Making Massive Connectivity a Reality: On the Way to 5G

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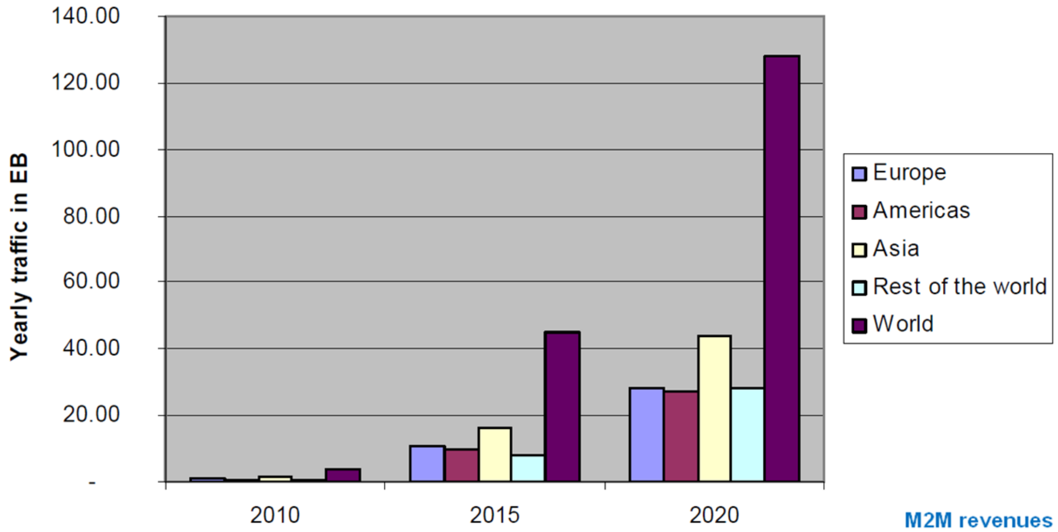
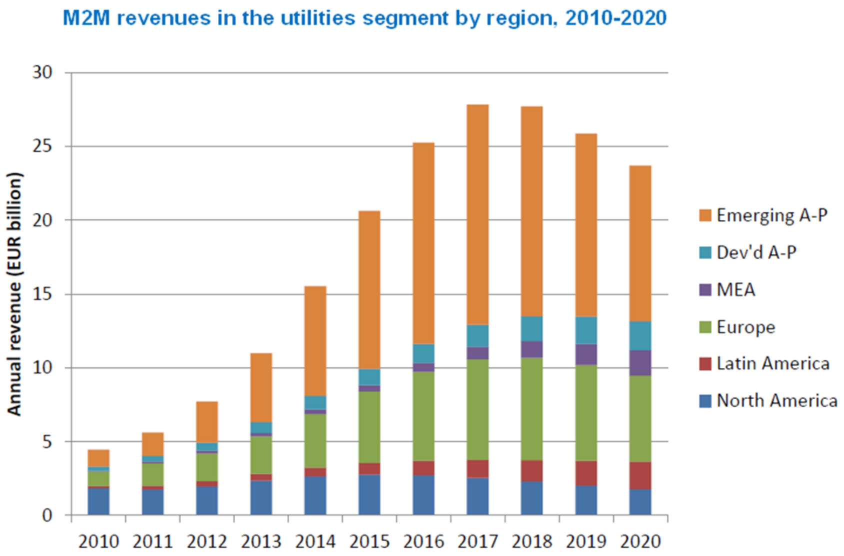
M2M Use Case Landscape

Growing M2M Market



Growing demands brings new revenue opportunity!

