsson Mobility Report, June 2016)

C. Models for delivering public Wi-Fi

2.12 According to a study carried out by the Wireless Broadband Alliance (WBA), Wi-Fi access is often provided as an added-value service to attract customers to another telecom service, such as cable or mobile, or to an unrelated service, such as a retail outlet, cafe or transport method. Therefore, much of the build-out of Wi-Fi services in current models is

driven by venues, or by aggregators focused on supporting access in a wide range of venues like airports, restaurants, hotels and malls. In addition, with the evolution of the concept of smart cities, Government agencies, municipalities and city authorities are also becoming a rising contributor to investments in public hotspots.[10]

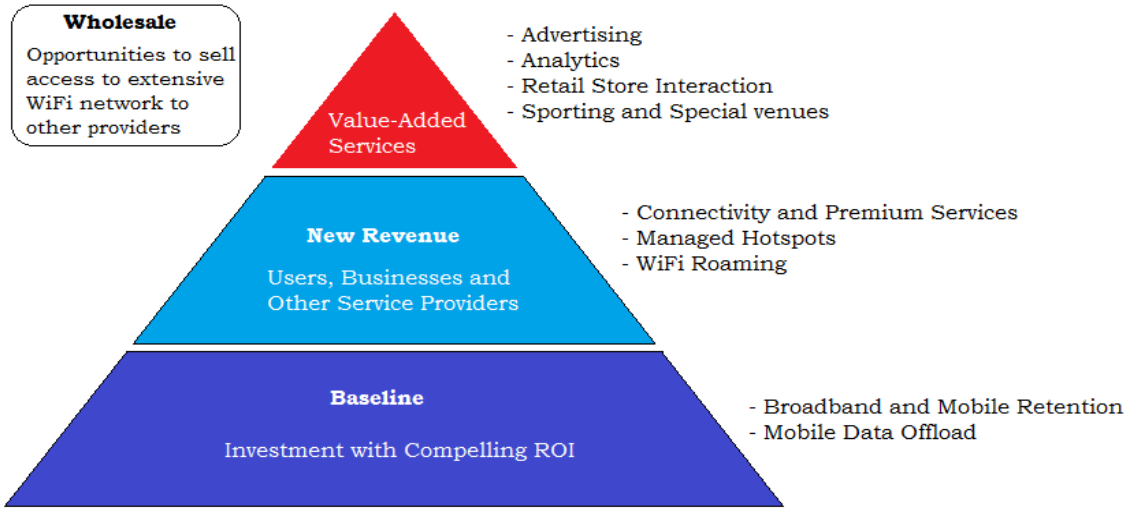
2.13 In terms of deployment of network capacities, wireless networks typically follow a line topology (point-to-point connections), star topology (point-to-multipoint connections) or tree topology (a combination of point-to-point and point-to-multipoint connections). However, other forms of network topologies, such as mesh topology are increasingly being deployed. A mesh topology consists of multiple nodes that are wirelessly connected with one another, and can therefore be used to share data across a large area using the interconnected nodes as routers. This makes it possible to share an Internet connection across multiple devices that are connected to the mesh network. Mesh topologies are increasingly being adopted in dynamic environments, where central infrastructure is hard to implement and network redundancy is desired.

2.14 In January, 2016, Mumbai Central Railway station became the first rail station in the country to offer public Wi-Fi services pursuant to collaboration between Indian Railway's telecom arm, RailTel Corporation and Google. This service is proposed to be extended to 100 railway stations in the coming year and subsequently to 400 stations, making it the largest public Wi-Fi project in India. In addition, public Wi-Fi hotspots have been launched at locations like metro stations, hotels, airports, cafes, markets, educational institutions, parks and other public places at various locations in the country.

[10] Wireless Broadband Alliance, Towards 2020: Emerging Opportunities for Wi-Fi Services, May, 2015, available at http://www.wballiance.com/resource/towards-2020-emerging-opportunities-for-wi-fi-services/.

2.15 In order to ensure that the Internet-access is delivered through Wi-Fi hotspots in a consistent and reliable manner, it is important that the network should be able to sustain itself through appropriate monetization techniques. Globally, there are a number of different models for the deployment and monetisation of Wi-Fi hotspots, where the costs of access may be borne by the end user, owner of the site where the access point is deployed, advertisers, sponsors or the Government. Figure 2.2 shows a Wi-Fi monetization opportunity pyramid.

Figure 2.2: Wi-Fi Monetization Pyramid



(Source: Cisco's Wi-Fi Opportunity Pyramid)

2.16 Think of Wi-Fi monetization opportunities as a pyramid, or set of layers. Each of the layers supports the subsequent layer above. Not only is it extremely difficult to make a compelling business case for a stand-alone layer without successfully implementing some of the business models in the previous layers, but it is not in the service provider's strategic interests to focus on only one of the layers. However, the service provider and its customers derive increasing value as they move up the Wi-Fi Monetization Pyramid.

