Evaluation of M2M Data Traffic Aggregation in LTE-A Uplink

[1]Yasir Mehmood
[2]Safdar Nawaz Khan Marwat
[3]Dr. Yasir Zaki
[1]Prof. Dr. Carmelita Görg
[4]Prof. Dr. Andreas Timm-Giel

[1]Communication Networks, (ComNets), University of Bremen
[2]Department of Computer Systems Engineering, University of Engineering and Technology, Peshawar, Pakistan
[3]Computer Science Department, New York University Abu Dhabi (NYUAD), Abu Dhabi, United Arab Emirates (UAE)
[4]Institute of Communication Networks, University of Technology, Hamburg, Germany

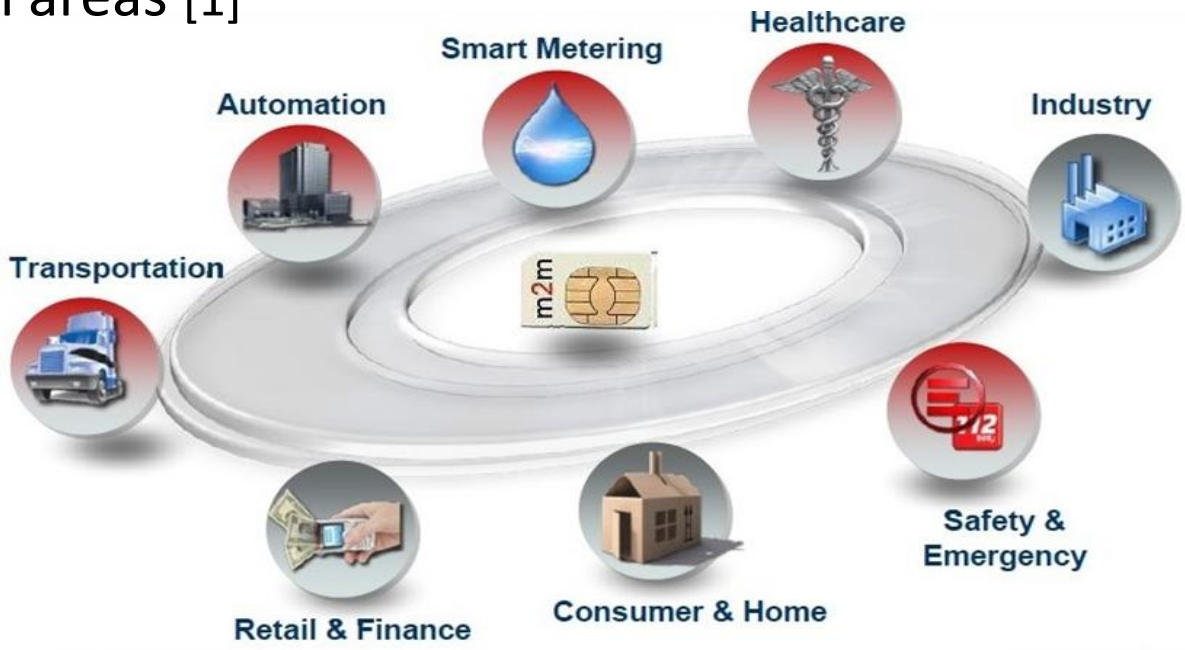
07 May, 2015

Agenda

- Introduction
  - M2M communication and cellular networks evolution
- Problem Definition – challenges for mobile networks
- Proposed Methodology
  - Uplink M2M data traffic aggregation
- Simulation Results and Analyses
  - LTE-A model and parameters description
  - Results Analyses
- Conclusions
- Outlook

M2M communication

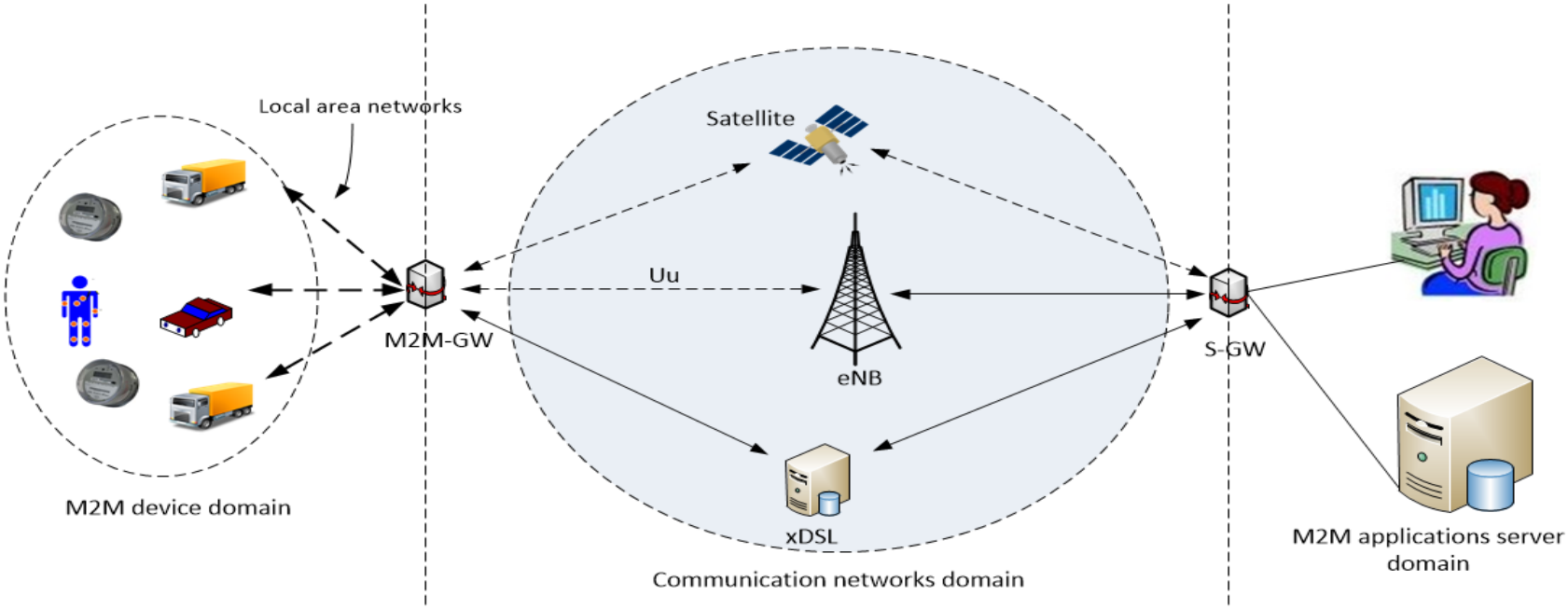
- Characteristics
  - Large number of devices transmitting small sized data
  - Higher ratio of uplink to downlink traffic volume
  - Mobility support e.g. logistics processes and ITS[1]
- Application areas [1]



