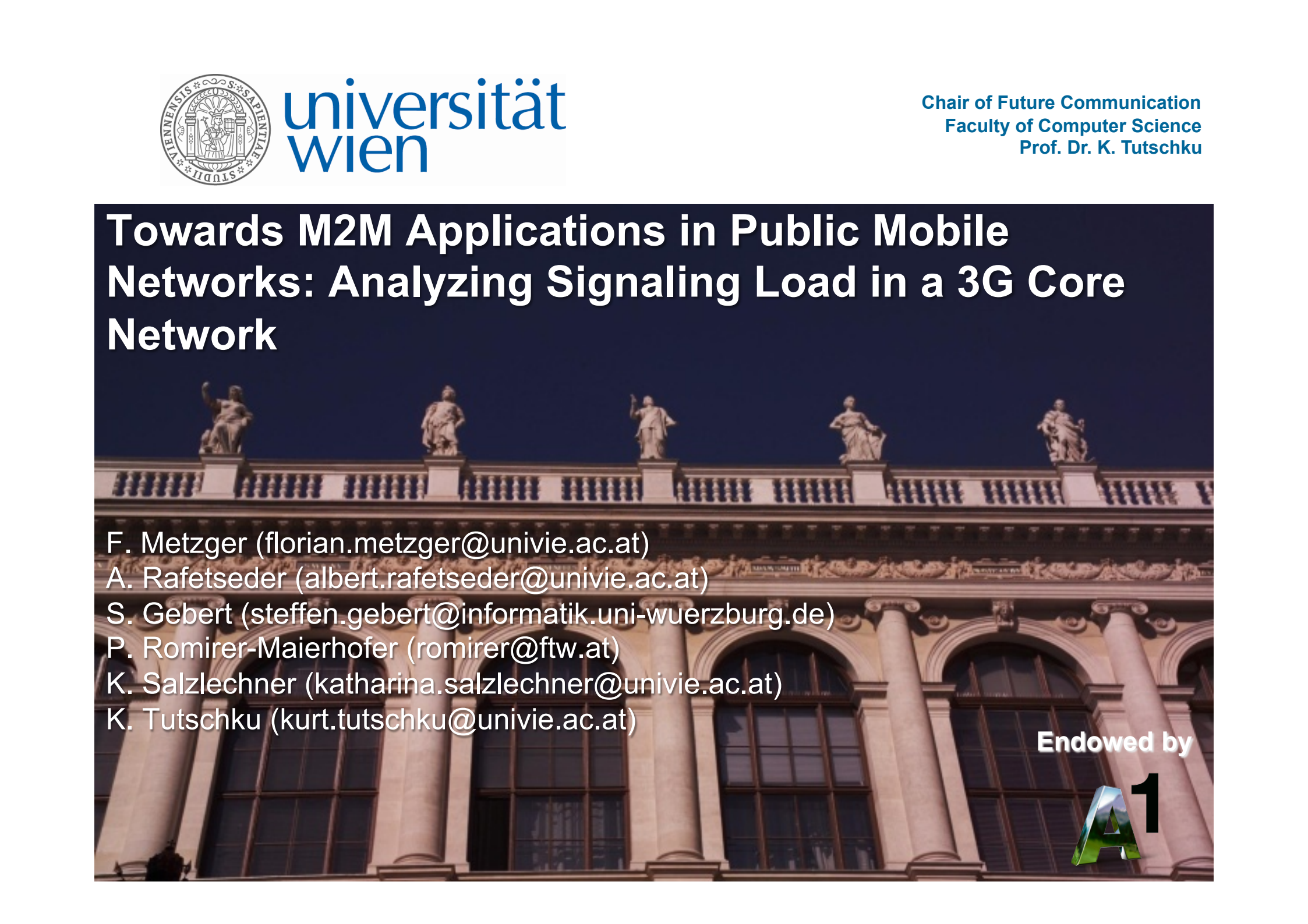

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Towards M2M Applications in Public Mobile Networks: Analyzing Signaling Load in a 3G Core Network