2.17 The core layers of Wi-Fi monetization opportunities in the pyramid, starting at the bottom, include:

a) **Baseline** – using Wi-Fi for broadband retention or mobile data offload offer a very compelling return on investment, largely based on cost reductions, to justify further investment in other layers of monetization.

b) **New Revenues** – leveraging the Wi-Fi network deployed in the Baseline layer to offer premium connectivity services, managed hotspots or Wi-Fi roaming offers opportunities to generate significant new revenues from Wi-Fi.

c) **Value Added Services** – increasing new opportunities are emerging to leverage the Wi-Fi network developed in the previous layers to provide new and innovative services related to advertising, location, analytics, retail store interactions and special venues, such as sporting facilities.

2.18 The following are some of the main models used for the provision of Internet access through public Wi-Fi networks:

Paid model: The end-user or the Wi-Fi hosting venue bears the cost for the use of the Wi-Fi network. The venue may in turn provide the service for free to its customers or indirectly build it into the amount charged to the customer, for instance by incorporating Wi-Fi charges in the price of the food and beverages served at a cafe.

Freemium model: Access is provided for free until a specified quota after which the user is charged for any additional access. The quota may be fixed in terms of usage time (e.g first 30 mins) and/or amount of data (e.g. first 500MB). This model is commonly used in airports, stations and other public places.

Advertisement-based models: The service is provided for free to the user but the provider earns revenues through advertisers and sponsors. There could be several variations of this model, for instance, the user may be required to view advertisements from sponsors or connect with the advertiser on social media in order to gain access to the network. Further, personal data collected from the user at the time of sign-in could also be monetised to earn revenues.

Aggregators: Wi-Fi aggregators like iPass and Boingo bring together the Wi-Fi networks of various operators by allowing customers to connect to affiliated hotspots around the world. The user may be required to pay a fixed monthly fee for the service or may be charged on a pay-as-you-go basis.

2.19 Table 2.3 provides a more detailed account of the current and future business cases for public Wi-Fi, based on the expectations of the service providers surveyed by the WBA. In addition to these commercial models, there also exist community-driven Wi-Fi models, such as community mesh networks, which have been deployed by several non-profit organizations to provide community based Internet and telephony services by installing low cost access points in a mesh topology. For example, the Digital Empowerment Foundation has implemented projects using wireless mesh networks on unlicensed 2.4 GHz and 5.8 GHz spectrum to provide Internet connectivity in remote areas in the states of Madhya Pradesh, Meghalaya, Assam, Rajasthan and Uttarakhand. Other examples include networks deployed by AirJaldi and Village Telco (which provides mesh networks through Mesh Potato devices, which can provide both traditional voice and data services).[11]

[11] Centre for Internet and Society, Unlicensed Spectrum Brief for the Government of India, June 2012; available at http://cis-india.org/telecom/unlicensed-spectrum-brief.pdf .

2.20 Community Wi-Fi models allow local governments, non-profit organizations, and citizens to leverage modern wireless technology to offer networks which are cheaper and more relevant to local needs. For instance, in rural areas, Panchayats can facilitate the provision of Internet access to the people of the village using Wi-Fi technology. The Government has already commenced a tremendous initiative, namely BharatNet, to create a high speed digital highway to connect all 2.5 lakh Gram Panchayats of the country using optical fibre. The next logical step would be for Panchayats and local entrepreneurs to utilise this Internet access to create Wi-Fi networks offering e-learning, e-governance, e-banking, e-health and other online services to the community. The provision of such Internet access services would, however, remain subject to applicable licensing requirements, as laid out by the DoT.

Table 2.3 Different Business cases for public Wi-Fi

Level of maturity	Business model
Well established	Pay-as-you-go access
	Free access driving other services
	Wholesale access
	Aggregation
	Managed service (venues and outdoor)
	Cellular offload (user driven)
	Added value for broadband subscription
	Advertising and sponsorship
Growing rapidly	Cellular offload (carrier driven)
	Community Wi-Fi hotspots
	Neutral host services
	Hotspots managed by venues and brands
	Wi-Fi roaming services
	Location-aware services
	Onload
	TV everywhere
	Large events
	Big data analytics
	City broadband projects
	Carrier VoWi-Fi
Emerging	Wi-Fi multicast and broadcast
	Smart city platforms
	Wi-Fi capacity marketplace/trading
	Transaction platform
	Internet of Things
	Personalized promotions and service bundles
	Context awareness
	Wi-Fi-first mobile services
	Quad play with Wi-Fi supporting most or all of the wireless element
	Full Wi-Fi/mobile integration (HetNet)
	Connected car

2.21 Globally, a large number of networks offering complimentary Wi-Fi services are funded by municipal corporations/Governments. This may include models for providing complimentary usage quota for users, like 20MB/day/user, where the state Government or local Government bodies bear the cost of the complimentary data usage.

D. Approximation of Wi-Fi Data Cost

2.22 TRAI has also tried to find out approximate cost per MB for the Wi-Fi network. On the basis of informal discussion held with various stakeholders, a Wi-Fi network of 20 hotspots was designed for a tier II city catering to around 40,000 subscribers and 10,000 concurrent users, it is estimated that cost per MB in Wi-Fi Network could be less than 2 paise per MB. Details of tentative estimates are tabulated in the following table. It is worth mentioning that consumers on an average are paying around 23 paise per MB for the data usage in the cellular Network (2G/3G/4G). This shows that the consumer tariff for data may reduce as much as 1/10th in Wi-Fi compared to mobile data. From the above, it is obvious that deployment of Wi-Fi network will not only enhance the speed of internet but also it will make data affordable to consumers and hence will be very helpful in bringing unconnected to the connected world.

