A Data Infrastructure for Global Perioperative Outcomes

(Technical Paper)

Comparison of 4G implementation in a developing country versus a developed one

(STS Paper)

A Thesis Prospectus Submitted to the

Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements of the Degree
Bachelor of Science, School of Engineering

Nathan Ohene
Fall 2019

Technical Project Team Members

Bhavana Channavajjala
Victoria Rho
Rex Focht
Angela Yi
Sarah Winston Nathan
Luke McPhillips

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Signature *Nathan Ohene*   Date 12/11/19
Nathan Ohene

Approved _____ Date 12/11/19
Donald Brown, Department of Systems and
Environmental Engineering

     Date 12/11/19
Approved _____
Kent Wayland, Department of Engineering and Society

General Research Problem: Rapid Technological Advancement in Rwanda

The Republic of Rwanda is a very small country located in central Africa. The nation has an epic history filled with turmoil. After being occupied by Germany and then Belgium, Rwanda gained its independence in 1962. In the years that followed, the nation endured totalitarian rule under Juvénal Habyarimana. He began his rule in 1973 after leading a military coup to overthrow the previous leader. In 1994, he was assassinated. This event sparked one of the most gruesome events in human history. Over the next 100 days, between 500,000 and 1 million Rwandans were murdered in the Rwandan genocide over racial tensions between the Tutsi and Hutu.

The state of the country after the genocide was dire. The economy and infrastructure had been destroyed. In this desperate state, the current president, Paul Kagame, took control of the country with very optimistic goals in mind. His goal was to transform Rwanda into a middle-income country by 2020. He is well on his way to achieving this goal. In the years since Kagame's leadership began, Rwanda has rid itself of corruption, established universal health care, and established 4G Long Term Evolution (LTE) coverage in more than 95% of the country (Reporter January 2 2018). Rwanda has become a shining example for other developing nations in Africa.

Many of Rwanda's perceived disadvantages have been the reason for its success. It's small size and population density have allowed for quick adoption of 4G LTE. Leaders also prioritized health care much more because of the horrific genocide. Rwanda has become competitive in some sectors for developed nations. It is changing the conversation about Africa from a place where aid and contribution goes. Rwanda is becoming a nation that can be the source of aid and contributions. The long-term goal for Rwanda is to provide a health care system and technological infrastructure that is constantly improving.

1

A Data Infrastructure for Global Perioperative Outcomes

Every society strives to provide the best health care for its citizens. Surgery, one of the most difficult professions, requires thousands of hours to reach mastery. Instead of having surgeons train for years to learn the best practices, they can learn from others. Surgeons need data from past surgeries in order to improve as quickly as possible. As smartphone use and network coverage has expanded throughout the country, there is an opportunity to establish a system for electronic medical data collection. Data that describes what happens before, during, and after surgery is called perioperative data. The collection of perioperative data is vital for surgeons because it allows them to learn and improve their skills and practices. It is especially useful in Rwanda and other developing countries where post-surgery complications are more common and more severe.

Rwanda needs cutting edge technology to collect enough quality perioperative data to help its citizens. Our technical project is to design and implement a Perioperative Outcomes Infrastructure for a hospital in Rwanda. This will involve a standardized process for recording data on paper and storing it electronically. We will use scanning software that is available on smartphones to scan the paper documents into electronic documents, and send them to UVA. These electronic documents will then be processed to extract data such as blood pressure and other vitals, medicine used, and postoperative care instructions. Once extracted, the data will be stored in a database maintained by UVA, and accessible by the Rwandan hospital.

In many developed countries, infrastructure that can electronically store perioperative data already exists. Hospitals have used scanners, high speed internet, and optical character recognition software to digitize their data. As far back as 2016, hospitals have put this data to use and improved their operations. Every surgery performed introduces new data, and this data

2

aggregates into insight. This insight can turn into rules or practices for surgeons to follow, and improve the profession as a whole.

We hope to establish this infrastructure so that it can make a difference for the care providers at this Rwandan hospital. We hope that by organizing and storing data that would otherwise be stored in file cabinets on paper, Rwandan hospitals can gain insight into how to improve perioperative outcomes.

STS Topic: Comparison of 4G implementation in a developing country versus a developed one

What are the societal advantages and disadvantages of 4G implementation in an underdeveloped country like Rwanda over those in the US or other countries that are already developed?