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Our View On M2M Communication

- Future M2M devices
  - use standard Internet protocols
    - TCP/IP, maybe even HTTP(S)
    - Well-known, well understood, readily available
  - use mobile network infrastructures
    - GSM/GPRS, UMTS, LTE
    - Existing infrastructure
  - will (just) be another type of Internet traffic pattern
- Very large potential number of devices
  - 4 million households with energy meters
  - 6.2 million cars
  - (your idea here)
  - Compare: 12 million subscribers in Q3/2010

Today's M2M Appliances

- Examples
  - Office coffee machines
  - Energy meters
  - GPS data loggers for taxis
  - Electronic Cash terminals („POS", „Bankomat")
  - Any System-on-a-chip / microcontroller (cf. Arduino 3G shield)

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Expected M2M Traffic Characteristics

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- Small amount of application-layer data
- Consequently, large overhead from lower layers
- Frequent, regular transmission intervals
  - E.g. 15 minutes for smart electricity meters
- Short on/off duty ratios
  - E.g. Low-power sensors
- Large-scale synchronization of events
  - E.g. remote over-the-air software updates
  - Data push „on the hour“ (01:00, 02:00, 03:00, …)

- …but is this a problem?

Mobile Core Network Signaling

- Traffic causes signaling
  - Mobile Networks are heavy on managing states and signaling procedures
  - Radio, Core, Accounting, Authentication, …
- Signaling is expensive
  - Generates load in the network
  - Network traffic, processing time, maintaining of states

- How expensive is signaling?
  - Sparse number of „real“ M2M devices to look at, but millions of smartphones
  - Classify devices and operating systems
  - Investigate the duration of PDP Contexts as measure of load
  - Duration/frequency trade-off of Contexts

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Today's M2M Appliances

- Today's smartphones cause M2M-like traffic, too!
  - Social and messaging status updates, Angry Birds, RSS, email, weather forecast, …
  - Automatic ad retrieval or data polling every x minutes
  - Media coverage of „signaling storms"

→ **We can observe smartphone signaling rather easily!**

- However: are these effects caused by the *applications* or the *networks*?

→ **Performance measurements in the networks**

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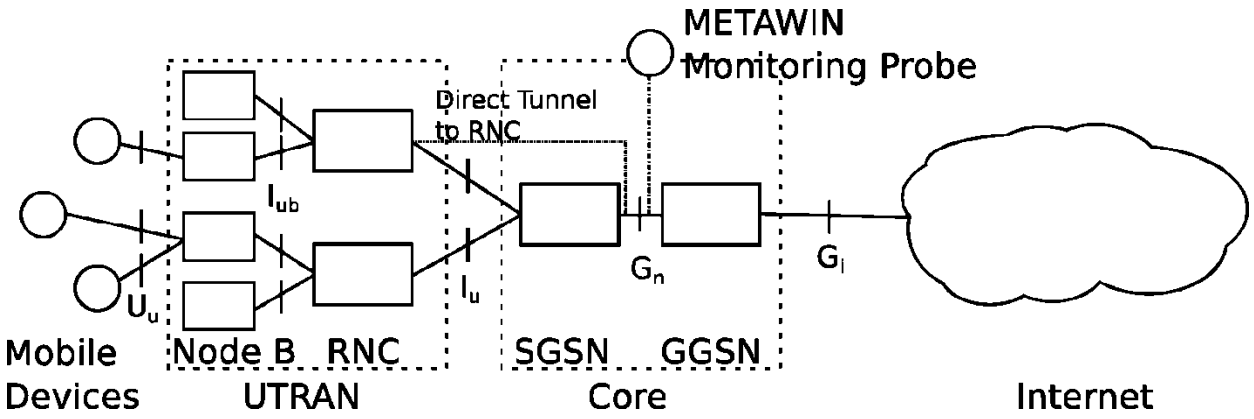
GTP Tunnel Management