Table 2.4 Cost Estimation for Wi-Fi Data

Broadband through Wi-Fi Hotspot for 20 Hotspots	
Number of Subscribers	40000
No of concurrent users	10000
CAPEX for ISP (approx)	
Details	**Cost (in Rupees)**
License Fee	20,000
Tower Cost	1,000,000
Access Point Equipment	11,200,000
AAA and BRAS	7,000,000
Servers (DNS, Syslog, MRTG)	250,000
Switch (Core+ distribution)	1,000,000
Routers	250,000
UPS/Generator	2,000,000
Total	**22,720,000**
OPEX for ISP (approx)	
Details	**Cost (in Rupees)**
Bandwidth Cost	45,000,000
Domestic Bandwidth Cost (connecting AP)	20,000,000
Tower Installation Rent	3,000,000
Server Software Charges AAA NAS	700,000
Operation & Maintenance Charges	2,400,000
Staff Cost	18,000,000
Total	**89,100,000**
Total Bandwidth (Gbps)	8.00
Per subscriber per month data use (GB)	10.00
Total Annualized cost (in Rs) (RoCE+Depreciation+OPEX)	94,098,400.00
Per MB cost (Re)	0.019603833

E. Regulatory framework in India

Unlicensed spectrum

2.23 As noted earlier, Wi-Fi is typically deployed within unlicensed spectrum over 2.4 and 5 GHz frequency bands. Recognizing the need for widespread Broadband deployment, and the potential benefits accruing from Wi-Fi technology, the Authority in its Recommendations on "Broadband India: Recommendations on Accelerating Growth of Internet and Broadband Penetration" of 29 April 2004, recommended the de-licensing of certain frequency bands. This would enable users to access the radio spectrum without the need for the regulations and restrictions that might be applicable elsewhere.

2.24 Accordingly, the Authority recommended that, "*The 2.4 – 2.48 GHz band should be de-licensed for low-power outdoor usage, and on the basis of non-interference, non-protection and non-exclusiveness. This de-licensing should be technology-neutral. Similarly, de-licensing should also be done for the 5.725 – 5.85 GHz band to facilitate deployment of Wireless Access technologies for Broadband. Additionally, the 5.15 – 5.35 GHz band should be vacated expeditiously and delicensed to further facilitate the objectives*."

2.25 Following these recommendations, certain frequency bands were de-licensed between the years 2004 and 2007. The details of unlicensed spectrum in India in the IMT and IMT Advance bands (suitable for Wi-Fi transmission) as on date, are shown in Table 2.5 below:

Table 2.5: Unlicensed Spectrum bands in India

Frequency range (MHz)	**Class of Transmitter**	**Maximum EIRP**	**Remarks**
2400-2483.5	Low power equipment. (IND62)	4 Watt	Can be used Indoor as well as outdoor.
5150-5350	Low power equipment for indoor applications only.(IND67)	200 mW	Low power (max EIRP 200 mW). Outdoor use permitted in 5150-5250 MHz range, but it is not license-exempt. (IND68)
5725-5875	Wireless access system including RLAN indoor only.(IND67)	200 mW	Low power (max EIRP 4 W) outdoor use for Wireless Access System incl. RLAN and Dedicated Short Range Communication (DSRC) permitted in 5725-5825 MHz, but it is not license-exempt. (IND71)
5825-5875	Low power equipment. (IND 72)	4 Watt	Indoor as well as Outdoor.

DoT instructions on Wi-Fi connectivity

2.26 On 23.2.2009, the Department of Telecommunications (DoT) issued instructions to all Internet Service Providers under the Internet Service Licence regarding provision of Wi-Fi Internet service under delicensed frequency band. The instructions highlight the importance of ensuring the security of Wi-Fi networks, which can be breached and misused by anti-social elements.

2.27 The instructions lay down the following norms for securing the use of Wi-Fi services:

- Licensee must ensure the provision of secured Internet services, including through Wi-Fi, through use of Login ID and password with a central authentication mechanism. Multiple simultaneous logins using the same ID are not permitted although a subscriber may be provided with multiple user IDs. Bulk login IDs will be created at Wi-Fi hotspots for controlled distribution.

- Temporary login ID for public Wi-Fi hotspots can be allowed after the Licensee or its franchisee follows either of the following procedures: 1) Retaining a copy of the subscriber's photo ID, which needs to be retained for one year; or 2) Provision of ID and password on subscriber's mobile phone through SMS, in which case record of the mobile number is to be kept for one year as identity of the subscriber.

- Licensees should deploy suitable customer premise equipment for wired/ wireless connectivity. Users who had deployed Wi-Fi routers themselves were also required to get the Wi-Fi connectivity registered with the Licensees within four months.