[1]Intelligent Transportation System

[1] EXALTED 2013, http://www.ict-exalted.eu/fileadmin/documents/EXALTED_WP2_D2.1.pdf [accessed: 10 Dec 2014]

M2M architecture

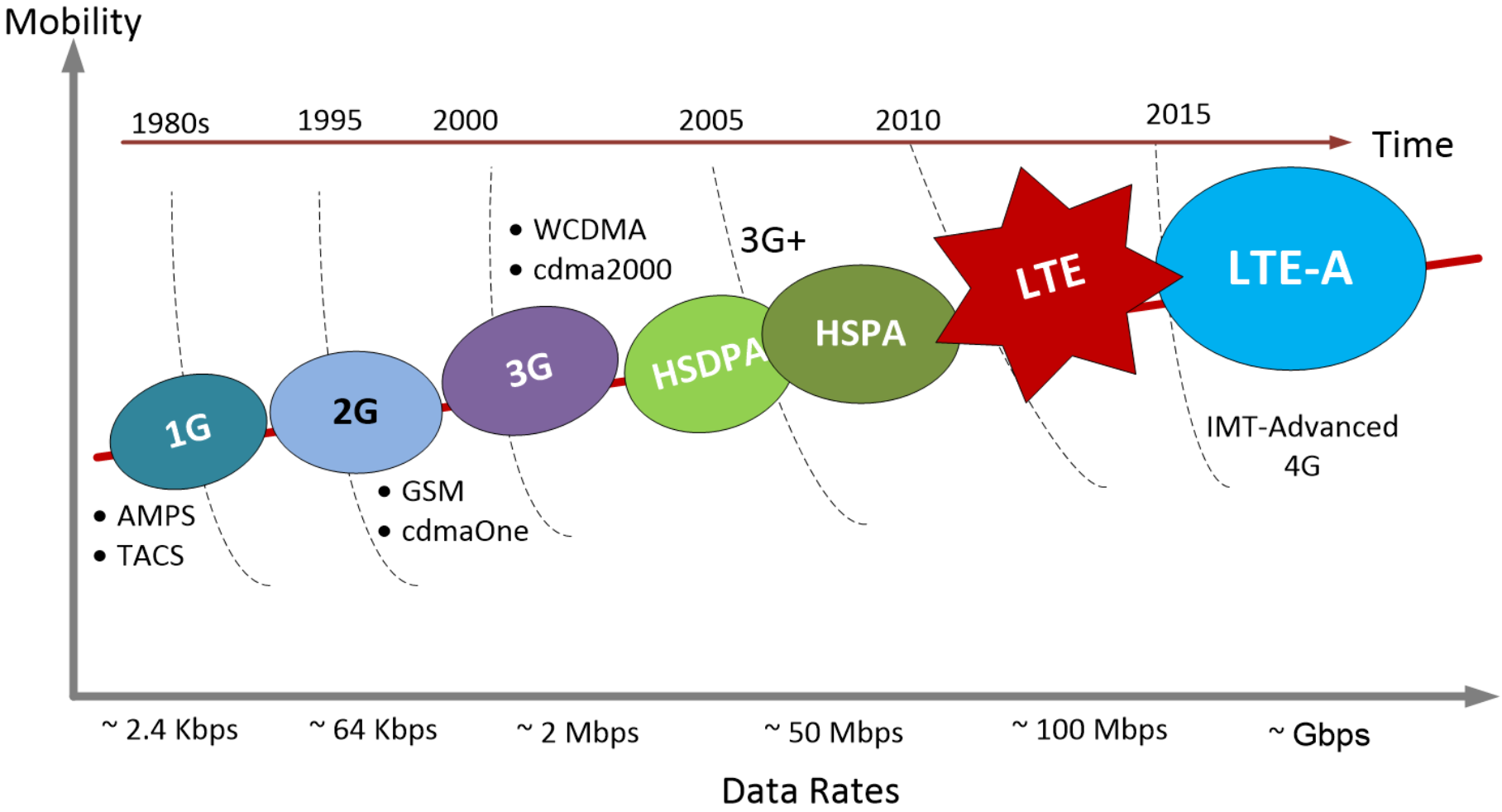


▪ Sensors ▪ Cellular modules ▪ IoT modules etc.	▪ WPAN ▪ WSNs ▪ WLAN etc.	▪ Mobile networks e.g. LTE-Advanced ▪ xDSL ▪ Satellite	▪ WPAN ▪ WSNs ▪ WLAN etc.	▪ Servers

- E-healthcare
- Logistics, Energy etc.
- Surveillance

M. Chen, J. Wan, and F. Li, "Machine-to-machine communications: Architectures, standards and applications.," KSII Transactions on Internet & Information Systems, vol. 6, no. 2, 2012

