Towards 5G DenseNets: Architectural and Data Transmission Advances For Effective Machine-Type Communication over Femto-Cells

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Introduction
- MTC Traffic
- Device deployment

Our Proposals
- Network Architecture
- Data Transmission

Conclusions
- Simulation Results
- Conclusions
- **Human-Type Communications (HTC)**
  - Human-triggered transmissions
  - Long connection period
  - Large amount of exchanged data during one connection
  - No energy consumption constraint

New transmission paradigm

- **Machine-Type Communications (MTC)**
  - No human intervention
  - Very short connection period
  - Usually one packet for each connection
  - Usually small data packets for each transmission
  - Strict energy consumption constraints
  - 5 billions of expected MTC devices by 2020
Device deployment

Issues
- Influence of MTC on HTC
- MTC devices located in challenging positions (e.g., indoor deployment)
- MTC typically located in strict areas (i.e., hot-spot)
- Overload of both radio access and core networks
- Effective interconnection with non-3GPP networks

Our proposal deals with the introduction of femto-cells (HeNBs) to handle MTC traffic

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### Network Architecture

**Goals**
- Separation of HTC and MTC traffics
- Overload reduction in the core network
- Higher capacity
- Low-latency connection among 3GPP and non-3GPP devices
Data Transmission

Data is originated here

Reserved Preambles for Ultra-Alarm Messages

Issues
- High latency
- High control overhead
- PUSCH Congestion

Goals
- Reduced latency and energy consumption
- Reduced control overhead
- Reduced PUSCH congestion and increased capacity
- Reduced latency for Ultra-Alarm Message

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eNB vs. HeNB: First analysis with only MTC devices

- 1000 MTC devices located at 100m from the eNB
- MTC devices concentrated in a restricted area (radius 50m)
- 5 MHz channel bandwidth, RA slot every 5ms
- Arrivals of MTC devices are uniformly distributed within a period of 60s
- Two scenarios
  - Case A: MTC devices are attached to eNB
  - Case B: MTC devices are attached to HeNB
eNB vs. HeNB: Second analysis with HTC and MTC

- Fixed HTC load (30 VoIP and 20 best effort users)
- Variable number of clustered MTC devices located at cell-edge (800m from the eNB)
- Arrivals of both MTC devices and HTC users are uniformly distributed within a period of 20s
- MTC devices transmit a 200 byte long messages every minute
- Two scenarios
  - Case A: MTC devices and HTC users attached to eNB
  - Case B: HTC through eNB, MTC through HeNB
  - Case C: MTC + 5 VoIP through HeNB
Ultra-Alarm Message
- Variable number of clustered MTC devices served by one HeNB
- Arrivals of MTC devices are uniformly distributed within a period of 20s
- MTC devices transmit a 200 byte long messages every minute
- One MTC device transmits one Ultra-Alarm message
- Delay from the Ultra-Alarm generation until the message reception by the actuator
- Three scenarios
  - Standard RA: contention-based random access procedure for Ultra-Alarm message transmission
  - Reserved RA: contention-free random access procedure for Ultra-Alarm message transmission
  - **Ultra RA**
    - One preamble is reserved for random access procedure of Ultra-Alarm message
    - At the reception of this preamble, the HeNB automatically sends a Ultra-Alarm message to the actuator
Data Transmission: One Bit Data

- Variable number of clustered MTC devices served by one HeNB
- Arrivals of MTC devices are uniformly distributed within a period of 20s
- Two Scenarios
  - Standard: standard data transmission procedure
  - Piggybacking: data is included in the Msg3 of random access procedure
Data Transmission: Varying the data size

- 30000 clustered MTC devices served by one HeNB
- Arrivals of MTC devices are uniformly distributed within a period of 20s
- Two Scenarios
  - ✔ Standard: standard data transmission procedure
  - ✔ Piggybacking: data is included in the Msg3
## Conclusions

### Core Network
- High scalability (i.e., the increase in the number of HeNBs does not involve network congestion)
- No overload at the MME thanks to the use of HeNB-GW
- No overload at the S-GW thanks to the use of HeNB-GW
- Paging optimization at the HeNB-GW
- Inter-connection with Trusted non-3GPP APs

### RA procedure
- Higher success probability for the transmission of the first preamble
- Reduced latency (i.e., switching time from idle to connected mode)
- Reduced energy consumption

### Data Transmission
- Reduced latency
- Reduced energy consumption
- Higher capacity (i.e., number of supported MTC devices)
- No negative impact on HTC services
- Reduced latency for Ultra-Alarm Messages
Thank You!!!

Questions?