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Performance Evaluation of Dynamic TDD in 5G Wireless Systems

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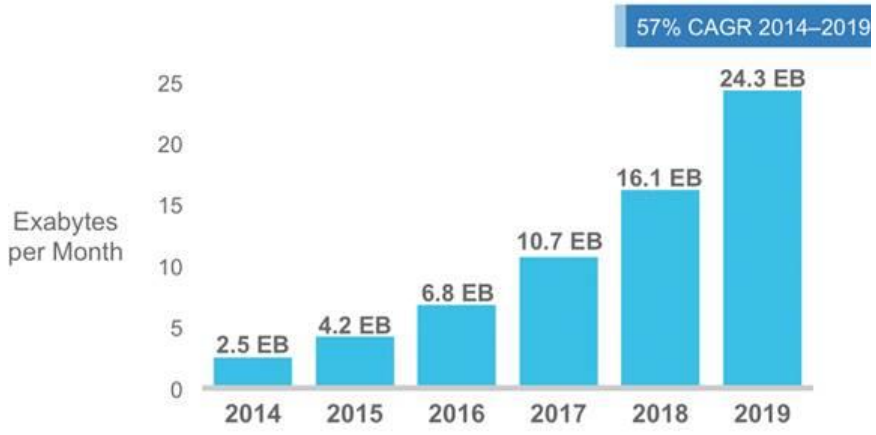
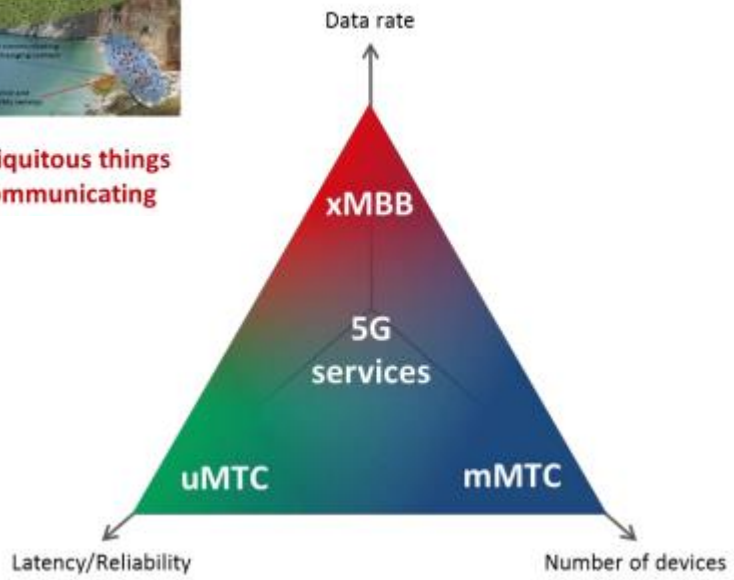
Ericsson 5G Vision

"Everything that benefits from being connected will be connected."





Source: [Cisco14], [METIS-D]

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STATIC TIME DIVISION DUPLEX (S-TDD)

- TDD systems use the same frequencies for both uplink and downlink transmission but are instead separated in time. In LTE, frequency and time slots are referred to as ”resource units”.
- Transmission occurs in blocks (=frames) of symbols. A switching point divides the number of time resources that is allocated for uplink and downlink traffic during the length of each frame. Base stations therefore transmit data synchronously in the downlink, and similar principle applies for uplink traffic from the mobile to the base station.
- The switching point is set based on the traffic pattern over a large time scale. This works well when the traffic distribution is almost the same in all the cells and varies only slowly with time.

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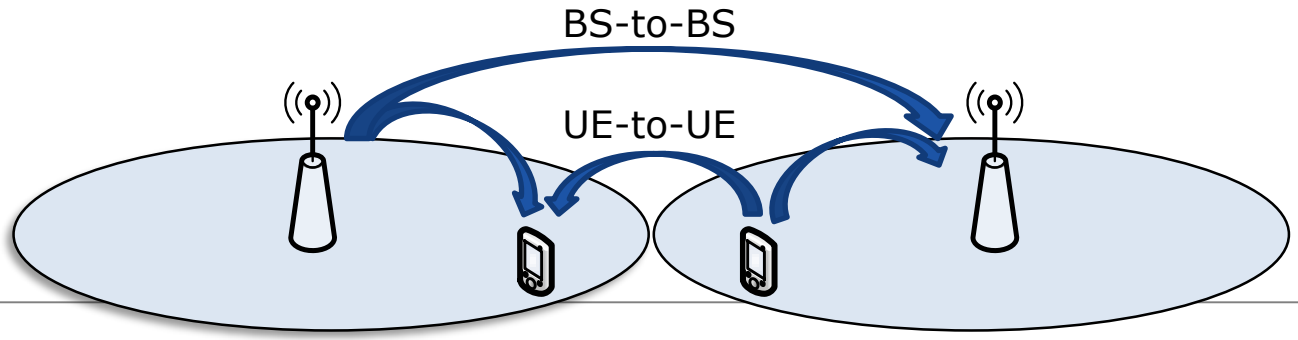
DYNAMIC TDD (D-TDD)