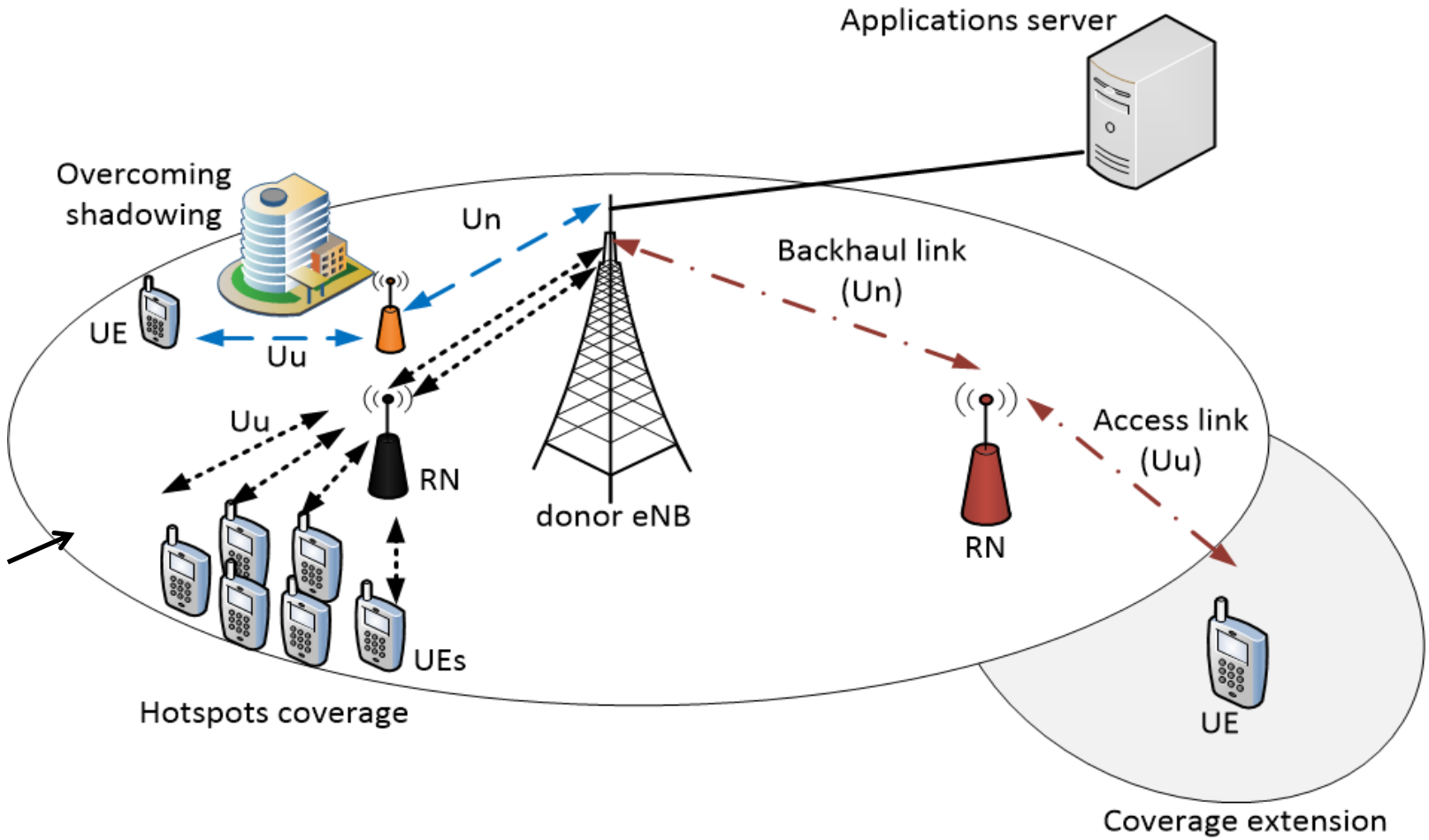
Cellular network evolution



Based on: UMTS – 3G Mobile Communication Systems, University of Bremen, U. Türke

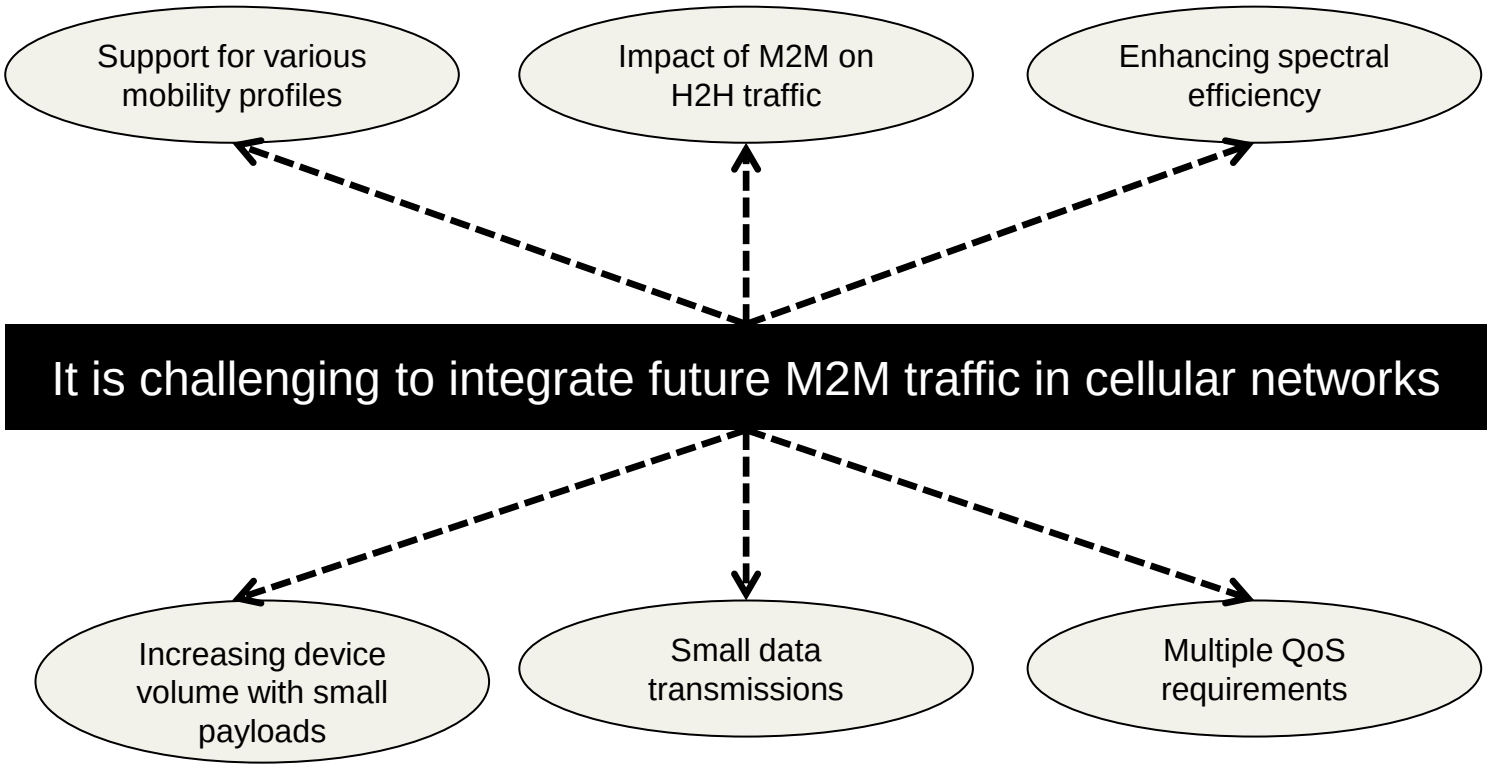
LTE-A enhancements

- Coordinated multipoint
- Carrier aggregation
- Small cell
- Relaying
- Multiusers MIMO



3GPP TS 36.216 V10.0.0, "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer for relaying operation", September 2010

Problem definition—mobile M2M traffic



[1] https://www.metis2020.com/documents/deliverables/

[2] 3GPP Technical Specification 23.888 V 11.0.0 (2012) System improvements for Machine-Type Communications

