Traffic-Centric Modeling of Future Wireless Internet Access Technologies

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***Abstract*—Modeling the performance of wireless networks is essential for the success of the Future Wireless Internet. Results obtained from a previous WLAN study suggest that Traffic-Centric Modeling (TCM) is a viable option for developing useful wireless performance models. In this extended abstract, a novel TCM methodology is briefly introduced. We intend to use TCM to develop models of complex wireless systems, such as IEEE 802.16 and 3GPP LTE networks.**

***Index Terms*—Traffic-Centric Modeling, Semi-Markov Process, Simulation, Wireless Networks.**

I. Introduction

Performance evaluation of wireless networks is key for the success of the Future Wireless Internet. Wireless networks need to be able to adapt to service needs and evolving contexts but are rigid in their architectural design. The EU FP7 FLAVIA [2] project aims to expose flexible programmable interfaces to enable service customization and performance optimization.

Hardware experimentation is not always a feasible option for evaluating performance management protocols. They require that great care to be taken when selecting and setting experimental parameters, particularly for wireless systems [3].

This extended abstract reports a novel modeling methodology, called Traffic-Centric Modeling (TCM), that is adept to model wireless networks. Results obtained from a previous wireless network study suggest that TCM is a viable and favorable option. We then conclude and highlight future prospects.

II. Traffic-Centric Modeling

A system performance model is traditionally made up of an abstraction of the workload and of the system hardware and software components, called the Workload Model (WLM) and the Machine Model (MM), respectively, as shown in Figure 1. The WLM feeds traffic into the MM, whereafter the data served by the system is collected and performance statistics are computed from them.

Differently, as Figure 1 shows, TCM shifts the data, i.e., the traffic, to the core of the model, yet still requires the WLM and MM, as before. The system is viewed from the perspective of that which requires service, i.e., the traffic, rather than of that which serves.

Furthermore, statistics are contained conveniently in the artifact used to represent the traffic, called the traffic-unit (t-unit), such that resulting performance can be formulated using its structural parameters.

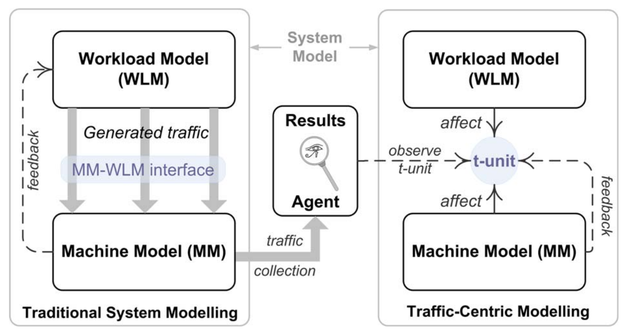

Figure 1. A comparison between traditional and traffic-centric performance modeling methodologies.

III. The Hybrid Model

A hybrid analytic-simulation model is the natural consequence of TCM. The analytic component, i.e., a semi-Markov chain (SMC), captures the attributes and possible behaviors of the unit of data to receive service in the network, i.e., the t-unit. A t-unit is the generalization of possibly the data frame, the fragment thereof, and so on. The simulation component is achieved by superimposing an execution algorithm over the underlying SMC structure. It represents the WLM and MM aspects.

The TCM process is represented by four steps, as shown in Figure 2.

1) Define the t-unit as a tangible entity with the set of possible and permissible actions it may experience, represented by an SMC, i.e., the *analytic* component.
2) Specify an execution algorithm, i.e., the *simulation* component, incorporating the WLM and MM, and superimpose it over the SMC.

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3) *Execute* the algorithm. SMC parameters, i.e., t-unit *experience*, are solved numerically.
4) Once the t-unit experience is known, performance statistics are to be computed using the SMC parameter values converged upon.

