System concept and implementation of next generation wireless M2M communications

Samuele Zoppi and Wolfgang Kellerer
Chair of Communication Networks
Technical University of Munich
{samuele.zoppi,wolfgang.kellerer}@tum.de

Introduction and motivation

- M2M application and devices will considerably increase in the next years (x100).
- Both cellular networks and Wireless Sensor Networks (WSN) are possible candidates to accommodate such devices.
- Nowadays radio resource management schemes must be redesigned to support design challenges of future 5G systems:
  - Energy efficiency
  - Ultra-reliability, low-latency
  - Massive number of devices
- Open source community plays now a fundamental role in the standardization and testing of future wireless communications.

M2M communication in 3GPP cellular networks

- Cellular networks can support future M2M communications thanks to:
  - Ready to use standard infrastructure
  - High-capacity and flexible infrastructure
  - 3GPP Rel.13 M2M architectural enhancements

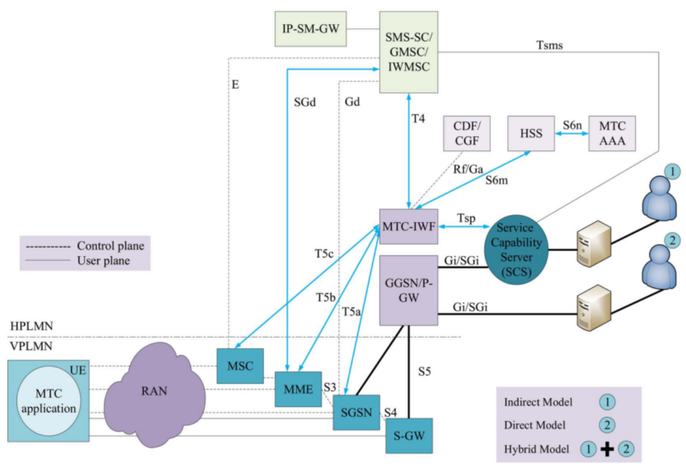


Fig. 1: M2M in LTE-A networks.

...however, several **open issues** must be tackled:

- Overload/ congestion of the network caused by massive number of devices
- Coexistence between wideband H2H and constrained M2M communications
- Support of low-energy and low-latency operations

OpenAirInterface - OAI

- Open source implementation of 3GPP Rel.10.
- Runs on any x86 Linux PC, C language.

- Full LTE stack implementation, from PHY to higher layers of E-UTRAN and EPC.

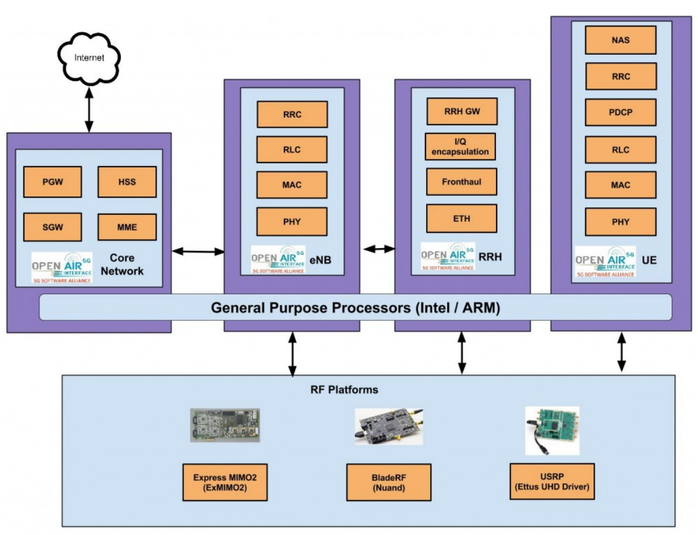


Fig. 2: M2M in LTE-A networks.

- Adaptable in several configurations with commercial UE, eNB and EPC.
- Different boards are supported (more under development):
  - ExpressMIMO2, Eurecom
  - USRP B210/X300, National Instruments

IEEE 802.15.4e WSN protocol stack

- Lastest generation ultra-low power and reliable WSN standard.
- Wireless Sensor Network enables M2M communications thanks to:
  - Cheap roll out of networks
  - Scalability support
  - High protocols flexibility
- Standardization of TSCH (Time Slotted Channel Hopping) MAC layer:
  - Time slotted frame structure enables **deterministic** behavior
  - Frequency Hopping ensures **reliability** against fluctuations of the wireless medium

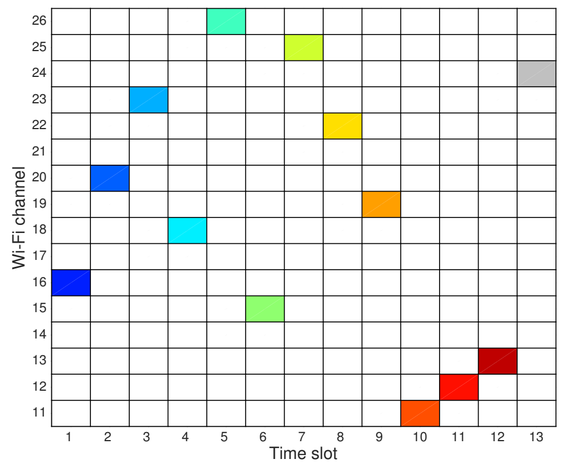


Fig. 3: TSCH scheduling of Resource Blocks.

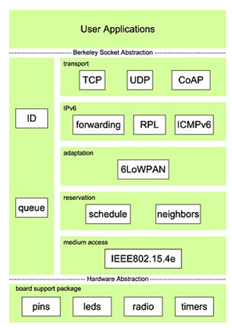
- Also in this scenario, several **open topics** must be investigated and are not standardized:
  - Scheduling of the Resource Blocks
  - Interaction with IEEE standardized upper layer protocols (RPL, 6LoWPAN, CoAP)

OpenWSN

- Open source implementation of IEEE 802.15.4e OSI stack for constrained devices.
- Implements the minimal configuration of TSCH

- On top of it, it provides IEEE 802.15 higher layers:
  - 6LoWPAN: IPv6 adaptation layer for WSN
  - RPL: routing protocol for low power lossy networks
  - CoAP: constrained and efficient web protocol over UDP

- Many boards are supported (Zolertia Z1, TelosB, OpenMote,...)



Conclusion and further research

- Different solutions will be able to accomodate next generation M2M communications.
- Several open issues must be addressed to enable M2M communication, both in cellular and wireless sensor networks.
- Tailored low-power and low-latency solutions must be investigated to enable massive number of devices (mMTC) and ultra-reliable communications (uMTC).

Relevant references

[1] Hugo Tullberg, Mikael Fallgren, Petar Popovski, David Gozalvez-Serrano, Thomas Rosowski,... . "Deliverable D6.6 Final report on the METIS 5G system concept and technology roadmap". *METIS 2020*, 2014.

[2] Fayezeh Ghavimi and Hsiao Hwa Chen. "M2M communications in 3GPP LTE/LTE-A networks: Architectures, service requirements, challenges, and applications". *IEEE Communications Surveys and Tutorials*, 17(2):525–549, 2015.

[3] OpenAir Alliance. OpenAirInterface website, 2016. `http://www.openairinterface.org`.

[4] IEEE Standard for Local and metropolitan area networks–Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs) Amendment 1: MAC sublayer. *IEEE Std 802.15.4e-2012 (Amendment to IEEE Std 802.15.4-2011)*, pages 1–225, April 2012.

[5] Berkeley. OpenWSN website, 2016. `http://openwsn.atlassian.net`