[3] Tarik Taleb, Andreas Kunz, "Machine Type Communications in 3GPP Networks: Potential, Challenges, and Solutions" *Communication Magazine, IEEE,* vol. 51, no. 3 March 2012

Problem definition—M2M traffic forecasts

- 53 million metering M2M devices by 2020 — OFCOM report [1]
- One billion cellular M2M devices by 2020, growing 25 per cent per year — GSMA report [2]
- The number of M2M device worldwide will grow to 3.2 billion in 2024 — M2M magazine [3]

[1] http://stakeholders.ofcom.org.uk/binaries/research/technology-research/2014/M2M_FinalReportApril2014.pdf Accessed: 6 May 2015

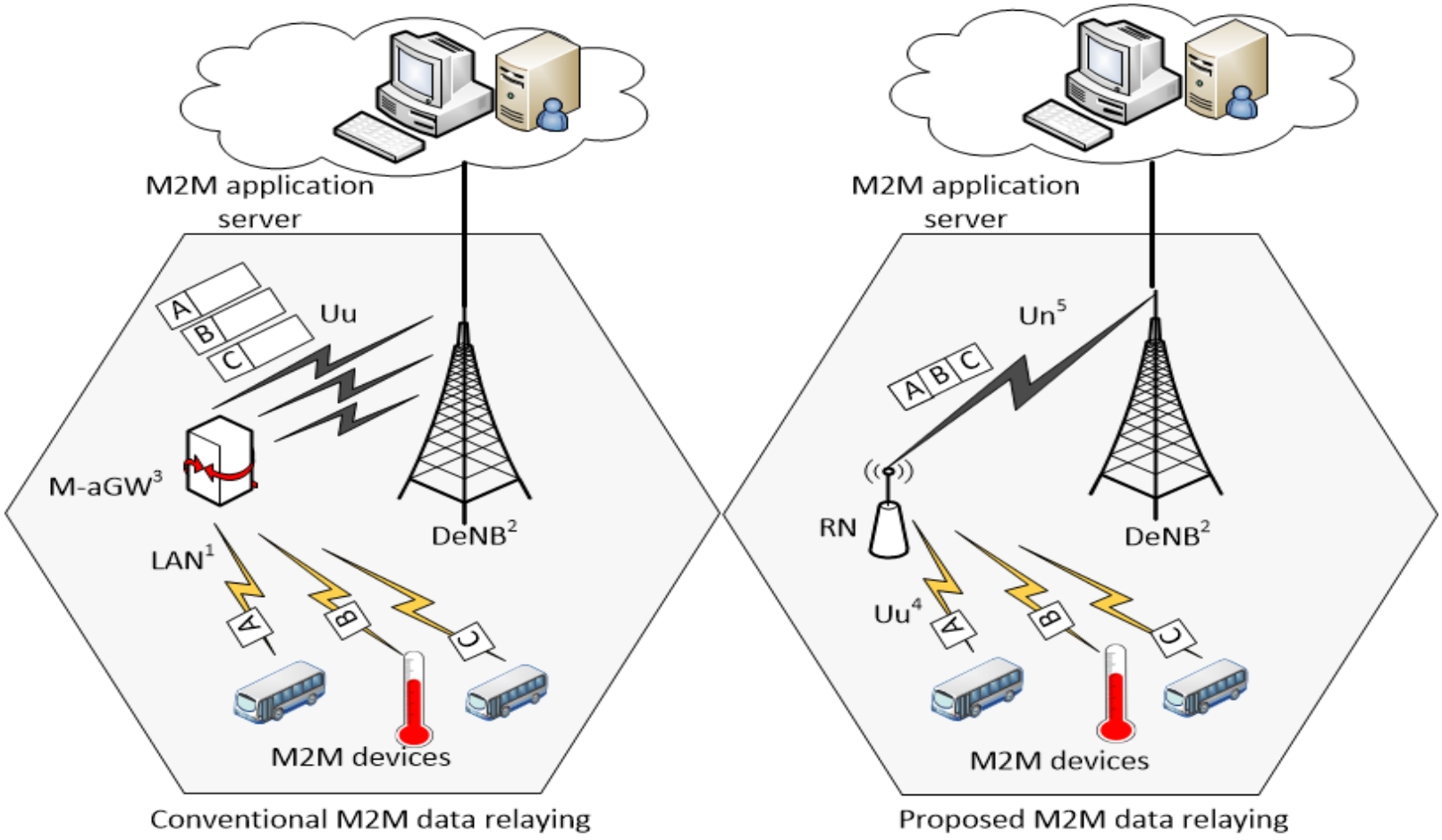
[2] https://gsmaintelligence.com/research/2015/02/cellular-m2m-forecasts-unlocking-growth/457// Accessed: 6 Feb 2015

