CARLETON UNIVERSITY

Department of Systems and Computer Engineering
SYSC4700 Telecommunications Engineering 2017

Professor Halim Yanikomeroglu

TERM PROJECT

WHEN MACHINE LEARNING AND BIG DATA MEET WIRELESS

SUBMIT THE REPORT IN PDF FORMAT AS AN EMAIL ATTACHMENT BY 11:59 PM, FRIDAY, APRIL 07.

Late submission without penalty: 11:59 pm, Sunday, April 9.

Award: The best project group members will receive individual certificates

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The term project is one of the most important components of this course. You should consider this project as an *opportunity* (not a hassle!) for you to learn more in an interesting area. Make sure that you get most out of this project.

1. Context

Here is part of the epilogue that I wrote for the book entitled "5G Wireless Technologies", edited by Professor Angeliki Alexiou, to be published in Fall 2017:

"Since the completion of the first 4G LTE standard in the late 2000s, the research community has been conceiving 5G, mainly from two tangled angles, the novel use cases and the enabling technologies. At the time of the writing of this book, the 5G standardization process has already started; the first 5G standards are scheduled to be finalized in the late 2010s. The 5G is expected to evolve throughout the 2020s; and, probably sometime in the latter part of the 2020s, the 6G standardization process will start, with possible deployments in the early 2030s. It is rather early at this point to over-speculate on 6G. Nevertheless, it is possible to highlight a number of important points in light of the experience gained from the first four or five generations.

The big promise of 5G is that the use cases in this generation will not be confined to the smart phone environment. Therefore, the success of 5G is closely tied to

how quickly and to what extent these novel use cases will have market acceptance. Although the maturity of the 5G technologies for enabling the new use cases is essential, this is not the only factor for the success of 5G; arguably, market-readiness of these use cases will play an even more important role. One of the reasons for the great success of 4G LTE has been that the standard involved a number of technologies which were highly successful in enabling a primary use case, namely, video delivery on smart phones. At the same time, there was a great market/demand for this use case – the right synergy for success. 5G is coming with many powerful enabling technologies, many of which are highlighted in this book. However, anticipating the market adoption timeline of the 5G use cases is more difficult, as this timeline depends on factors beyond engineering. For example, the fully autonomous and connected vehicle paradigm cannot become a reality in a short time frame. A number of new use cases, such as this one, require policy and legislation chances which are inherently long processes. Therefore, during the latter part of the 2020s, when the 6G standardization is likely to occur, the discussions around many of the use cases attributed to 5G will likely to continue in the 6G context as well.
…

5G marks the start of a new era in wireless. The road towards 5G has been very exciting. The road towards 6G will be even more exciting…"

2. Description

This project is on the use of two emerging enablers, namely, machine learning and big data analytics, in future wireless networks. The project is not on the theory of these enablers, rather, it is on the application of these enablers on novel use cases (applications).

An example discussed in the lectures is given here as well. The network can learn and/or predict a user's likes & dislikes and can deliver an application (such as video) in a way to maximize the satisfaction of the particular user taking into account that user's preferences, the context, the value of the application to the user at that point in time, and so on. There is no point in delivering an ultra high quality video if the user is in a crowded bus (as the user's situation will not allow her/him to fully enjoy the video), while the user may expect a much better experience if this is the prime leisure time for the user at her/his home, especially if this is the type of video that the user would like most. If the network can "differentiate", it may also charge the user in a different way – they higher the value is to the user, the higher the cost may be. As such, the mentioned enablers may facilitate win-win situations to all stakeholders.

In scenarios of this type, "feedback" from the user to the network plays an essential role in "learning". However, an extensive level of feedback expectation

of the network may annoy and irritate the user. Therefore, some or all of the feedback can be collected in a non-intrusive way, for instance, through “sentiment analysis”.

In the project, you are expected to envision a scenario that utilizes machine learning and big data analytics in a wireless application (for instance, the intelligent transportation systems, smart cities, …). Your creativity is the key. However, keep in mind that this is an engineering project, not a science fiction one. So, your project will need to be built on solid engineering principles.

3. **Requirements**

The report will address the followings, in separate sections:

3.1 – Briefly describe 4G LTE and LTE-Advanced

3.2 – Describe 5G

- timeline
- novel uses cases
- technical specifications
- novel technologies.

3.3 – Describe machine learning.

3.4 – Describe big data analytics.

3.5 – Come up with a wireless scenario in which machine learning and big data can be utilized.

3.6 – Conclude your report with some closing remarks.

3.7 – Provide a reference list at the end of the report.

Carefully substantiate your claims throughout the report.

4. Carleton References

USER-IN-THE-LOOP

- Rainer Schoenen and Halim Yanikomeroglu, “User-in-the-loop: Spatial and temporal demand shaping for sustainable wireless networks”, IEEE Communications Magazine, vol. 52, no. 2, pp. 196-203, February 2014.
  http://ieeexplore.ieee.org/abstract/document/6736762/

- Meisam Mirahsan, Rainer Schoenen, Halim Yanikomeroglu, Gamini Senarath, and Ngoc-Dung Dao, “User-in-the-loop for HetHetNets with backhaul capacity constraints”, IEEE Wireless Communications, Special Issue on Smart Backhauling and Fronthauling for 5G Networks, vol. 22, no. 5, pp. 50-57, October 2015.
  http://ieeexplore.ieee.org/abstract/document/7306537/

