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‘Wi-Fi’ght It?

I. Intro:

“The convenience of wireless networking and lightweight handheld devices have led to a large-scale adoption of wireless technologies. Corporations, universities, hospitals, homes, and public places are deploying these networks at a remarkable rate” [35].

By definition, Wi-Fi is “a facility allowing computers, smartphones, or other devices to connect to the Internet or communicate with one another wirelessly within a particular area” [1]. Now, take out the “particular” and imagine that the government gave Nationwide wi-fi coverage to everyone, much like South Korea is currently deploying. Unbeknownst to most, Google has been moving to push the White Space proposal, which is “pending before an FCC panel [and] aims to make access to the Internet and phone calls [fast] and easy for millions of people across the United States” [20], for a little under a decade.

For such a robust country with all the means to build the world’s most advanced Wi-Fi infrastructure, the U.S. government is purposely blocking Google’s, or really any company’s, attempts to bring cheap, fast and reliable internet access to the masses in favor of the more traditional, big mobile network carriers and telecommunications companies such as AT&T, Intel, T-Mobile and Qualcomm - all of whom have been consistently opposing the move - because they help fund the country economically. It is evident that without the competition to drive them, with the government’s favoritism of the capitalist monopoly, and aided by the general public’s uneducated blind trust, communications companies have been left to underdeveloped Wi-Fi coverage in comparison to South Korea and as a result, citizens have come to trust this accepted norm because they simply do not know any better. We wish to show that nationwide Wi-fi is better overall, with respect to the White Space theory, than the data-plan centric infrastructure that currently dominates the country.

II. Background:

In Comparison to South Korea:

"South Korean internet is actually magic". As illogical as that may sound, "magic" is the way that people have come to describe the small Asian country's internet. [11]. South Korea's internet download speed, which has consistently ranked as the fastest in the world for years, is more than 100 times faster than the U.S.'s, which was ranked 14th last year [5]. However, even with the fastest internet speed, even as a tech giant, Korea is constantly on a never-ending search to better quality and quantity in internet service.

For one, South Korea is known to offer the best hotel Wi-Fi services in the world, with 92% of tested hotels meeting regulatory standards [12]. In stark contrast to that, the United States offers only the bare minimum of internet connections in places where Wi-Fi is currently free such as at cafes and hotels. Only a low 36% of U.S. hotels tested met these same regulatory Wi-Fi standards, certainly with the contingency that most of these connections would not allow for non-HD Skype video calling [11]. Even more impressive, in 2013 South Korea announced its plans to add over 10,000 hotspots around the country with the goal to provide full, free nationwide Wi-Fi coverage by 2017 [10]. Everything considered, the United State's internet services seems juvenile at best.

White Space:

White Space

/(h)wīt spās/

noun.

1. *In page layout, illustration and sculpture,* ***white space*** *consists of the strategic visual sections of a page/illustration that are left unmarked and thus uncluttered by any specific aesthetic detail [39].*
2. ***White space*** *is defined as the unused frequencies allocated to broadcasting services - often used as buffering gaps between high-powered transmissions carrying broadcast TV to avoid interference - but that are left unused in particular areas of the country [20].*

The prospect of harnessing white space to offer more reliable, fast internet services is what drives our research paper, but not in the way one might expect. Google and other companies undoubtedly sees that "white space could be used to provide wireless broadband internet access, similar to Wi-Fi but over much longer distances, to mobile devices like tablets and phones" [19]. The key here is not the mere thought that the government, as well as carriers, should actively try to use white space but more of the fact that there currently exists viable options to implement a Nationwide Wi-Fi infrastructure. The key here is that this country has all the means to improve its mediocre internet standards but that great leaps are not being made, significant technological advancements in the field are irresponsibly being stunted.

III. Approach:

Surveys:

First, we sought to prove that the masses remain oblivious to the nation's low Wi-Fi quality and poor coverage, and thereby are blindly trusting telecommunications companies and the government. We found that the best way to do this was to survey both Americans and Koreans who were/are consistently exposed to these contrasting levels of Wi-Fi quality and quantity.

A total of 117 people were surveyed using Qualtrics, an "Online Survey Software & Insight Platform" offered in partnership by the University of Texas at Austin for its students and faculty [33]. 17 of these results were deemed unusable because they either failed to complete the entire form or because they did not meet our qualifications. Survey 1 was taken by 50 participants who were strictly from the United States and did not have prior access to Wi-Fi/Data Plans outside of the country for consecutive periods longer exceeding two weeks. The other 50 participants took Survey 2 and originated from South Korea and/or had access to Wi-Fi/Data Plans in the aforementioned country for at least three consecutive months. Figures 1-5 in the Appendix attached show our relevant and applicable survey results. Note that several questions in the Surveys 1 and 2 consisted of open, short answer questions and could not be represented graphically.