[3] http://www.machinetomachinemagazine.com/2014/08/20/report-m2m-device-connections-forecast-2014-2024/ Accessed: 6 May 2015

How to deal with a thousands of machine devices?

Proposed Methodology—M2M Data Traffic Aggregation in LTE-Advanced Uplink

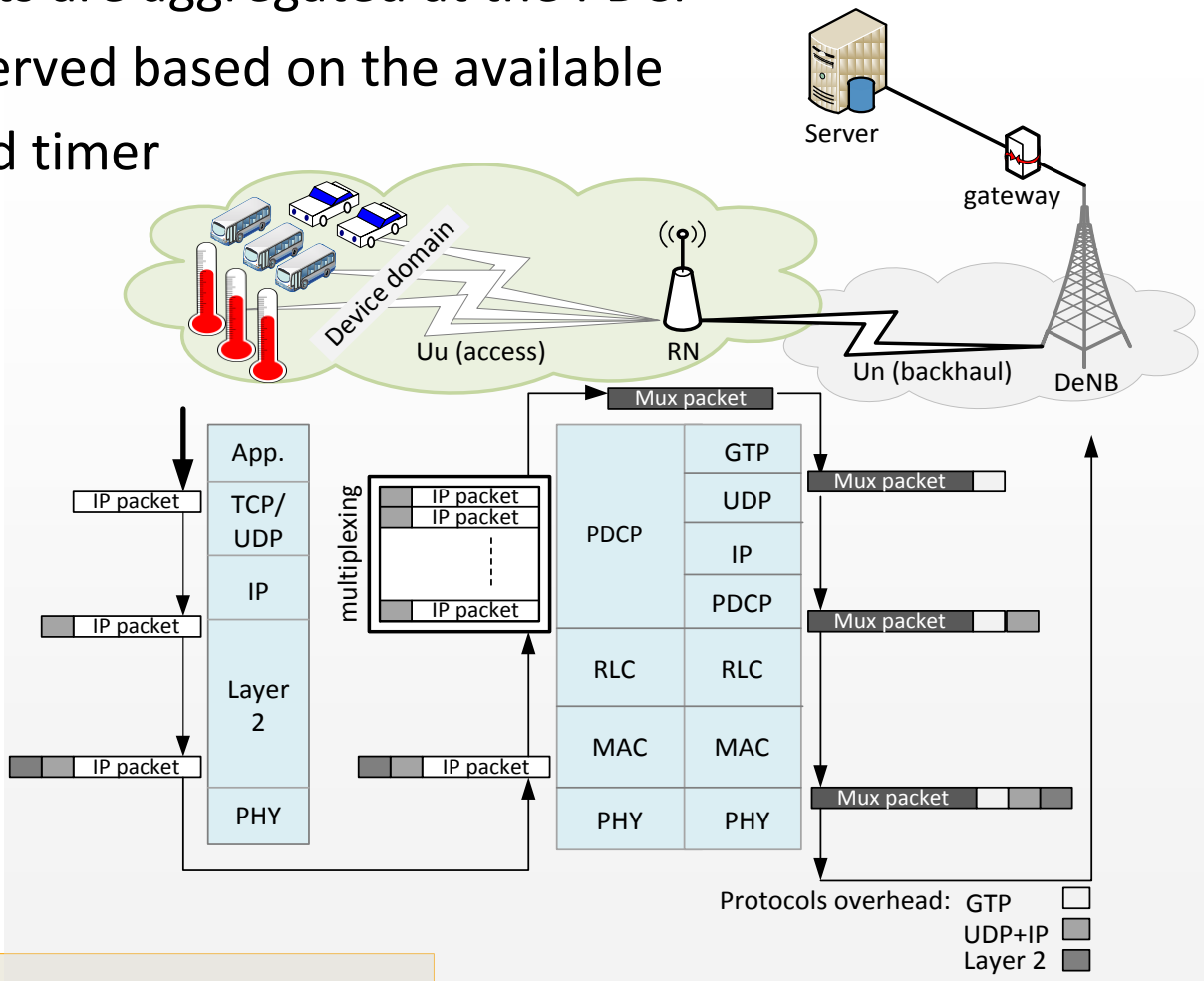
M2M uplink data traffic aggregation



1: Local area network; 2: Donor eNodeB; 3: M2M access gateway; 4: Access link; 5: Backhaul link

M2M uplink data traffic aggregation

- Relay node is used to aggregate uplink M2M traffic
- Small M2M data packets are aggregated at the PDCP
- Aggregated packet is served based on the available transport block size and timer