- The Licensees should suspend the Internet services of any subscriber who is using Wi-Fi connectivity without being registered with the Licensees.

Chapter III

Issues in Proliferation of Public Wi-Fi Network

3.1 In India, with the rapid growth in the wireless subscriber base, the mobile platform is being used to provide a host of new applications like m-banking, e-education, m-health, data transfer, social networking platforms, online gaming, mobile TV etc. As noted above, while globally, the proliferation of public Wi-Fi network has registered an exponential growth, in India the growth has only been moderate. Wi-Fi technology holds much promise for a country like India which is intent on achieving universal access to information and communication technologies for its population, both in densely populated urban areas as well as remote rural areas where the telephone or cable infrastructure are not yet fully deployed.

3.2 The following sections discuss some of the key issues that need to be addressed in order to ensure better proliferation of public Wi-Fi services in India.

A. Availability of Unlicensed Spectrum

3.3 While most of the frequency bands recommended for de-licensing by the Authority have been exempt from licensing requirements, outdoor use of 5.725 - 5.825 GHz band is still licensed. Accordingly, the Authority in its recommendation on "Delivering Broadband Quickly: What do we need to do?" dated 17 April 2015 recommended that "*the de-licensing of the 5.725 - 5.825 GHz band for outdoor usage needs to be carried out in the next 6 months. DoT must release larger quantities of unlicensed spectrum (as has been done in many parts of the world) for better quality of service and reducing the strain on existing networks.*"

3.4 Similar to the approach followed in India, many other countries have set aside certain bands exclusively for unlicensed users in an effort to provide maximum flexibility for innovation and lower entry costs for some types of ubiquitous wireless devices.

3.5 A summary of the unlicensed spectrum in USA and Europe is shown in Table 3.1 below:

Table 3.1: Unlicensed Spectrum in USA and Europe (in MHz)

Band	Quantity of Unlicensed Frequencies in Band (MHz)	
	USA	**Europe**
TV White Spaces	0-150	-
863-870 MHz	-	7
902-928 MHz	26	-
1880-1930 MHz	10	20
2400-2483.5 MHz	83.5	83.5
3550-3700 MHz	50 + 100 (In pipeline)	-
5150-5350 & 5470-5825 MHz	555	555
5350-5470 & 5850-5925 MHz	195 (In pipeline)	-

(Source: FCC White Paper - The Mobile Broadband Spectrum Challenge: International Comparisons)

3.6 Apart from de-licensing frequencies typically utilised under the Wi-Fi standard, there are several other frequency bands which can be utilized for wireless provision of Internet access. Most countries have already de-licensed the 60 GHz band and this band has a good device ecosystem. The 60 GHz band is also known as V-band or WiGig band (Wi-Fi at 60 GHz) using IEEE 802.11ad protocol.

3.7 In its Recommendations on "Allocation and Pricing of Microwave Access (MWA) and Microwave Backbone (MWB) RF carriers" dated 29 August 2014, the Authority recommended that, *in order to increase broadband penetration in India, the usage of high capacity backhaul E-band (71-76 / 81-86 GHz) and V-band (57-64 GHz) may be explored for allocation to the telecom service providers.* The Authority further

recommended that: (a) Channel bandwidth for E-band (71-76 GHz and 81-86 GHz) should be 250MHz with a guard band of 125MHz at the top and bottom of each 5 GHz band and more than one channel can be allowed and allocated for aggregation. (b) Channel bandwidth for V-band (57-64 GHz) should be 50MHz with a 100MHz guard band at the beginning of the band and more than one channel can be allowed and allocated for aggregation.

3.8 Another avenue being explored by certain jurisdictions, is that of utilizing TV White Spaces, i.e. unutilised frequency bands which were earlier used to prevent channel leakages between analogue broadcasts of television programming, to create a wireless backhaul for supporting further development of wireless Internet access, and other experimental technologies.

B. Business viability and incentives

3.9 It is observed that although the adoption of Wi-Fi services in homes and offices is fairly high, the adoption of 'public' Wi-Fi (i.e. in public locations) has not taken place at a comparable scale. This may be attributable, in part, to the lack of incentives for operators to invest in Wi-Fi networks. Wi-Fi is often perceived as a free service so operators may be under pressure to price it low. Wi-Fi in mobile platforms (buses/metros) also takes a hit on account of the fact that the backhaul used is licensed 3G/4G.

3.10 For a viable business model to exist in which ISP is expected to invest in CAPEX and OPEX to set-up and maintain Wi-Fi networks, there may be a need to consider other incentives to be provided to ISPs and Wi-Fi operators, such as Right of Way permissions, permission to setup kiosks at select locations to promote Wi-Fi services, etc. Similarly, commercial models for deployment of public Wi-Fi services which involve transfer of assets at the end of contract period, such as BOOT, may need to be

assessed taking into account the feasibility of return on capital on investments in network and equipment deployed by the ISP.

C. Logistics of deployment of public Wi-Fi

3.11 The deployment of public Wi-Fi services may also be delayed on account of logistical concerns, such as difficulty in log-in procedures; restriction on simultaneous login through multiple devices using the same user ID and password; privacy and security concerns, lack of a framework on roaming between Wi-Fi networks and difficulties in making payments for Wi-Fi access. It is important to identify all such factors that may be posing logistical issues in the adoption of public Wi-Fi services and appropriately address the same.

