Design Factors of SOHO from 5G Demarcation Options

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***Abstract*—Our project hopes to use 5G cellular along with 5G LAN integration to connect with individuals or patients and follow their health needs. The idea that a person could wear a devise that when worn, could notify them or a central station monitoring device, if there were impending health issues is amazing to me. Fire fighters already have the ability to see thru smoke with the use of a special screen on their helmet and 5G cellular will make that equipment that much better. However, in order to achieve that, there needs to be seamless coverage inside and out. We wish to explore the underling technology that makes 5G NR (New Radio) so amazing. 5G cellular has issues traveling thru building structures, this is where 5G LAN needs to work hand in hand with 5G cellular, in order for the mobile devices that we are exploring to work seamlessly inside and out. In the short term a backup reliance to 4G technology would have to be in place in the event of loss of 5G signal.**

***Index Terms*—5G cellular**
5G LAN
Small Cell Networks
Femtocells

I. Introduction

Imagine wearing a device that could inform you of an impending medical emergency. 5G cellular technology has the potential to do this and much more. There are some issues to be worked out with 5G and one of them is that it does not travel thru structures very well. Large communication companies like Verizon are rolling out their own versions of 5G LAN systems. These systems are in their infancy and are still being developed and tested so there is not a lot of technical data available but it is coming rapidly. We are on the cutting edge. "The 3rd Generation Partnership Project (3GPP) unites [Seven] telecommunications standard development organizations (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC), known as "Organizational Partners" and provides their members with a stable environment to produce the Reports and Specifications that define 3GPP technologies." [1]

5G is an exciting, new, trending technology that has the potential of changing the landscape of virtually everything we do in our day to day operations. The capability of having Gigabyte speed on the fly is tremendous. First responders will be able to send pertinent, life-saving data to medical personnel prior to the arrival of emergency vehicles in real time enabling them to better triage and deliver care in an unprecedented fashion. Fire fighters will be able to scan structures in real time and provide feedback to the command center. These changes can be significant and can be measured as being as dramatic as the evolution of transportation from horse and buggy to space flight. The evolution of data for Small Office Home Office, (SOHO), users occurred rapidly. It began with dial-up modems with a maximum bandwidth of 56Kbs in the mid 90's. This quickly gave way to Integrated Service Digital Network, (ISDN), which offered a maximum speed of 128Kbs in the late 90's and early 2000's. Asynchronous Digital Subscriber Lines, (ADSL), provided speeds up to 768Kbs initially, then up to 3Mbps in the mid 2000's. Emerging bonded cable pair and Fiber optic technologies pushed bandwidth from 15-30Mbps with BPON, (Broadband Passive Optical Network), in the mid 2000's to 100Mbps by 2010. GPON, (Gigabyte Passive Optical Network), increased the capability of fiber optic systems to Gigabytes speeds. All of the prior mentioned Technologies have one thing in common, they all emerge from a known, established Demarcation point, (Demarc), also known as the MPOP, (Minimum point of Penetration). 5G, on the other hand, typically does not originate from a pre-established demarc and there is not much, if any, information described in demarcation processes or stand installation procedures for this new technology. Our goal is the establishment and development of the demarcation of this new technology.

II. Small Cell Technology

The transition from 4G to 5G technology is an interesting topic. Many wonder why we even need to change the status quo. Although change is not always bad, some people tend to linger on the thought process of "if it ain't broke, don't fix it". Many have even asked "why are we even changing to this 5G thing"! 4G is not capable of sustaining the network presence or bandwidth required to sustain the (IoT)1, Internet of Things and it will not allow them to maintain their full functionality or their full range of capability. The significant difference between the two is the capability of 5G to function via a network array of distributed active and passive antennas. The antenna networks are classified as small cell, macro cell, radio access network (RAN), and distributed antenna network (DAS). The antenna type and network type are determined by the communication infrastructure used by the supplying entity which are mostly the last mile providers ATT and Verizon.

Femtocell, Picocell, Microcell, and Metrocell are all types of small cell networks. [2] Femtocells are the smallest of the small cell devices and use the least amount of power. Femtocells are used to extend network connectivity to SOHO

applications and are powered and connected directly by the end user. Picocells are small base stations as well that are deployed in places like office buildings and shopping malls. They differ from Femtocells in that they are managed and configured by a network operator who pays for the connection to the network and the resources required to operator the device. The Microcell is another low power cellular base station. It differs only slightly from the Picocell in its coverage area which is controlled by the amout of power given to the device. [3]

Metrocells are deployed to fill in gaps in coverage within buildings. Metrocells are much like femtocells because they have been successfully deployed in SOHO configurations but differ by offering expanded capacity and coverage range. They are capable of having 16 to 32 subscribers at a range from less than 100 meters to several hundred meters depending on the environment. Metrocells are high- capacity but utilize very low power to accomplish their goal. Macrocells are the legacy high power basestations. They have a range of 20 miles. A C-RAN is a relatively new concept. C-RAN combines the signal from multiple radios deployed throughout a large building by processing them into a single, seamless cell. A DAS is composed of a network of small radio heads placed in a strategic configuration throughout a specific location, such as a large venue, to significantly increase the cellular bandwidth for an event without overloading the existing cellular tower. Each radio head is directly connected to a hub by fiber optic cable. The hub is then connected to a cellular base station which performs the routing and processing of data. [4]