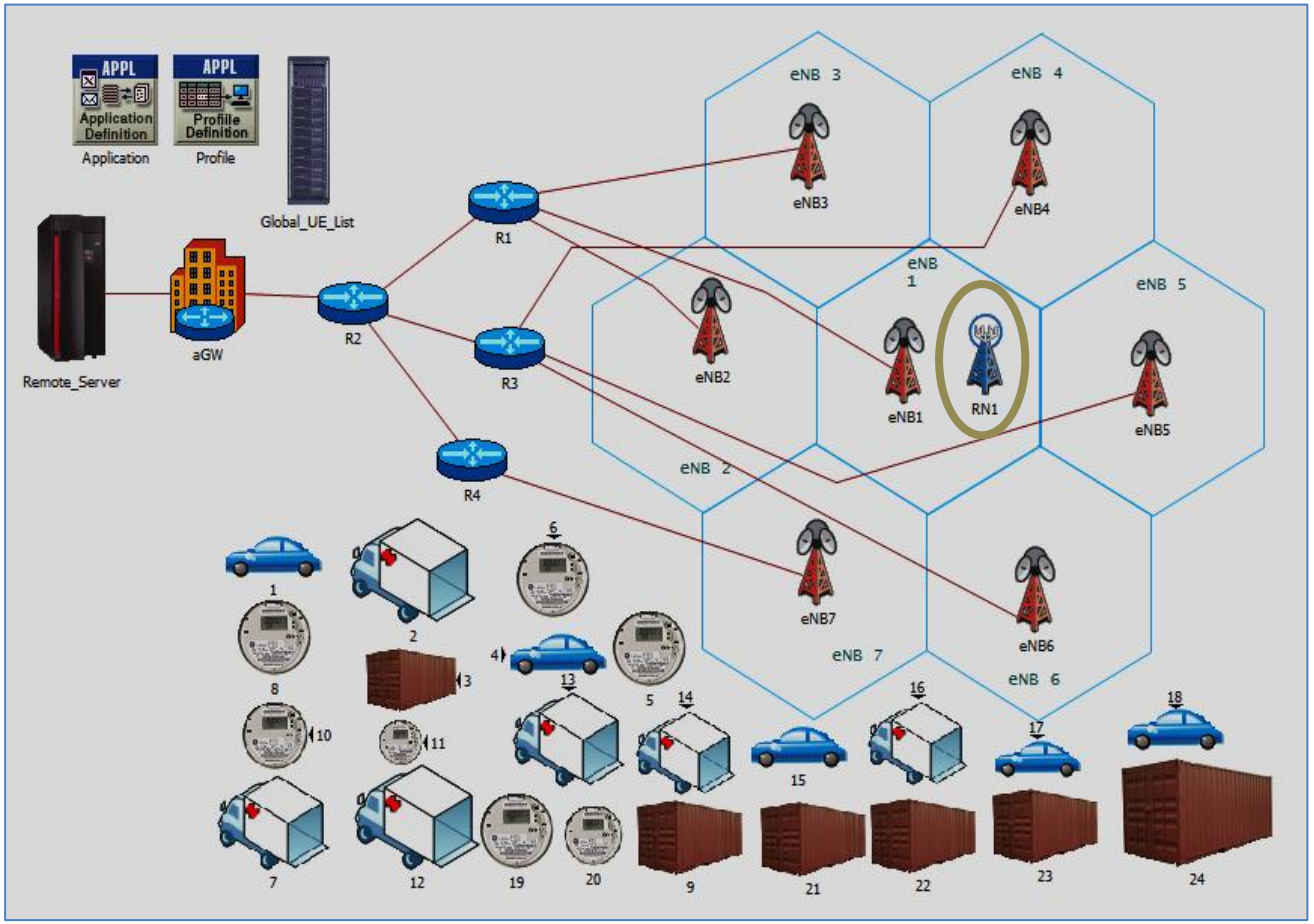
GTP: GPRS tunneling protocol
UDP: User datagram protocol
PDCP: Packet data convergence protocol
RLC: Radio link control
MAC: Medium access control
PHY: Physical layer

Simulation Results and Analyses

[1] https://www.metis2020.com/documents/deliverables/

Simulation environment—(LTE-A model[1])

Parameters	Values
Cell layout	Single cell (7 DeNBs)
Inter DeNB distance	500 m
Transmission bandwidth	5 MHz
No. of PRBs	25
No. of PRBs for RN	5
Uplink DeNB scheduler	BQA [1]
Simulation length	1000 sec
eNB coverage radius	350 m
Max terminal power	23 dBm
Frequency reuse factor	1
MCS	QPSK, 16QAM, 64QAM,
Channel models 1. Path loss 2. Slow fading	From Vienna simulator [2] 1. 128.1 + 37.6log10(R), R in km 2. Log-normal shadowing, correlation 1, deviation 8 dB
M2M traffic model	
Message size	42 bytes at the PHY layer
Inter-send time	1 s
Device state	No mobility