Customer log-in experience

3.12 As per the existing requirements laid down by the DoT, a user has to either provide a photo ID or avail of a one-time password (OTP) option through SMS in order to use a public Wi-Fi service. It is observed that places with high population density - like airports, busy markets, national monuments, railway stations etc. - often face cellular network congestion leading to delays in the delivery of the OTP. This leads to a poor customer experience and often deters consumers from using public Wi-Fi services.

3.13 Further, log-in problems are also faced by foreign tourists when they try to obtain an OTP by SMS using their home country's ISD code and mobile number. At present, there is no explicitly defined criterion on whether the OTP can be sent to a foreign mobile number.

3.14 One of the options that may be considered to alleviate concerns of OTP based login to access public Wi-Fi services is by adopting differential login options depending on the nature of the customer accessing the

public Wi-Fi network. For instance, various types of customers can be categorized as follows:

a) ISPs own customers - Customers may be allowed to use Wi-Fi hotspots affiliated with that ISP through a permanent User ID and Password based access.

b) Adhoc Customers – Such customers may continue to use OTP based login. However, the validity period of 'Temporary Login' credentials as has been specified in DoT letter dated 23rd Feb 2009, may need to be clarified.

c) Digital form for acquisition of Wi-Fi customers - Customers may be given an option to register for Wi-Fi through a mobility-like customer acquisition form (CAF) based on which a unique permanent User ID and password gets allocated to the customer.

i) This CAF can be similar to Mobile SIM CAF however the entire process can be done online by the customer himself.

ii) The customer would fill in his/her details; upload proof of address and proof of identity. This activation could be based on the Aadhar Card since it can be electronically verified from Government Data Centre.

iii) Since SIM is not required to be issued here, there is no requirement to capture MSISDN/ ICCID/ IMSEI numbers, Plan Details. Therefore, "Physical" presence of customer at the Store gets obviated.

iv) Further, there is no requirement to have the customer's "Wet-Ink" signatures on the CAF application.

v) Post filling of digital CAF and uploading of requisite documents, rest of the process would be same as in any SIM activation i.e., checking of documents, go-ahead given by the activation officer and tele-verification. Post this, the user would be prompted to create a unique user ID and password.

Access by international travellers

3.15 It is estimated that up to 70% of international travellers do not use traditional mobile services, instead often relying on Wi-Fi networks to stay connected while traveling abroad.[12] Yet, we currently have no framework in India for the provision of public Wi-Fi access to foreign tourists.

3.16 As noted above, foreign tourists often face challenges in accessing Wi-Fi Internet services due to the OTP requirement. To a limited extent, they overcome this issue by purchasing Wi-Fi roaming cards through international Wi-Fi roaming aggregators like Boingo, iPass etc. At present, there is no clear framework in India to guide travellers using such roaming packs on how to activate such connections and documents, if any, to be provided/ collected for the same.

Infrastructure sharing/ Roaming facilities

3.17 Due to network and cost limitations, most internet service providers are not in a position to provide uninterrupted Wi-Fi coverage to their users across various geographic locations, particularly so in case of international travellers. This poses a significant challenge in the widespread adoption of Wi-Fi services and calls for the adoption of mechanisms that can provide for ubiquitous Wi-Fi services, across service providers.

[12] Wireless Broadband Alliance, 2015, Wi-Fi Roaming Business Case White Paper: State of the Industry and Market Drivers, available at http://www.bsgwireless.com/wp-content/uploads/2015/12/Wi-Fi_Roaming_BusinessCase_Whitepaper.pdf.
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3.18 As noted earlier, public Wi-Fi networks can be used for mobile data offload to ease network congestion on mobile networks in high density public footfall areas. ISPs may use this feature for their own mobile traffic offload or may decide to enter into an agreement with other ISPs for sharing of public Wi-Fi infrastructure on rental/ revenue share basis. This would be somewhat akin to roaming arrangements in cellular services. It would also help in resolving interference issues which can come up due to access points of different service providers installed in a location using the same unlicensed ISM band.

3.19 There may therefore be a good business case for a 'neutral Wi-Fi network' wherein subscribers of all ISPs can access high speed broadband connection through Wi-Fi without duplicating infrastructure. The neutral network can allocate separate SSID to each cellular operator. ISPs can get into agreements with one another for facilitating roaming of a Wi-Fi subscriber of one network to other networks. This way, the customers will have easy movement from and to different geographical locations, without necessarily buying services through multiple ISPs. To take an example, in September 2014, Comcast and Liberty Global, the two leading cable multi service operators in the U.S. and Europe respectively, formed an agreement to offer international Wi-Fi Roaming connectivity to their subscribers.[13]

3.20 Besides direct arrangements between ISPs, another model to facilitate Wi-Fi roaming across networks is through the use of a Wi-Fi hub or exchange model, which can provide a central connectivity point between the visited Wi-Fi networks and the user's home network. The WRIX (Wireless Roaming Intermediary Exchange) standards developed by the Wireless Broadband Association provides such a framework for Wi-Fi interconnection, data clearing, financial clearing and the exchange of Wi-

[13] Id.