Interviews:

On the other hand, in order to get educated opinions on the subject matter, we interviewed the following experts in the Wireless Networking and Communications field:

1) Dr. Lili Qiu, Associate Professor in Computer Science Department at University of Texas at Austin
2) Mi Kyung Han, Doctoral Student in Computer Science Department at University of Texas at Austin; studying under Dr. Lili Qui
3) Swati Bakland, Doctoral Student in Computer Science Department at University of Texas at Austin

IV. Results:

The results of our surveys show that Americans generally do not realize how much better Wi-fi could be and that most are not aware of the White Space Proposal, much less of the concept of White Space [Figures 1-5]. The survey actually showed that Americans generally thought that their Wi-Fi services were superb, though we know this to be a half truth.

One American student who wished to remain anonymous commented, "We're the United States. Our internet has to be one of the fastest. As far as I know, internet speed is really fast here. Sometimes you have to let videos buffer and stuff but that's just on Youtube; it's not because our internet is any slower than another country's."

On the other hand, a Korean student said, "Sometimes I think that the internet here is fast, but then I go to Korea for vacation and I think about how I managed to survive in the States. It sucks here. I can literally stream live HDTV on my phone from the underground subway in Korea and over here I have to wait hours to Torrent a single movie."

The surveys accurately proves that Americans tend to overestimate the quality of Wi-Fi services and we can arguably go as far as to say that they have blind faith in the carriers.

V. Current Situation: Measures Being Taken

Google lately has been trying to work around legislation, as is evident by Google Fiber, which provides “a connection that's up to 100 times faster than today's basic broadband speeds” [31]. It seems as though they are trying to get the masses on board first with a paid service before tackling the much more difficult task of giving access to Nationwide Wi-Fi to the country. The government will not be able to put off the issue for much longer if this keeps up.

In fact, Many cities, such as Buffalo (MN), Ripon (CA), Philadelphia (PA), and Portland (OR), have deployed or are planning to deploy [Municipal] city-wide wireless networks” with the help of smaller, local companies such as such as Tri-County Wireless and Tri-Net Solutions [35]. Municipal broadband is a broadband internet service provided partially or fully by a local government and they have been “rapidly taking a leading role in legislative debates around the country” [45].

VI. Disadvantages to Nationwide Wi-Fi

We will first try to understand the mindset of those who oppose Nationwide Wi-Fi, namely the traditional cellphone carriers, as to better understand the situation. As a whole, the two overwhelming problems seems to be the issue of security and the economic costs of implementing such a rigorous infrastructure.

Carriers’s Loss of Revenue:

More directly related to the large telecommunications companies is the interest of protecting against the great potential for revenue loss. The carriers’s contentions; the reasons why they are deciding to lobby against the White Space Proposal are crystal clear: the inevitable spectrum of communication over Wi-Fi “would cripple their traditional business [plan] of enabling calls over their own network.” [17]. That is to say, allowing Wi-Fi to replace data plans would cause a tremendous loss in potential profits and “it would follow the bleeding that’s already happening in SMS revenues” [17]. Thanks to free social-messaging applications like WhatsApp, Kakao Talk, Line, Pinger and GroupMe, carriers are projected to lose $54 billion in texting fees by 2016. If anything, Facebook’s $19 billion purchase of mobile-messaging startup WhatsApp Inc. “is a stark reminder of how much money phone carriers are losing out on as

competitors let users text and chat at no charge" [42]. Of course, carriers still make money for transporting data for these "free" messages but they make little to nothing when compared to what they traditionally used to. Considering all of this, it is evident that going at this current trend, it would be in the carriers's better interest to deny the country of Nationwide Wi-Fi because most of their revenue comes from data service.

Building Cost & Taxes:

As previously mentioned, many cities in the country have deployed municipal broadband networks. These cities, which serve as the closest representation of what Nationwide Wi-Fi would be like on a smaller scale, indicate how expensive it would be. Municipal networks are mostly funded by the government but it would be foolish to assume that a majority of the costs to deploy Nationwide Wifi would come from the government alone. Most likely, much higher taxes would come into effect. It is undeniable that municipal broadband networks are expensive. The 6,000 miles of fiber in Chattanooga, which is contested to be the best example of a town that implemented municipal broadband, cost just under 300 million dollars to construct according to a report by CBS news [45].