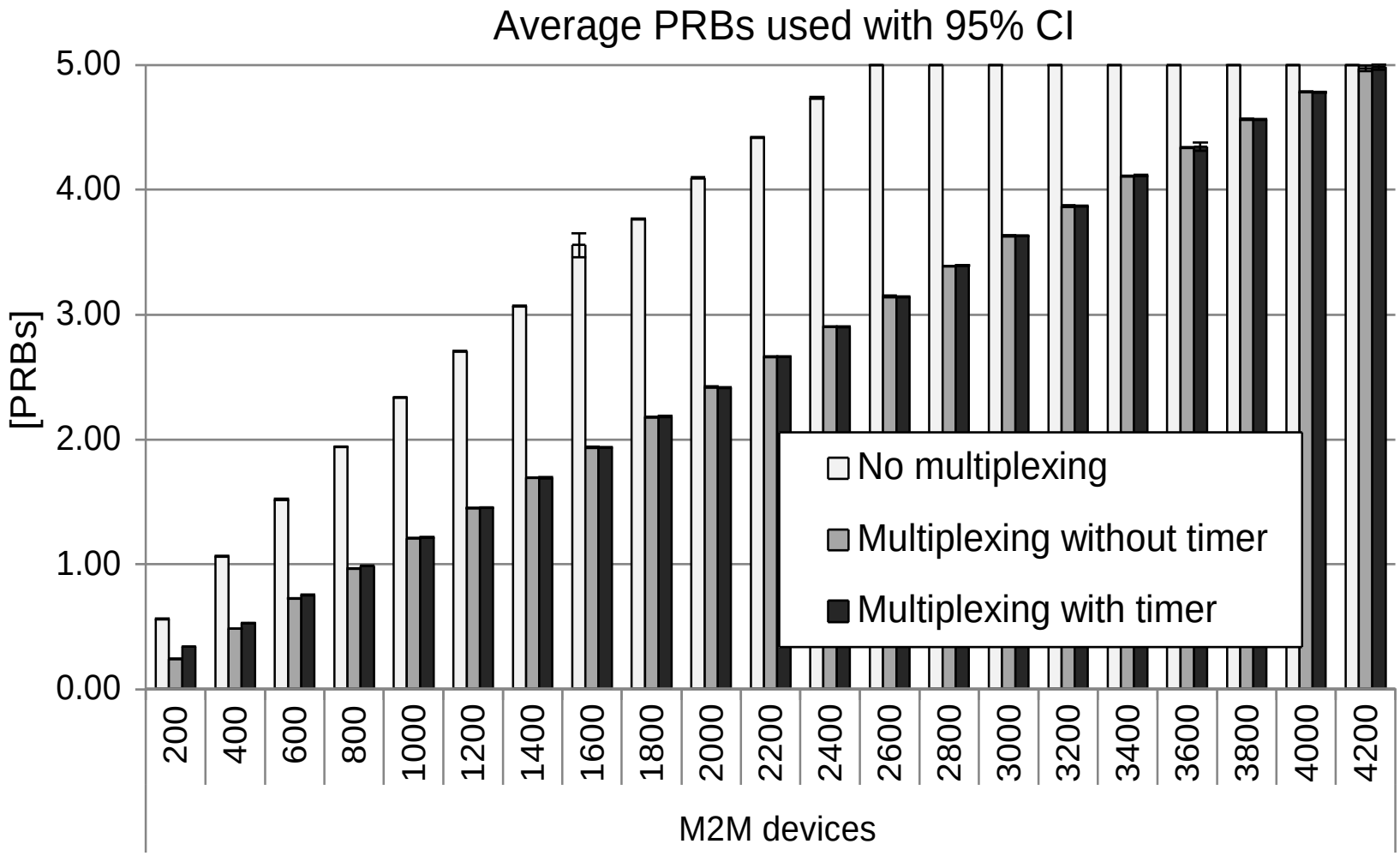


[1] Safdar Nawaz Khan Marwat, Thushara Weerawardane, Yasir Zaki, Carmelita Goerg, and Andreas Timm-Giel, "Analysis of Radio Resource Allocation in LTE Uplink," *Wireless Personal Communications*, vol. 79, no. 3, pp. 2305-2322, December 2014

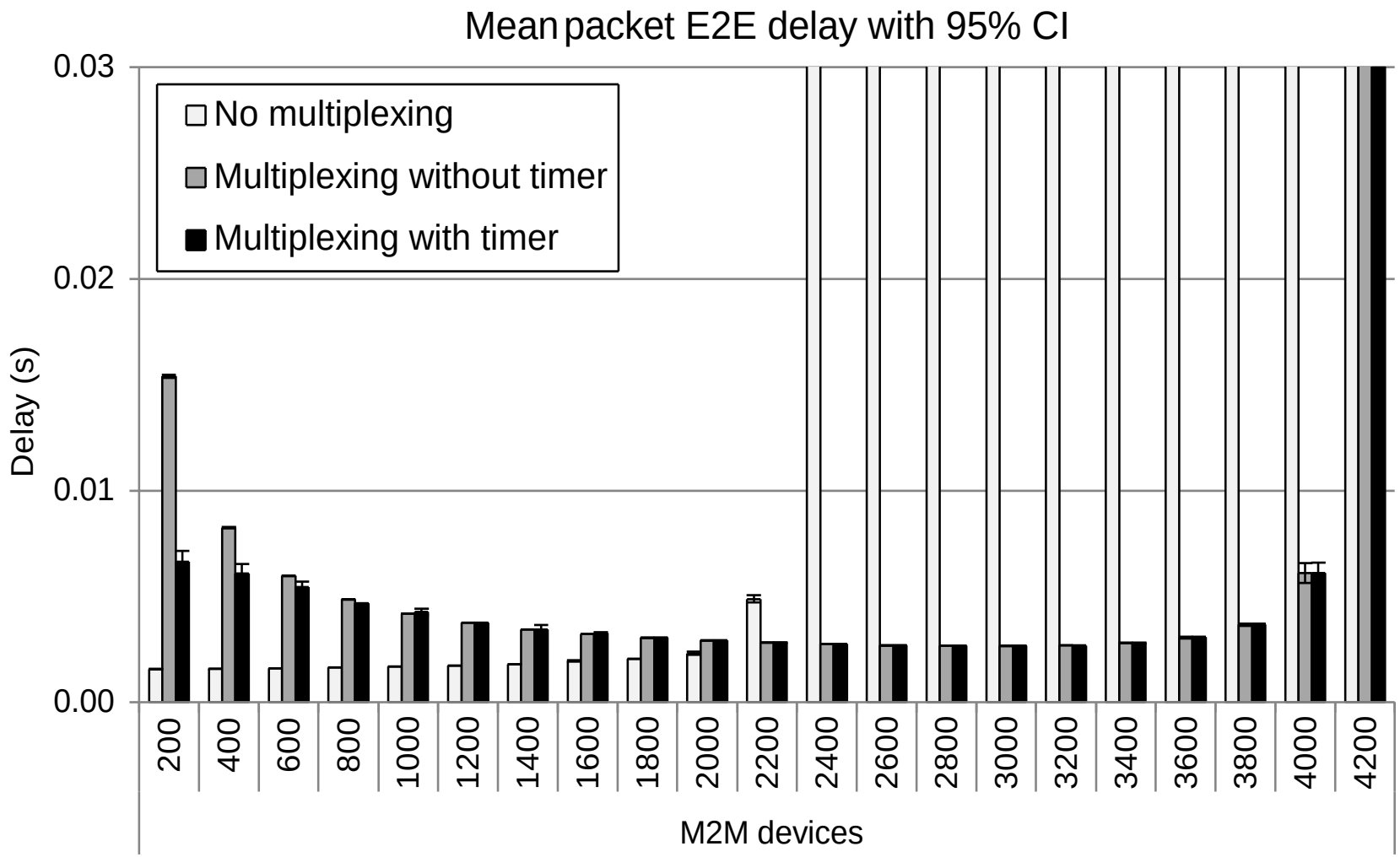
[2] http://www.nt.tuwien.ac.at/research/mobile-communications/vienna-lte-a-simulators/2010