Fi location information between operators (the customer's home network provider and the visited network provider) over the cloud. Such a hub would perform the following two general functions:

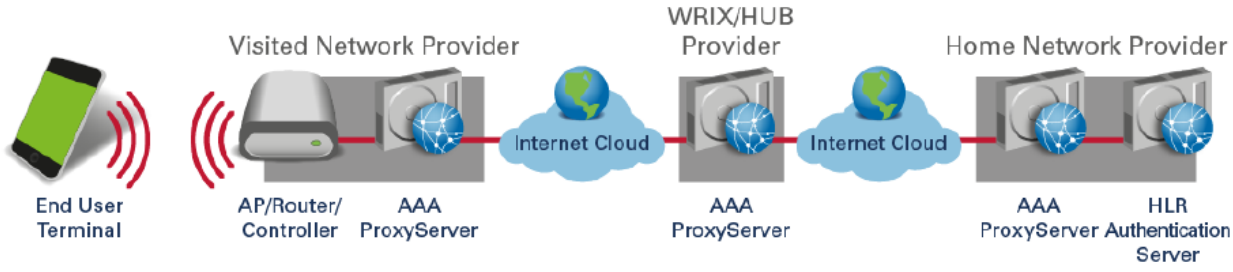
- *Inter-connectivity* – maintaining information associated with each Wi-Fi access point in each Wi-Fi network, and managing the authentication/authorization process of an end-customer.

- *Settlement and clearing* – accounting of usage between networks and reconciling that usage across the visited Wi-Fi networks.[14]

3.21 The WRIX standards have been well established and have been adopted by third party Wi-Fi hubs around the world such as Accuris Networks, BSG Wireless, Point Dume and Syniverse. They provide a secure and streamlined method to allow Wi-Fi roaming for the end user and ensure a seamless experience. Several network operators around the world, such as AT&T, Emirates DCH, PT Telkom Indonesia, NTT DOCOMO and Vodafone, have created departments, which coordinate with these Wi-Fi hubs.[15]

3.22 An illustration of the WRIX framework proposed by the WBA is provided below:

Figure 3.1: WRIX/ HUB Model for Wi-Fi Roaming



(Source: WBA Wi-Fi Roaming Business Case White Paper)

[14] Id.
[15] Id.

Further, the WBA and the GSMA have also been collaborating towards providing a framework for interwork between the RADIUS and Diameter protocols for interconnections and authentication, with a view to facilitate both Wi-Fi roaming and Wi-Fi data offloading over 3G/LTE networks.[16]

3.23 In addition, the Wi-Fi Certified Passpoint certification launched by the Wi-Fi Alliance in 2012 is another technological development that seeks to offer an industry-wide solution to eliminate the need for users to find and authenticate a Wi-Fi network each time they connect to it. Passpoint certification is based on the Wi-Fi Alliance's Hotspot 2.0 specification using IEEE 802.11u. It is designed to automatically discover and select networks based on user preferences, provisioned operator policy and network availability.[17] However, the automated login process can work only in circumstances where both the wireless device and the access point support the 802.11u standard.

3.24 Concept of public Wi-Fi will have real meaning when any entity is able to share its data with another user – who could perhaps be its neighbour or a casual visitor - and the former is suitably compensated for this sharing. This compensation could be in the form of money credited on a payment platform or credit in terms of minutes and or data download, which s/he can use in some other Wi-Fi network. Such an arrangement is feasible if the individual users are registered on a common platform wherein they are authenticated and the record of their payment and credit etc. are maintained. Presently, reselling of data services is not permitted. However, to popularise the usage of Wi-Fi, suggestion on this issue are

[16] GSMA Wi-Fi Guidelines, available at http://www.gsma.com/newsroom/wp-content/uploads/IR.61-v10.01.pdf.

[17] Wi-Fi Alliance, Wi-Fi CERTIFIED Passpoint: An essential and strategic solution for service provider Wi-Fi deployments, October, 2014, available at http://www.wi-fi.org/download.php?file=/sites/default/files/private/wp_Wi-Fi_CERTIFIED_Passpoint_Industry_20141008.pdf

sought from stakeholders. The authentication process can be centralized and can be made as a onetime affair using, for example, AADHAR. On subsequent occasions of usage by the same device, the user need not be authenticated again. As for the user, he is interested in good quality of service and also a foolproof payment system. A user would also not like to expose his fund beyond the Wi-Fi service utilized by him. It is felt that such an arrangement will increase Wi-Fi access to public and generally be beneficial to the society as a whole.

3.25 During the discussions, some stakeholders have suggested that Wi-Fi hotspots can be developed like any small scale industry and it should be possible to start this business by shop owners and unemployed youths etc. This can be done by some “light touch” regulation so as to create good employment opportunity for people and simultaneously reap the benefits of broadband penetration. Such a model will work much like a Public Call Office (PCO) wherein youth were registered for providing PCOs’. The Wi-Fi hotspots can, however, be easily managed as compared to PCO, as the operator of the hotspots will not be serving the customer physically as all the transactions will happen electronically through the payment gateways etc. The stakeholders are encouraged to provide their suggestions on this kind of a model and further suggest removing any entry barrier in this business model.