Introduction

Rwanda is still a developing country. It lacks many useful infrastructures that developed countries have. Most roads outside of the capital are not developed. Most citizens do not make more than $720 per year. But the country is quickly improving its citizens' quality of life. Rwanda is currently undergoing an industrial revolution. If they were in the same position as a country like the United States during their industrial revolution, an ambitious health care project like a Perioperative Outcomes Infrastructure would not be possible. However, Rwanda is in an advantageous position because its citizens have access to mobile phones. As stated earlier, Rwanda is a country with 4G LTE coverage in 95% of the country. Further, 75% of people have cell phones (Reporter, January 3, 2018), 20% of these being smartphones (Nsehe, 2019). Because of the ubiquity, ease of use, and utility of these devices, it is much easier to establish a data collection system. Developed countries have used expensive physical infrastructure and

3

equipment to establish the same technology that my group hopes to implement. However, hospitals in Rwanda can implement it with nothing more than its employees' mobile phones. This project highlights an advantage that a developing country has over a developed one. It is important to understand the advantages and disadvantages of a country that is underdeveloped in order to recognize unique opportunities that would not be possible for developed countries.

Background

Although Rwanda is developing quickly, there is no denying that it is a very poor country like many other Sub-Saharan African countries. It has many great qualities, but it is still lacking in education, agriculture, and safety. This may raise the question: if the country is struggling mightily, why do 75% of people have access to mobile phones? The head of a prominent African telecommunications company states that "For many Africans, the cell phone is a productive tool. It is not a luxury item" (Seemungi, 2014). Mobile phones can replace other important infrastructure by allowing people to access information remotely. Regular mobile phones, not smartphones, have changed the lives of millions of Rwandans. They use phones to buy and sell products, send money to friends, and run their businesses. All the while, they can still use phones to talk to friends and family. For comparison, in the US, there are landlines, banks, roads, and other expensive forms of infrastructure that facilitate these processes. It only became possible to send money through smartphones a few years ago through apps like Venmo and CashApp. However, this has been possible in Africa since 2007, before the smartphone was even popularized, using an SMS service called mPesa (Seemungi, 2014). Africans are able to send money to their loved ones in an instant, and most of them do not even have a bank account.

Citizens of Rwanda have an expertise over their phones that other developed countries' citizens do not have because depend on them so heavily. In the digital age, it goes without saying

4

that most citizens are experts with their phones. However, it is especially true in Rwanda because citizens need to be on their phones to live their lives as opposed to somewhere like the United States where it is optional.

African developers have created lightweight apps that operate through text to serve the same purpose of many of the memory intensive smartphone apps used in developed countries. Some apps give the price of goods or allow businesses to post their products for people to query. These apps take away the costs of travel and labor for the businesses that use them, significantly increasing their profits. The apps are fundamentally changing the economic landscape in Africa, and through innovation that has never been seen outside of it. The fact that Rwanda has 95% 4G LTE allows all these apps to be accessible nearly anywhere in the country. This is part of the reason that Rwanda is the best place in Africa to do business according to the World Bank (World Bank, 2019).

Theoretical Framework

I hope to discuss how cell phone communication has evolved as a sociotechnical system in Rwanda. In a manner similar to biological evolution, the cell phone has evolved differently in different environments. To some, it may seem behind for a feature phone to be used more than a smartphone, but I would like to see what the data actually suggests. This will involve a discussion about mutual shaping. I plan to discuss how the Rwandan economy and lack of physical infrastructure have shaped the popular apps and usage of the feature phone. I will also explain how social and cultural life in Rwanda has changed as a result of the technology. Different people have different uses for the 4G LTE network. I hope to find out what these specific groups are, and how their lives have changed.

5

Current Literature

The published research about 4G implementation in Rwanda focuses on the technical aspects of the implementation. Some research analyzes how reliable the 4G LTE network is. It also suggests areas for policy makers in Rwanda to focus on when regulating the network (Kazenga, 2017). Literature also surveys Rwandan citizens to understand the perception of this new technology in the country (Ramadhani, 2015). The research does not address how implementation in Rwanda compares to that of a developed country.

Many African entrepreneurs discuss how innovation in Africa differs from that in developed countries. They speak anecdotally about their experiences, but it would be helpful to have a research paper describe these differences. I hope to find this in the literature. I also hope to find out how the varying reliability of the network impacts how citizens interact with it. I would like to understand how developers write the apps with the constraints around the network reliability in mind, and how entrepreneurs can leverage it to provide services for citizens.

Evidence

I plan to study the laws that regulate 4G to understand the legal differences that the implementation of the network has. I will find the formal definitions of a 4G network and if the differences affect anything. I will look at different companies and find testimonies from them about the way 4G has changed their business. I also hope to understand how the economy has changed in Rwanda since 4G has been introduced through metrics such as GDP and unemployment rate. I will compare this change to the change that has occurred in developed countries. I hope to understand the legal, economic, and cultural differences of Rwanda to developed countries that 4G has made since being implemented.