- Ziyang Wang, Rainer Schoenen, Halim Yanikomeroglu, and Marc St.Hilaire, “Load balancing in cellular networks with user-in-the-loop: A spatial traffic shaping approach”, IEEE International Conference on Communications (ICC) 2015, 8–12 June 2015, London, UK.
  http://ieeexplore.ieee.org/abstract/document/7248723/
  http://www.sce.carleton.ca/faculty/yanikomeroglu/Pub/ICC2015-zwrshymsh-PRESENTATION.pdf

- Rainer Schoenen and Halim Yanikomeroglu, “Dynamic demand control with differentiated QoS in user-in-the-loop controlled cellular networks”, Workshop on Mobile and Wireless Communication Systems for 2020 and beyond co-located with IEEE IEEE Vehicular Technology Conference (VTC2013-Spring), 2–5 June 2013, Dresden, Germany.
  http://ieeexplore.ieee.org/abstract/document/6692523/

- Rainer Schoenen, Gurhan Bulu, Amir Mirtaheri, Tamer Beitelmal, and Halim Yanikomeroglu, “First survey results of quantified user behavior in user-in-the-loop scenarios for sustainable wireless networks”, IEEE Vehicular Technology Conference (VTC2012-Fall), 3–6 September 2012, Quebec City, QC, Canada.
  http://ieeexplore.ieee.org/abstract/document/6399067/

- Rainer Schoenen, Gurhan Bulu, Amir Mirtaheri, Tamer Beitelmal, and Halim Yanikomeroglu, “Quantified user behavior in user-in-the-loop spatially and demand controlled cellular systems”, European Wireless (EW 2012), 18–20 April 2012, Poznan, Poland.
  http://ieeexplore.ieee.org/abstract/document/6216846/

- Rainer Schoenen, Halim Yanikomeroglu, and Bernhard Walke, “User in the loop: Mobility aware users substantially boost spectral efficiency of cellular OFDMA systems”, IEEE Communications Letters, vol. 15, no. 5, pp. 488-490, May 2011.
  http://ieeexplore.ieee.org/abstract/document/5765870/

- Rainer Schoenen, Gurhan Bulu, Amir Mirtaheri, and Halim Yanikomeroglu, “Green communications by demand shaping and user-in-the-loop tariff-based

control", IEEE Online Conference on Green Communications (GreenCom'11), 26–29 September 2011.
http://ieeexplore.ieee.org/abstract/document/6082509/

PRICING

- Rainer Schoenen, Hamza Umit Sokun, and Halim Yanikomeroglu, "Green cellular demand control with user-in-the-loop enabled by smart data pricing using an effective quantum (eBit) tariff", IEEE Vehicular Technology Conference (VTC2016-Fall) as an Invited Paper, 18–21 September 2016, Montreal, QC, Canada.
http://www.sce.carleton.ca/faculty/yanikomeroglu/Pub/VTC2016Fall-rshushy.pdf

- Rainer Schoenen and Halim Yanikomeroglu, "Economics of user-in-the-loop demand control with differentiated QoS in cellular networks", IEEE International Symposium on Personal, Indoor and Mobile Communications (PIMRC 2012), 9–12 September 2012, Sydney, Australia.
http://ieeexplore.ieee.org/abstract/document/6362516/

5. Report

A group is normally formed by three or four students. Five-member groups are not allowed.

There are two deadlines ahead of you:

- Deadline 1: 4:00 pm, Friday, March 10. Email the names of your group members to the course TAs Irem Bor (irembor@sce.carleton.ca) and Mehmet Cagri Ilter (ilterm@sce.carleton.ca), with cc to me (halim@sce.carleton.ca). This e-mail must be copied to all the group members (only Carleton cmail addresses should be used).

- Deadline 2: 11:59 pm, Friday, April 7. Send the report as a PDF attachment to the course TAs and myself, with cc to all the group members.

- Deadline 3 (for those who miss Deadline 2): 11:59 pm, Sunday, April 9 (no penalty)

Missing the first deadline may result in some penalty in your overall mark for this project.

Each group will write one report. All group members will get the same mark. It is up to your group to organize the work and allocate tasks to group members. Your group output will be a report which addresses the above issues. Include references (papers, internet, etc.), with enough information that they can be verified by readers.

- Do not cut-and-paste from other sources (especially online sources) or use others' ideas, unless they are acknowledged and properly referenced. Violating this rule amounts to plagiarism, which is a serious instructional offence (see "instructional offences" in the undergraduate calendar, and www.plagiarism.org for definitions and examples of plagiarism). Reference to "other sources" also includes any overlap of your own work in other courses, such as fourth year projects, for example.

The report itself (without figures) should be no more than 10-15 pages of double-spaced text; you may put as many figures as you deem appropriate. Your marks will be based on the correct knowledge and persuasiveness revealed in your report, its organization, coherence and clarity, and use of references.

6. SYSC 4700 PROJECT MARKING FORM – Winter 2017

		Mark	Max	Comments
Overall organization and clarity, including presentation format (proper acronyms, coherence, informative pictures, …)			**10**	
Proper use of **references throughout the report (no cut-and-paste from internet)**			**10**	
Completeness and persuasiveness in answering requirements posed in project description:				
Q3.1	Describe LTE/LTE-A		**10**	
Q3.2	Describe 5G		**10**	
Q3.3	Describe machine learning (ML)		**10**	
Q3.4	Describe big data analytics (BDA)		**10**	
Q3.5	Wireless scenario with ML & BDA (novelty		**30**	
Q3.6	Closing remarks		**05**	
Q3.7	References		**05**	
Total			**100**	