[1]The LTE-A model is developed in the OPNET Modeler jointly by the ComNets (Communication Networks), University of Bremen, Germany and the Institute of Communication Networks, University of Technology, Hamburg, Germany.

Results comparison—average PRBs



Results comparison—average E2E delay



Conclusions

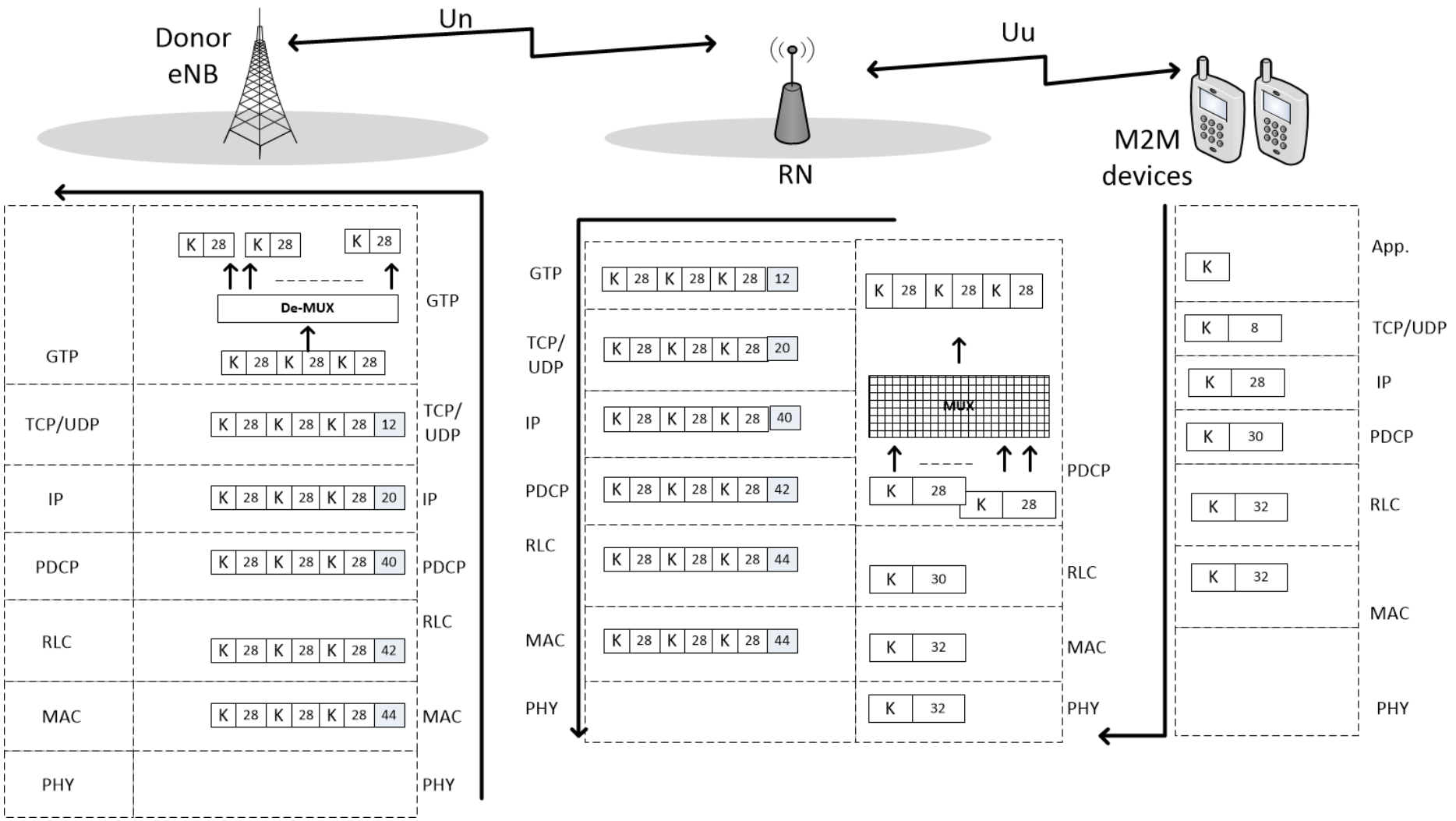
- Increasing M2M traffic might significantly degrade the performance of regular LTE-A traffic due to small sized payloads
- The limited radio resources can be efficiently used for mobile M2M communications with the proposed data aggregation scheme
- Approximately 38% more machine devices are served with the proposed scheme as compared to traditional relaying
- The expiry timer has no significant impact on the M2M delay in the high loaded scenarios

Outlook

- Quality-of-service (QoS)-aware data traffic aggregation for the uplink M2M traffic
- Implementation of data traffic aggregation for the downlink M2M traffic

Thank You !!

back-up


Donor
eNB
Un
Uu
RN
M2M
devices
GTP
TCP/UDP
IP
PDCP
RLC
MAC
PHY
De-MUX
MUX
App.
TCP/
UDP