Our experts, in particular, had much to say on the matter. Doctoral student Swati Bakland said that Nationwide Wi-Fi would only be possible if services were offered on some sort of subscription plan to offset the building costs. Similarly, Dr. Lili Qiu said that "in order to cover the entire nation you need a lot of base stations [and hot spots]. The main question remains [to be] if there is a company willing to invest enough [money] for hardware and also for human resources to put up hotspots everywhere to get Wi-Fi everywhere."

Security:

Since we are considering Wi-Fi on a national scale, it is inevitable that we must think of the security vulnerabilities involved. Nationwide Wi-Fi would most definitely be offered through hotspots. By their very nature, "Wi-Fi hot spots need to have low security settings to enable roaming so that users can connect to it" [43]. Unlike cellular connections, where cellular signals constantly changes its frequencies for the purpose of connectivity, Wi-Fi connections run on a

single IP address. Then, we must also consider that wireless communication, including White Space, is broadcast over radio waves [21]. This means that an attacker could get into the router and extract data from it by intercepting the signal between some users and the router through various attacks such as Man In The Middle or by eavesdropping over the airwaves to pick up unencrypted messages [22]. Wi-Fi connections are far more susceptible to attacks for this reasons - both from web attackers and network attackers [43].

We must also consider the reachability and scale of these potential vulnerabilities. A larger network means that successful attackers have a larger target. Modern attacks that are manifested in the form of worms, Trojans, viruses, etc. are highly dangerous in that most are designed to spread like wildfire. Consider the possibility of a network variation of Code Red II, arguably the worst computer virus in history, spreading over the National Wi-Fi [44]. It would undoubtedly be a devastating denial of service attack.

Admittedly, better security measures must be developed before Nationwide Wi-Fi is rolled out and constant updates would have to be made in order to minimize vulnerabilities. Since computer security, much less network security specifically, is somewhat of a niche market, taking measures to secure the Wi-Fi networks alone would prove to be extremely difficult. This leads us to our next topic: potential challenges to offering Nationwide Wi-Fi.

VII. Challenges to Nationwide Wi-fi:

Managment & Infastructure:

Wireless networks pose significant management challenges in the following ways. First, a wireless network is a complex system with many interdependent factors that affect its behavior [35]. The factors include traffic flows, network topologies, network protocols, hardware, software, and most importantly, the interactions among them. The fact of the matter is that the interactions among these factors are not well understood.

Second, “in a study of South Korea's Internet infrastructure, the International Telecommunications Union cited "unique housing patterns and high population density" as key factors behind its world-class broadband speeds. More than 60% of the population lives in apartments, and most people live within four kilometers of the local telephone office” [16].

Density undoubtedly has to do, in part, with why South Korea's internet speed is the fastest in the world and why they are more easily able to offer Nationwide Wi-Fi.

Balance of Power:

The successful outcome of Nationwide Wi-Fi heavily relies on government planning and participation. Experts agree that the South Korean government's timely and well-executed internet policies gave it a huge head start in developing advanced internet services. However, a key difference between South Korea and the United States is that "culturally, Koreans trust their government and each other a little more than most western citizens do" [11]. However, the problem lies in the fact that The United States's constitution heavily relies on checks and balances. The debate over Nationwide Wi-Fi from lawmakers' point of views is centered around a tug of war between cities, states and the federal government's ability to provide such services. and towns over the town's ability to provide the service [45] In the case of cities with municipal wireless networks, many states are pushing legislation which limit the ability of local communities to provide this sort of municipal access [45]. It will be both culturally and constitutionally difficult for lawmakers to allow for government interference for the good of the cause.

VIII. Advantages to Nationwide Wi-Fi:

So far only disadvantages and challenges to Nationwide Wi-Fi have been discussed but now it is time to see everything from another perspective.

Healthy Competition

Competition absolutely fuels technological advancements and to say otherwise would be naive [9]. What sets Korean carriers apart from the United States's is that "the Korean government took decisive action in the private sector, adopting a consistent policy of deregulation that they maintain today" in order to foster a competitive atmosphere by ensuring "that barriers to entry were low for new Internet Service Providers" [11]. That is, the Korean government activity ensures that their telecommunications companies do not monopolize the industry, as is in the case of the United States. To put it frankly, the carriers in the United States

don't risk much by not upgrading expensive infrastructure, by not making their services any better than minimally necessary, as it is nearly impossible for anyone who isn't Scrooge McDuck or Google to enter the market [11]. This lack of competition is the true reason why the country's internet standards fail to surpass other countries'.