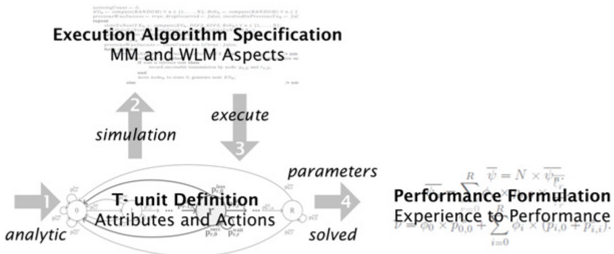

Figure 2. Four steps of the TCM process.

IV. Preliminary Results

In a study of an IEEE 802.11 network [4], TCM results were compared to that of the widely-accepted analytic model of Bianchi [1]. It is clear that the TCM model is very accurate. Furthermore, in the study, two unsaturated workload conditions were considered. This illustrates the relatively small amount of effort required to extend the model, i.e., to relax assumptions that would otherwise, most probably, require a great effort to rethink the model, should it even be possible.

Figure 3 shows the normalized mean throughput results for a varying number of nodes operating the Basic Access mode of the Distributed Coordination Function (DCF). Other metrics and modes of operation were considered as well but are not reproduced here.

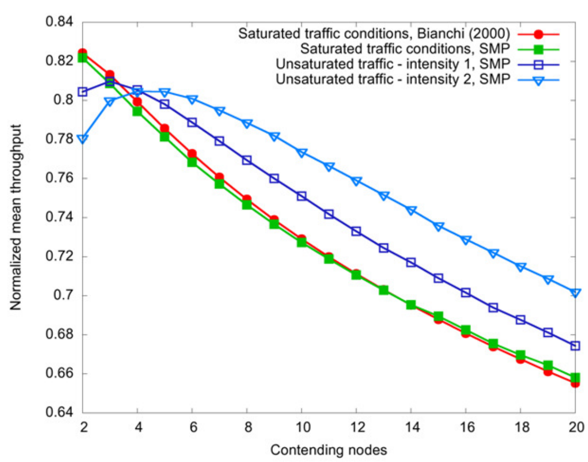

Figure 3. Normalized mean throughput results for a varying number of nodes operating Basic Access mode showing different load intensity options.

V. Conclusion

In this extended abstract we only very briefly touched on the key ideas behind the novel TCM methodology and advocated its applicability to wireless network performance evaluation. It should prove useful to projects that are concerned with the success of the Future Wireless Internet, such as the EU FP7 FLAVIA project, who are driving a paradigm shift from pre-designed link services to programmable link processors.

The IEEE 802.11 hybrid model should be extended to account for more realistic channel and workload conditions. The QoS-aware version of the DCF is another direction.

We intend to apply TCM to more complex wireless systems, such as IEEE 802.16 and 3GPP LTE networks. This would be more challenging since these networks are connection-oriented and have many more complex mechanisms specified.

A relatively fast extensible and accurate model is desired to evaluate complex wireless network performance. TCM is a candidate modeling solution.

Acknowledgments

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References

[1] G. Bianchi, "Performance Analysis of the IEEE 802.11 Distributed Coordination Function," *IEEE Journal on Selected Areas in Communications*, vol. 18, no. 3, pp. 535–547, March 2000.
[2] CNIT, "FLexible Architecture for Virtualizable future wireless Internet Access," 2011. [Online]. Available: http://www.ict-flavia.eu/
[3] P. Kritzinger and A. Symington, "A Hardware Test Bed for Measuring IEEE 802.11g Distribution Coordination Function Performance," in *Proc. 2009 IEEE International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems (MASCOTS)*, September, pp. 61–67.
[4] P. Pileggi and P. Kritzinger, "Traffic-Centric Modelling by IEEE 802.11 DCF Example," in *ASMTA'11: 18th International Conference on Analytical and Stochastic Modelling Techniques and Applications, LNCS 6751*. Springer-Verlag Berlin Heidelberg, 2011, pp. 219–233.