6

STS Conclusion

Those familiar with the market say that Africa is rising. However, many still have a very negative view of the continent. When some people think of the continent, they think of mud huts, disease, and poverty. The only thing that people find of value when they think of Africa is commodities like gold, cocoa, and coffee. Rwanda is the shining example that this is no longer the case. Rwanda is competitive in many sectors with developed nations. Rwanda is taking a unique path to development, and they are doing so with different circumstances to the developed world. Therefore, it is important to understand the differences as it pertains to sociotechnical systems. These differences have implications to how citizens live, and how the technology develops.

General Conclusion

At the turn of the century, Rwanda was a small nation with big problems. It has transformed into the leader of the African Industrial Revolution. Many people have preconceived notions about Africa and Rwanda. Their views do not reflect the present. They have not heard about countries like Rwanda where technological infrastructure is advancing in ways that have never been seen before. Every citizen of Rwanda can receive health care. This cannot be said for some developed nations. Rwanda has 95% 4G LTE coverage. This also cannot be said in other developed nations. It is important to take a closer look at the country, and try to understand the differences that led to this technological development. It is also important to understand that there is more than one way for technology to develop. Although, we can analyze the social impact of technology, we do not yet understand the quantifiable impact that this technological advancement has had on the economy and the productivity of the country. There is still a large

7

amount of research that can be done. A good place to start is a survey of the mutual shaping of

cell phone technology and society in Rwanda.

References

Essien, M. (2015, December 21). How Africa Can Lead in the Global Technology Space [Video file]. Retrieved from https://www.youtube.com/watch?v=XjsYNnMmetM

Kazenga, T. M., Tuyishimire, J. B. , Garba, A. A., Saint, M and Deen, L. (2017) Development of Internet of Things indicators in Rwanda based on stakeholder analysis. *2017 International Conference on Information and Communication Technology Convergence (ICTC)*, Jeju, 2017, pp. 622-627. doi: 10.1109/ICTC.2017.8191054

Mufuruki, A. (2014, December 30). Is Africa Really "Rising" [Video file]. Retrieved from https://www.youtube.com/watch?v=OjgJ2KpyJ5w.

Nana-Sinkam, S. (2016, June 16). How Mobile Phones Are Shaping the Next Wave of African Innovation [Video file]. Retrieved from https://www.youtube.com/watch?v=PCUJXpVbRDk.

Nsehe, M. (2019, October 12). Ashish J. Thakkar Launches Smartphone Factory In Rwanda. Retrieved from https://www.forbes.com/sites/mfonobongnsehe/2019/10/07/tycoon-ashish-j-thakkar-launches-smartphone-factory-in-rwanda/#9ba6b8b481a7.

Okonjo-Iweala, Ngozi. (2016, June). How Africa can keep rising [Video file]. Retrieved from https://www.ted.com/talks/ngozi_okonjo_iweala_how_africa_can_keep_rising#t-16484.

Seemungal, M. (2014 February 15). Mobile phone usage explodes in Africa, spurring innovation [Video file]. Retrieved from https://www.pbs.org/newshour/show/mobile-phone-usage-explodes-africa-spurring-innovation

9

Ramadhani, N., Kalaskar, P., & Satpute, V. (2015). A Study on Consumer Perception towards Adoption of 4G Mobile Technologies in Rwanda. *American Scientific Research Journal for Engineering, Technology, and Sciences, 14*(2).

Razavi, L. (2018, May 8). How Rwanda's Capital Became an African Tech Leader. Retrieved from https://medium.com/s/story/how-rwandas-capital-became-an-african-tech-leader-66e00edc74d.

Reporter, T. (2018, January 2). 4G internet network coverage reaches all districts - KT Rwanda. Retrieved from https://www.newtimes.co.rw/section/read/226815.

Reporter, T. (2018, January 3). Rwanda's mobile telephone penetration rises slightly to 75.5% in November. Retrieved from https://www.newtimes.co.rw/section/read/226813.

Pistone, J., Steinacker, D. (2015, May 26). The Power of Mobile in Africa [Video file]. Retrieved from https://www.youtube.com/watch?v=XWPFsSab10A.

Vosloo, S. (2018, February 24). The Feature Phone is Not Yet Dead in African Countries. Retrieved from https://www.ictworks.org/feature-phone-not-dead-africa/#.XcP2LOhKg2x.

World Bank, Doing Business Index. (2019). Doing Business Rankings [Data file]. Retrieved from https://www.doingbusiness.org/en/rankings.