Contrastingly, to again look at South Korea as an example of an innovative country thriving on competition, in 2005, "the large telecommunication companies came under pressure as smaller competitors began to pick up large pieces of the DSL (then the primary connection method in Korea) market" [11]. In response, Korea Telecom began to break ground on fiber optic networks throughout Korea, preserving their business and upgrading the country's internet capabilities. It is precisely this kind of competition that creates an innovative technological environment [11].

And, really, the "lack of effective competition amongst Internet Service Providers in the US" is what leads to higher pricing [43], which is what leads us to our next point. While we pointed out that Nationwide Wi-Fi would be expensive to deplore, it would be an investment for the future rather than a complete loss.

Economically

a. *Affordability:*

Due to high data plan fees, not everybody can afford the Internet. There are kids and adults who are not able to access it. However, with Nationwide WiFi, connecting to internet becomes affordable to anyone who wish to access it. WiFi is offered through a series of antennas that are installed. This means that you will be able to access to high speed Internet, which has firm reliable connection than the cellular network.

b. *Increased Job Market*

Because Nationwide Wi-Fi will take a great deal of development, this opens up numerous jobs. In computer related jobs in particular, there will be more roles related to all aspects of security, Wi-Fi, and architecture. And because hot-spots and fibers need to be built, manual labor will also be required.

Technological Improvements

a. *Speed and Unlimited Usage:*

If you own a smartphone, you probably heard of the terms 3G, 4G, and LTE. The meaning of these terms are the generation of network technology. The 3G network was the first technology that had enough speed for users to use cellular data. However, when the cellular providers, such as AT&T, Verizon, T-Mobile, Sprint, and etc, upgraded their cellular data speed from 3G to 4G, a story of using cellular data has changed significantly. Theoretically, 4G can deliver up to 10 times faster cellular data than 3G [8]. For example, let say you want to download a 5-minute video. It takes 42-54 seconds with 3G, 5-12 seconds with 4G, and 4-8 seconds with 4G LTE to download a video. But if you switch to Wifi, you get more speed with better stability.

Wifi performs a few times faster. It provides better performance with good signal strength, no network congestion, and no limitation of data usage. With two most recent Wifi technologies, wireless N and wireless AC, you get theoretical data transfer speed of up to 600 and 1300 Mbps respectively. But in real world scenario, wireless N gives 40~50 Mbps and wireless AC gives 70~100 Mbps [8]. Still they are both faster than 3G, 4G, or LTE. Not only wifi has superior speed over cellular data speed, it does not limit users to use data. You can use continuously until you get bored without any worry.

b. Battery Efficiency

It is proven that using 4G or 4G LTE saves battery life of any mobile device than when using 3G. It is not a significant save. However, if you switch from using cellular data, for example 4G, to Wifi, you save quite a bit. During Apple's WWDC event, Apple has announced that on iPhone 5S, you can use up to 8 hours when on 3G, 4G, or LTE, but you can extend your usage hours up to 10 hours when on Wifi [9]. When your smartphone is on 3G, 4G, or LTE, it requires a lot of battery power to constantly pinging the cell towers, such as transmitting data to and from them. Constantly searching for which signal to connect to and when to switch to different, better signal is a huge drain of battery power.

Consequently, Wifi uses much less battery power. The main reason is that it does not have to keep searching for a better access point. Once it is connected at a certain

point, it stays at it until it is told to. Also WiFi connection is made within few feet whereas cellular signal connection is made on hundreds or thousands of feet. Shooting a signal to few feet away versus hundreds feet away also makes huge difference [8].

IX. Ethical Analysis:

By social contract theory, Americans have a right to better, more affordable Wi-Fi services, even if they are not aware that they are being cheated, because they are trusting that the government and carriers will provide them with quality service. However, the big aforementioned telecommunications companies also have a right to protect their profits and they are legally allowed to hire lobbyists under the Constitution, assuming that they aren't using illegal means to bribe government officials [40]. Then, there's the government that has a duty to think in the best interest of its citizens. Overall, however, these companies have a right to be capitalist, given that the United States is not Socialist and with nationwide Wi-Fi, the government would inevitably have to take more power. Nationwide Wi-Fi through the use of the White Space "faces opposition from telecom companies who say those airwaves should be sold for licenses with the money going to the U.S. Treasury" [18]. All citizens, including the masses who indeed have a right to better services, have the right to live in a Capitalist environment. Thus, by the Social Contract Theory, would it not be better to forego nationwide Wi-Fi?

X. Conclusion:

The masses blindly trust the government and carriers to provide them with quality internet service but lack of competition and fear of change has stunted the United States's ability to further develop the technologies such as ones to potentially harness the White Space needed to improve internet standards.