3.26 During the discussions, some stakeholders have informed that similar model works in some countries. These models are basically community Wi-Fi or Shared Wi-Fi models. One example is FON Wi-Fi Network: **Fon** (Fon Wireless Ltd.) is a company that operates a system of dual access wireless networks. Members, whom the company calls "Foneros", agree to share a part of their bandwidth as a Wi-Fi signal, so that they can connect to other members' hotspots. Consumers who choose not to share their Internet connection can buy Wi-Fi access passes or credit from Fon.

3.27 The ISPs should be enthused to facilitate a model suggested above as this will be a win-win situation for them in view of the increased consumption of data by the public and the model as such will be a source of generation of employment in the country.

Payment Procedures

3.28 As discussed earlier, users can benefit greatly from seamless connectivity across Wi-Fi networks and interoperability between different service providers providing broadband services through Wi-Fi. Presently, there is no centralised mechanism for payment across networks, making it a cumbersome process for a user to pay for the usage of each hotspot as s/he moves from one place to another.

3.29 At Mumbai airport Wi-Fi services are being provided under the brand name of Ozone-GVK and RZone by the ISP Ozone. After the freemium the user has an option to upgrade to paid service. During the discussion M/s Ozone informed that not more than 10% of the users upgrade from the free to the paid service in any month.

3.30 Similar situation has also been reported by BSNL for Varanasi Ghats. It was informed that on daily basis there are 400 to 500 users using free Wi-Fi, however, the figure drops to 70-80 after the free usage period.

3.31 During the survey on slow off take of data usage through public Wi-Fi, consumers informed that (a) mechanism of payment is cumbersome (b) even if you buy voucher and there is balance of data, it cannot be used on some other hotspot and this effectively makes data costlier to them.

3.32 Subscribers of Wi-Fi services can currently pay for the use of hotspots either through the purchase of physical Wi-Fi vouchers or by making electronic payment through credit card, debit card and net-banking. The

following are some issues that may be faced by consumers in these payment models:

- Available modes of payment cater only to a very small section of population who have access to electronic modes of payment.
- Online transactions on public networks risk the theft of financial information of the user.
- Different operators have back-end arrangements with different payment gateways and no single platform is available for use across the country.
- Physical vouchers also suffer from logistic problems and associated distribution costs.

3.33 While using Wi-Fi services, consumers may find certain distinct advantages in opting for pay-as-you-go tariff plans instead of fixed contracts. For instance, a user may not want to commit to a long term contract; avoid unexpected bills; or perhaps as a light user, the subscriber may not want to pay for a connection that is used infrequently. In such circumstances, a pay-as-you-go pay tariff plan can enable the user to monitor his/her usage and top up the usage allowance only when needed. Pay-as-you-go customers appreciate not being tied to a lengthy duration contract and the freedom that it gives them. But, there are a few possible downsides to a short term or prepay deal, particularly the fact that prices per GB of data allowance or an amount of days' usage tend to be a little higher vis-à-vis the prices on contract.

3.34 Given this background, one of the possibilities of implementing a risk-free and friction-less mode of payment for Wi-Fi services is to develop a payment platform which would facilitate easy access to Wi-Fi services across ISPs and through any instrument of payment viz; credit cards,

payment wallets, bank accounts etc. Such a platform should ideally offer the following facilities:

i) It should provide for registration of the ISPs on to the platform and also all types of payment agencies/instruments. A customer should be able to register himself/herself on this platform using any one of the payment instruments mentioned above and access the Wi-Fi service seamlessly across the ISPs in any part of the city or any State of India.

ii) This way the payment arrangement should be totally interoperable and agnostic to the payment instrument.

iii) A customer should be able to "pay as you go" so that s/he pays only for the amount and duration of data usage and not on the basis of already fixed data limits or duration.

iv) There should be complete traceability of access made by any customer so that all the security requirements are billed into the system to avoid any malpractices or security risks.