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III. Project Requirements

5G wireless integrated with 5G or 6G WiFi LAN, used in an attempt to overcome 5G's shortfall when it comes to passing thru Glass. Yes you read that right. The windows that we have installed in most SOHO applications are coated to keep UV Rays out of our space for heating and cooling efficiency, the same UV rays block the 28GHz signal 5G is riding on. Verizon was working on this, back to 2017 in order to make this the main entry into the SOHO not at the traditional D-mark. [5]

IV. 5G Deployment Scenarios

5G networks will enable enhanced mobile broadband services with higher data rates, lower latency and more capacity, as well as new use cases that will generate additional revenue streams for the operators. The ability to handle multiple, tailored use cases is what makes 5G more exciting than previous versions of mobile technology. Telecom vendors and parties involved in deploying 5G technology should make sure that the new technology is backward compatible with 4G and older cellular technologies. The key here is to create a win-win scenario where 5G works alongside the current 4G services as we slowly transition to faster and improved services. Managing the available spectrum between the 4G and 5G will be crucial for the better development of future 5G services. Since faster speeds is one of the key selling points with 5G, telecom operators should take advantage of exiting 4G hardware and build a platform where 4G and 5G will co-exist and leverage it to gradually upgrade the services to 5G standards starting with the cell sites and antennas. Fog computing my help bridge the gap that has been found when it comes to bringing 5G into the SOHO. The problem is that the 28Ghz signal that 5G rides on is blocked by the coating that is on most of our exterior windows. The mm wave is left on the window sill.

V. 5G Commercialization

Commercialization of 5G will focus on three topics

1. Enhanced Mobile Services

2. Integrating IoT devices into 5G services in a massive scale

3. Integrating Critical Services into 5G services

The key here to use existing LTE technology as a road map to 5G. This process will enable parties involved to iron out issues as they arise from the daily use. This can range from software to hardware to cyber security. Another element to consider is that 5G services should be backward compatible with LTE and the IoT devices currently in use.

VI. Diverse Needs of IoT Applications:

• Mobile Health Wearable, Gateways, Remote Patient

Mobile Health wearable can keep patients safe from potential life threatening issues by sending vital information to the nearest health care provider. Doctors can keep track of patients health remotely using IoT and 5G services.

• Ubiquitous Coverage

Ubiquitous coverage can be accomplished by using both 5G and 4G along with backward compatible services to provide continuous mobile coverage

• Smart Cities Lighting, Traffic Sensors, Smart Parking

Utilizing 5G with Machine Learning and IoT, we can reduce our carbon foot print by burning less fossil fuels to managing traffic on the streets.

• Connected Building Security, Video Surveillance, Smoke Detectors

Keeping the public safe using IoT can save lives. From video surveillance to smoke detectors, IoT and 5G raises the bar in our day to day living standards.

• Asset Tracking Fleet Management, Pet/Child Trackers, Shipping

why pay of satellite services when you can track your trucks and packages using IoT devices and 5G.

• Environmental Monitoring Agriculture

5G and IoT devices will make things affordable when it comes to monitoring our environment. From humidity to forest fires, IoT and 5G are game changers.

• Entertainment to Concert fans

Attach an IoT device (hand band) to the concert fans and let them feel the music like they never felt before.

[6]

• First Responder, AR Firefighter helmet. No more will a firefighter have to crawl along the floor and keep one hand touching the wall because the room is full of smoke. Before

now firefighters relied on thermal imaging camera to navigate hot spots. The use of a thermal imaging camera does not have a live view and the firefighter would have to stop to review the image, also loose the use of one hand to operate the camera. The AR firefighter helmet from a company called Quake has developed a helmet using a system they call C-THRU. This system combines thermal imaging, toxicity sensors, and edge detection built into an OBA with selective noise cancellation for better communication. . The system as it is designed now connects with a control device located outside. I believe that with 5G cellular interrogation this device could become more mainstream and eventually more affordable.

[7]

A. Literature Review

VII. Using 5G with Wireless Body Sensory Network along with IoT and Smart Mobile

Here we look at mobile health care utilizing IoT devices and 5G. This technology carries great potential in several areas. Mobile health care using 5G can reach far off places where health care services are nearly close to none. Doctors and nurses can diagnose and monitor patients connected via IoT devices utilizing Wi-Fi, ZigBee or Bluetooth tied to a 5G Smartphone.This gives the health care providers better flexibility when it comes to providing better services.This is a game changer in 3rd world countries.Doctors and nurses can share patient info on how to provide better care from their finger tips. [8]