- In cases where network utilization is very low due to very high density of base stations, the bursty nature of mobile broadband data means that traffic variations will be large between cells. To reduce latency and improve throughput, a more flexible switching based on a shorter (faster) time scale can be beneficial in such cases. It is considered one of key technologies for 5G wireless systems. [CS15]
- Such systems are however prone to more co-channel interference from both uplink and downlink transmission.



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PROBLEM

- Investigate feasibility and potential performance gains of dynamic TDD in specific deployment scenarios envisioned for high-speed user data rates and ultra-high capacity networks.

MOTIVATION

- Deriving mathematical expressions for system-level KPIs is either hard, untractable, subject to many assumptions and simplifications, or all of the above.
- Second best thing – a proper simulation framework emulating real-world conditions.

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APPROACH

- Implement a simulation framework in MATLAB and use the provided system level models in the METIS deliverables to calibrate it.
- Focus on METIS test cases designed to deliver very high end user data rates (xMBB). Construct and extend the simulation framework to also include dynamic duplexing (D-TDD).
- Evaluate the system performance in terms of relevant performance metrics (KPIs).
- Make proper conclusions of the results and provide explanations to assumptions and potential deviations from the calibrated model and its impact on the results.

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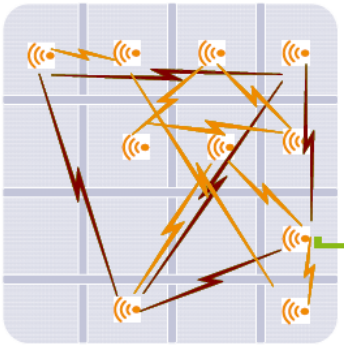
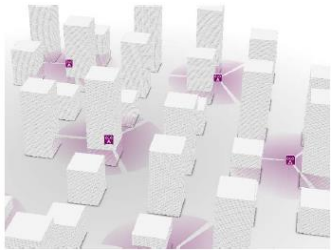


TC1



TC2

TASK

- Construct the simulation framework in MATLAB using existing resources provided by METIS and made available on its webpage for LTE and LTE-A.
- Simulate performance for the following two test cases:
  - TC1: Virtual reality office.
  - TC2: Dense urban information society (Madrid grid scenario).
- Simulate for static duplexing and assume symmetric traffic distribution between uplink and downlink.
- Simulate for dynamic duplexing.
- Evaluate the results and quantify the gains of dynamic TDD.

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SPECIFIC DETAILS

- WINNER II A1 path loss model to be used below 6 GHz, and ray tracing in the mmWave band (30-300 GHz).

EXAMPLE OF KPIs

- [METIS-D]

Table A-1: Main KPIs defined for TC1 [MET13-D11].

KPI	Requirement
Traffic volume per subscriber	36 [Tbyte/month/subscriber] in DL and UL, respectively
Average user data rate during busy period	0.5 [Gbps] DL and UL, respectively
Traffic volume per area	100 [Mbps/m^2] DL and UL, respectively
Experienced user data rate	1 [Gbps], UL and DL, with 95% availability (5 [Gbps] with 20% availability)
Latency	10 [ms] round trip time

MISCELLANEOUS

- METIS-I and -II is a European collaboration project between industry and academia. It aims to lay the foundation for 5G by providing technical enablers needed to address the user requirements envisioned for the year 2020 and beyond.

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REFERENCES

- [Cisco14] Cisco Systems, Inc., "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2013-2018", White Paper, February 2014.
- [METIS-D] METIS deliverables, URL: https://www.metis2020.com/documents/deliverables/?doing_wp_cron=1432463338.3175609111785888671875
- [METIS-S] METIS simulations, URL: https://www.metis2020.com/documents/simulations/
- [CS15] H. Celik and K. W. Sung, "On the Feasibility of Blind Dynamic TDD in Ultra-Dense Networks", IEEE VTC Spring Workshop (MWC2020), Glasgow, Scotland, May 11-14 2015.