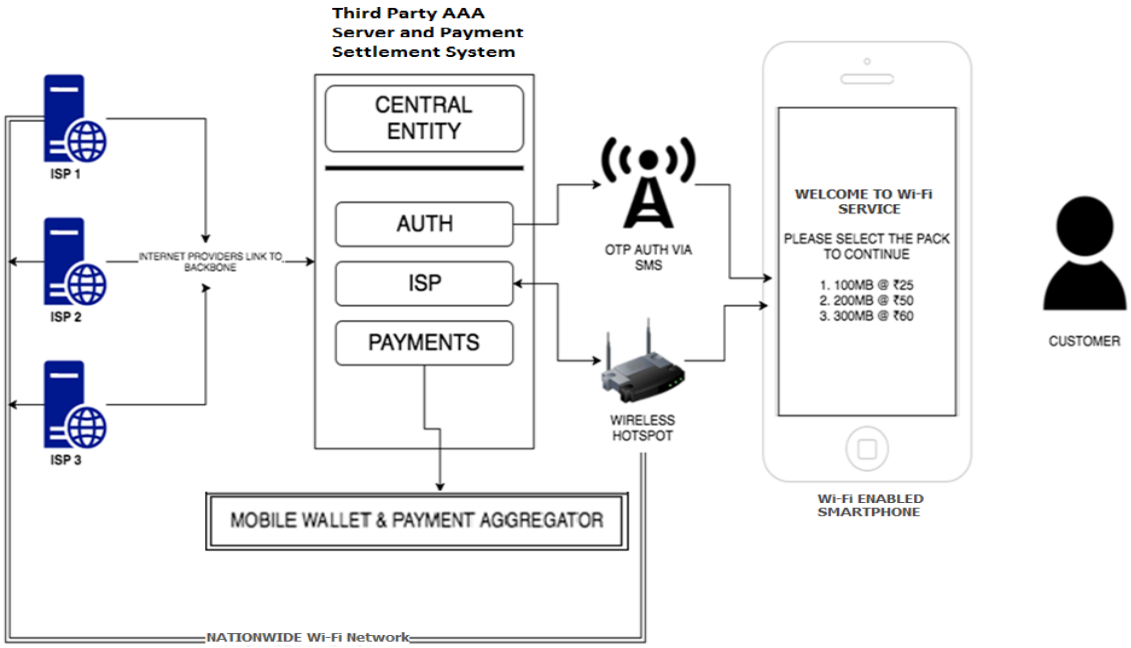
v) It is also desirable to permit the customer to fix a limit on the money to be spent or the access of Wi-Fi service so that the customer is assured that his/her account will not be debited beyond a certain limit, unless expressly authorised.

3.35 One of the possible modes that could be put to use to achieve this purpose is the Universal Payment Interface (UPI) of the National Payments Corporation of India (NPCI). A number of banks have already been registered in this system and it offers a safe payment option to make payments through the user's bank account, without in any way exposing the bank account. It is therefore possible for ISPs to register on

this platform pursuant to which users can avail the services of ISPs by linking the payment to their bank accounts.

3.36 Further, keeping in mind the emerging need for providing seamless and ubiquitous nation-wide Wi-Fi network, a hub model based on the WBA WRIX standards may be explored by operators, which also integrates a payment aggregation platform as described above:

Figure 3.2: Possible Hub-based model for Wi-Fi Roaming and Universal Payments in a Nationwide Wi-Fi Network



3.37 The country is still in a green field deployment phase in terms of adoption of public Wi-Fi services. There is thus a need to resolve the challenges and risks being faced in the process and lay a strong foundation for the development of new and innovative models that support the expansion of Wi-Fi enabled Broadband connectivity. This will see Wi-Fi networks and service providers starting to evolve towards a meaningful position in the advancement of initiatives related to Internet of Things, Smart Cities and eventually '5G'.

Chapter – IV

Issues for Consultation

Q1. Are there any regulatory issues, licensing restrictions or other factors that are hampering the growth of public Wi-Fi services in the country?

Q2. What regulatory/licensing or policy measures are required to encourage the deployment of commercial models for ubiquitous city-wide Wi-Fi networks as well as expansion of Wi-Fi networks in remote or rural areas?

Q3. What measures are required to encourage interoperability between the Wi-Fi networks of different service providers, both within the country and internationally?

Q4. What measures are required to encourage interoperability between cellular and Wi-Fi networks?

Q5. Apart from frequency bands already recommended by TRAI to DoT, are there additional bands which need to be de-licensed in order to expedite the penetration of broadband using Wi-Fi technology? Please provide international examples, if any, in support of your answer.

Q6. Are there any challenges being faced in the login/authentication procedure for access to Wi-Fi hotspots? In what ways can the process be simplified to provide frictionless access to public Wi-Fi hotspots, for domestic users as well as foreign tourists?

Q7. Are there any challenges being faced in making payments for access to Wi-Fi hotspots? Please elaborate and suggest a payment

arrangement which will offer frictionless and secured payment for the access of Wi-Fi services.

Q8. Is there a need to adopt a hub-based model along the lines suggested by the WBA, where a central third party AAA (Authentication, Authorization and Accounting) hub will facilitate interconnection, authentication and payments? Who should own and control the hub? Should the hub operator be subject to any regulations to ensure service standards, data protection, etc?

Q9. Is there a need for ISPs/ the proposed hub operator to adopt the Unified Payment Interface (UPI) or other similar payment platforms for easy subscription of Wi-Fi access? Who should own and control such payment platforms? Please give full details in support of your answer.

Q10. Is it feasible to have an architecture wherein a common grid can be created through which any small entity can become a data service provider and able to share its available data to any consumer or user?

Q11. What regulatory/licensing measures are required to develop such architecture? Is this a right time to allow such reselling of data to ensure affordable data tariff to public, ensure ubiquitous presence of Wi-Fi Network and allow innovation in the market?

Q12. What measures are required to promote hosting of data of community interest at local level to reduce cost of data to the consumers?

Q13. Any other issue related to the matter of Consultation.