- PDP Context
  - User traffic tunnel between on Gn path (SGSN to GGSN)
  - Tunnel states held at nodes
- Create, Delete, Update Context request/response signaling pairs
  - Part of larger control plane procedures and state machines
- GTP signaling involved in almost all of the network‘s interaction

➔ Good picture of the overall network control plane by observing GTP signaling

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Data Set & Methodology

- Passive measurements of a network operator‘s Gn interface (METAWIN platform)
- Supported by the FTW strategic project Ursa Major
- One week long, anonymized user traffic flow data and GTP tunnel management messages
- GTP CREATE and DELETE event timestamps
- Device/OS classification based on TAC information
  - We can classify >90% of signaling messages

- Look at Cumulative Distribution Functions (CDFs) of GTP tunnel durations
- Indirect load metric
  - Short tunnels: higher signaling load
  - Long tunnels: more state to be held in the network

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Device Type Classification

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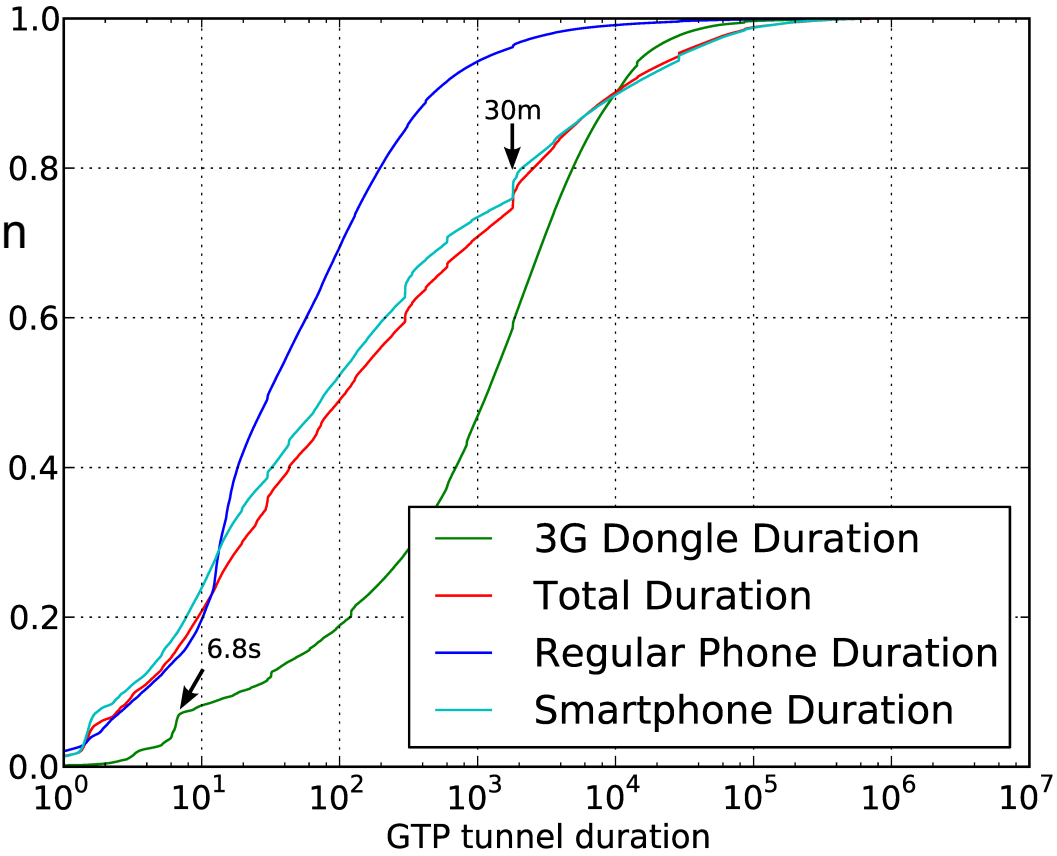
- PDP Context CDFs for three device classes
- Indications of different user groups and behaviors
  - Long laptop sessions
  - Short feature phone sessions
  - Smartphones dominate total distribution
- Dongles: longest median tunnel duration, therefore least signaling (despite largest user traffic portion!)