In order to fully understand 5G, we will need to break it down and explain every aspect possible.Citing Amy Nordrum's article, "5 Myths about 5G", she talks about various information that has been collected about 5G technology. To start off, she touches upon the fact that experts have said 5G will be the future's 'hot spot' system. The concept behind it is that 5G will be deployed over SO cell networks and comparing to a traditional cell tower that broadcasts signals indiscriminately, it will have single base stations that will be on rooftops and lamp posts that will act as hyper-local areas. The big problem behind this is that labeling 5G as a hot spot system at such an early part of it's life, it's closing itself to future innovations. Another big concept that we wanted to clarify is "5G will replace 4G". Many people think that 5G is going to get rid of 4G completely and that it will act as our sole network. This goes back to 2G and 3G, which are still utilized around the world. Even though 5G and its entities may revolutionize things, there are various cases that say that 4G is more useful in that situation. Although 5G is going to be leading, 4G isn't going anywhere anytime soon. The positive side of 5G that is referenced in the article is that 5G might not need substantial investing to make it widespread. She states that, "5G will be deployed on existing infrastructures." [9] Capital expenditures are expected to drop when 5G is deployed as predicted by the roll out of LTE, which caused no influx in Capital. [9]

Here we will talk about some other papers that we find in Google Scholar that look like they are on our topic. What we find we will talk about, and each time cite it, and those citations will appear in our Bibliography at the end. Our final part of the Literature Review we will say that in all these other papers that we looked at, we found that there was a great need for something that all of the others missed, which is what our paper has, which is a comparison and contrasting of the different options of this or that category.

For example, There is a great paper called "What will 5G Be?" and we might find an idea there [10] and then later in our Literature Review we talk about Polar Codes, and we cite it here [11].

B. Acronyms

3GPP 3rd Generation Partnership Project

IoT Internet of Things

SOHO Small Office Home Office

ISDN Integrated Service Digital Network

ADSL Asynchronous Digital Subscriber Lines

LTE Long Term Evolution

HVAC Heating, Ventilation and air conditioning

ARIB The Association of Radio Industries and Businesses, Japan

WBSN Wireless Body Sensor Network

ATIS The Alliance for Telecommunications Industry Solutions, USA

CCSA China Communications Standards Association

ETSI The European Telecommunications Standards Institute

TSDSI Telecommunications Standards Development Society, India

TTA Telecommunications Technology Association, Korea

TTC Telecommunication Technology Committee, Japan

BPON Broadband Passive Optical Network

GPON Gigabyte Passive Optical Network

Demarc also known as the MPOP

MPOP mimimum point of penetration

DAS Distributed Antenna System

C-RAN Centralized Radio Access Network

SO Small Office

AR Augmented Reality

OBA Oxygen Breathing Apparatus

NR New Radio (5G)

C. Equations

Punctuate equations with commas or periods when they are part of a sentence, as in:

$$a + b = \gamma \tag{1}$$

D. Figures and Tables

[2]

[2]

[12]

Solution	Description	Technology	# Users	Cell Radius
DAS	Typically fed by a macro or micro base station. High power, multi-frequency, multi-carrier.	UMTS HSPA+ LTE	Up to 1,800 users per base station	Up to 3 miles
Wi-Fi	A wireless access point connects a group of wireless devices to an adjacent wired LAN.	802.11b 802.11g 802.11n	Up to 200 users per a 3-radio access point	65 feet
Microcell	Short-range base station used for enhancing indoor and/or outdoor coverage.	UMTS HSPA+	32 to 200 users	Up to ≈1 mile
Metrocell	High-capacity, low power device that fills in coverage holes within buildings.	UMTS HSPA+	16 to 32 users	10,000 – 20,000 square feet
Picocell	Typically used for indoor applications such as office buildings, airports, and malls.	UMTS	32 users	Up to 750 feet
Femtocell	A small, low-power cellular base station typically used for a home or small business.	UMTS	4-6 users	40 feet

Fig. 1. Data transmission distances

Small Cell Type	Cell Radius	Power Level (Watts)	Number of Users
Outdoor DAS (oDAS)	1 mile	20	3,000 per sector
Indoor DAS (iDAS)	Up to 200 feet per antenna	2	2,500 – 3,000 per sector
Microcell	1 mile	10	1,800 per baseband unit
Metrocell	500 – 1,000 feet	5	200
Picocell	750 feet	1	32
Femtocell	50 - 60 feet	0.1	4 - 6
Wi-Fi	50 - 60 feet	0.1	Up to 200 per access point

Fig. 2. Small Cell Network

a) Positioning Figures and Tables: Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation "Fig. 4", even at the beginning of a sentence.

TABLE I
TABLE TYPE STYLES

Table Head	Table Column Head		
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[a]Sample of a Table footnote.

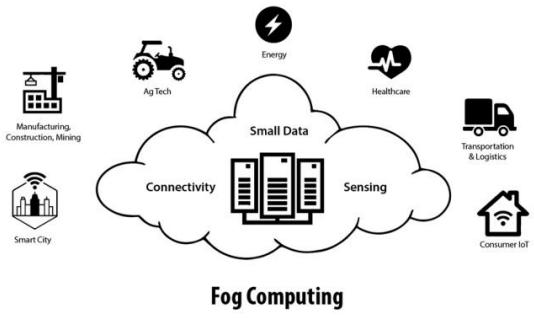

Fig. 3. Fog Computing

Fig. 4. Example of a figure caption.

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