There are undoubtedly many challenges with the task of deploying Nationwide Wi-fi, mainly due in part due to the vast infrastructural changes that must be made by both the government and by the traditional cellphone carriers. However, for the sake of improving internet quality and quantity and for the purpose of creating healthy competition to enact

technological advancements, the government must steadily work in cooperation with carriers to raise above 14th place; to pave the road to a new era of fast, reliable internet.

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APPENDIX:

Interviews:

In order to get expert opinions on the matter, we interviewed the following people:

1) Dr. Lili Qiu, Associate Professor in Computer Science Department at University of Texas at Austin - Wireless Networking and Communications
2) Mi Kyung Han, Doctoral Student in Computer Science Department at University of Texas at Austin studying under Lili Qui - Wireless Networking and Communications
3) Swati Bakland, Doctoral Student in Computer Science Department at University of Texas at Austin - Wireless Networking and Communications

Survey Results:

A total of 117 people were surveyed using Qualtrics, an "Online Survey Software & Insight Platform" offered in partnership by the University of Texas at Austin for its students and faculty [33]. 17 of these results were deemed unusable because they either failed to complete the entire form or because they did not meet our qualifications. Survey 1 was taken by 50 participants who were strictly from the United States and did not have prior access to Wi-Fi/Data Plans outside of the country for consecutive periods longer exceeding two weeks. The other 50 participants took Survey 2 and originated from South Korea and/or had access to Wi-Fi/Data Plans in the aforementioned country for at least three consecutive months. Figures 1-5 in the Appendix attached show our relevant and applicable survey results. Note that several questions

in the Survey 2 consisted of open, short answer questions and could not be represented graphically.

Figure 1.

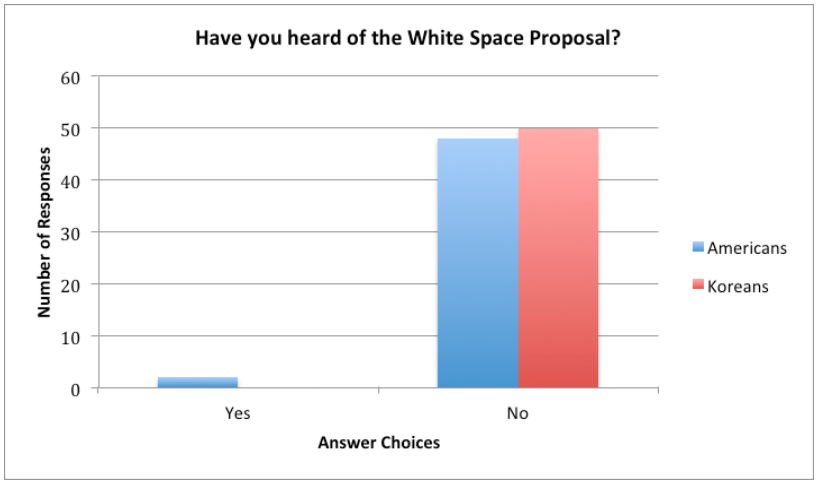

Figure 2.

Figure 3.

Figure 4.

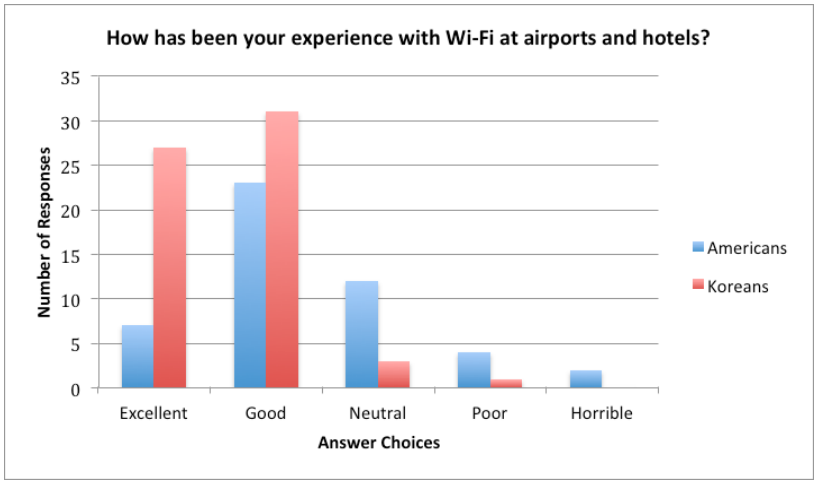

Figure 5.