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Operating System Classification

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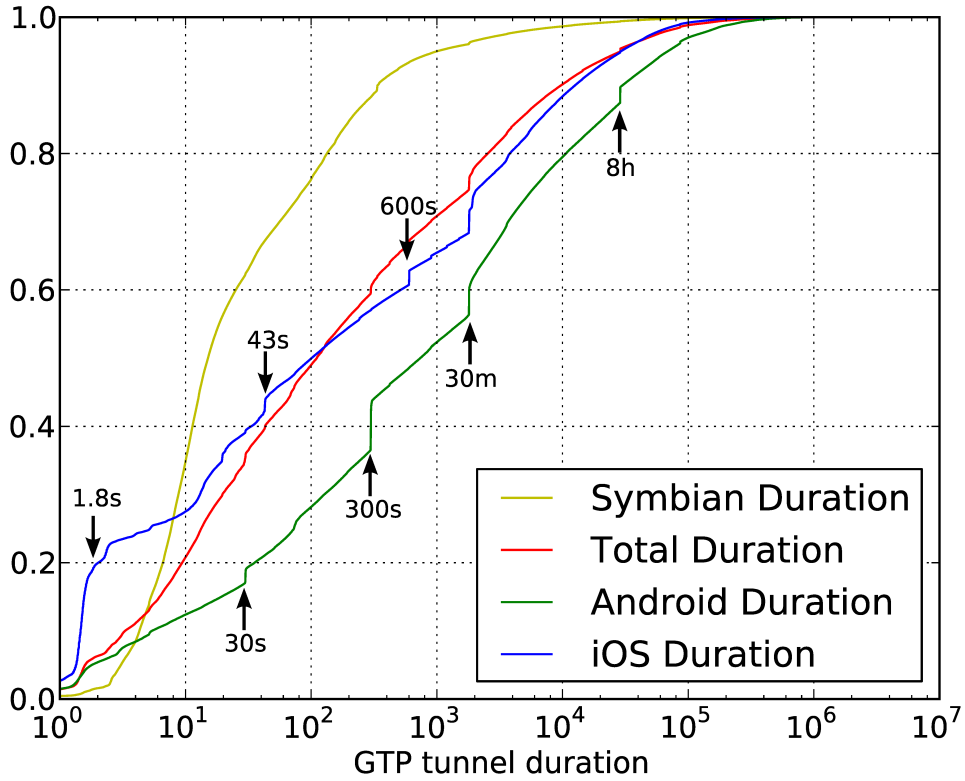
- PDP Context CDFs for devices with known OS
- Peaks in more than one class at the same time could indicate network rather than OS influence
  - 30min: possibly radio IDLE state transition
- Distinct behavior for all device/OS types
  - Might relate to „user types“
- Many short iOS tunnels (>20% shorter than 2s)
  - M2M-like traffic patterns?
  - High signaling load



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Conclusions

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- Most future M2M applications will use off-the-shelf technology and concepts:
  - Extremely numerous: millions of households, cars, …
  - Use existing protocols (TCP/IP) and networks (3G, 4G)
  - Low-volume, regular, frequent traffic

  → Impacts on networks yet not known

- Extract hints from current smartphone signaling
  - We can actually measure this (METAWIN, Ursa Major)
  - Initial observation: 3G dongles, smartphones, feature phones all have different tunnel duration distributions
  - Strong influence of operating systems
  - Currently, smartphones dominate
  - M2M‘s short and frequent traffic patterns could cause high signaling

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Next Steps

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- Data mining
  - Identify M2M-like traffic and signaling patterns
  - Quantify direct user traffic overhead (GTP-U, traffic types)
  - Correlate signaling and user-plane traffic (session duration, inter-arrival time)
  - Number of concurrent tunnels over time
  - Tunnel management processing delay
- Modeling
  - Fitting distributions for user session and tunnel durations/interarrival
  - Queueing theory model of core signaling: Load-dependent behavior
  - Extrapolation and new hypotheses

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Thank you for your attention!

Questions?