But as well as CHALLENGES…

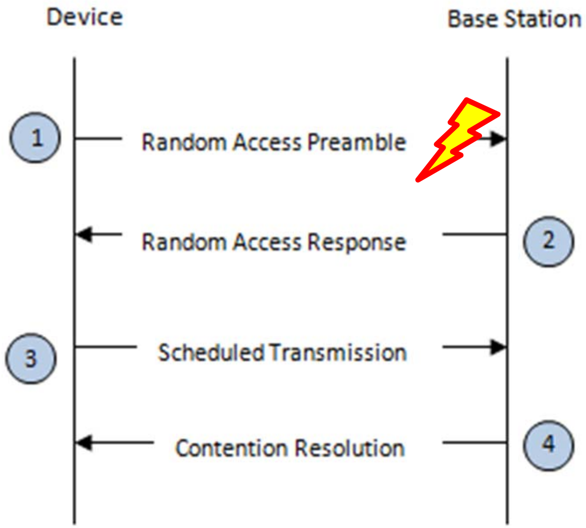


Source: Machina Research

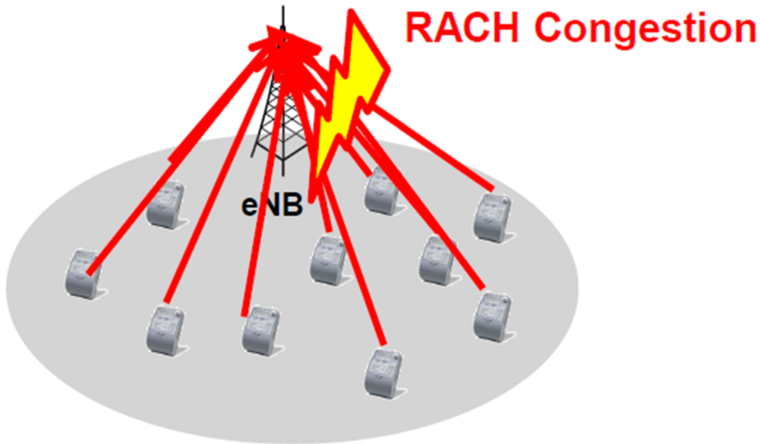
Signaling Congestion

Problem: simultaneous network access from massive M2M devices!

Random Access Procedure



Collision in the Random Access Channel (RACH)

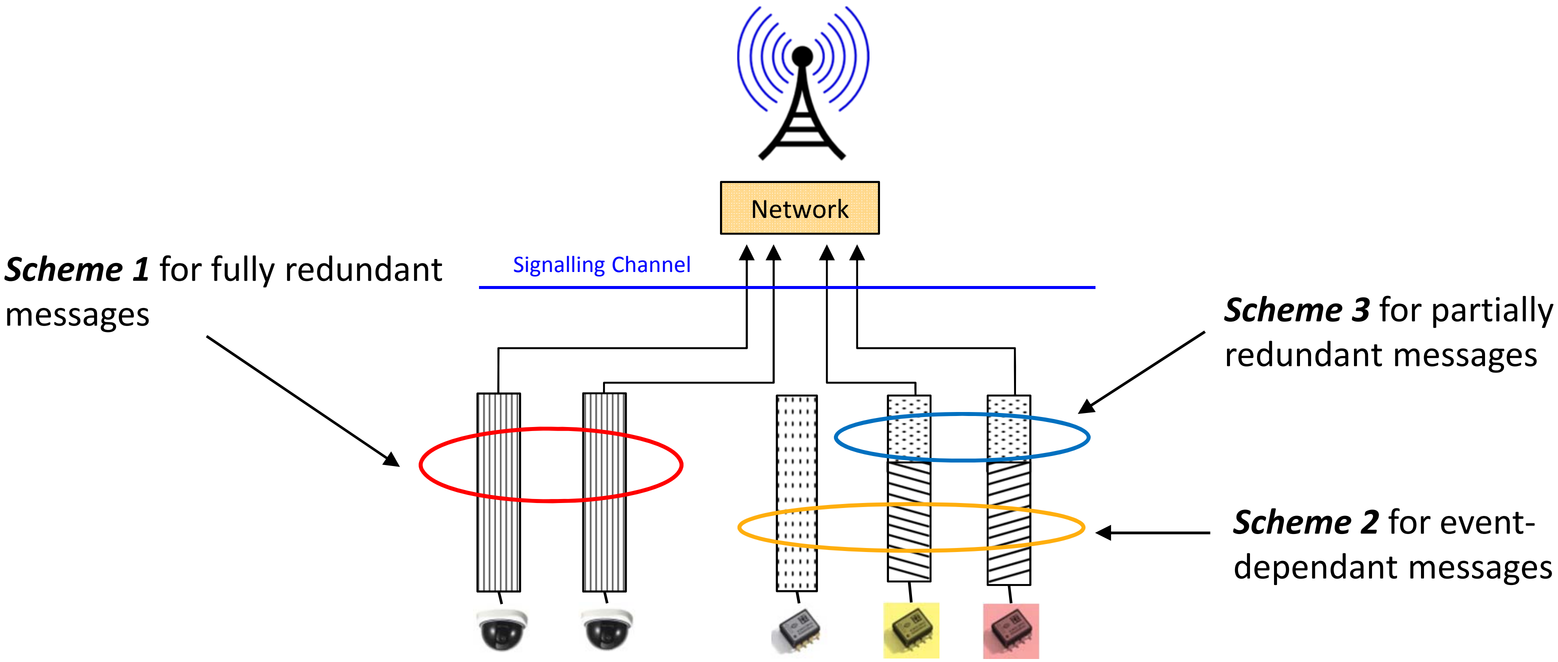


➡ Signaling Congestion and Network Overload

Context-Awareness for Massive Signalling

- Increased *signaling overload* and *signaling congestion* are the major bottleneck which hinders support of massive connectivity in the 5G network.
- A high redundancy in the transmitted messages can be observed during the congestion period, sent by a group of correlated/associated devices.
- The correlated messages can be classified into two types:
  - **Fully redundant message:** Repeated message sent by different devices. Transmission is unnecessary if the data has been transmitted by others.
  - **Diverse but correlated message:** correlation in two dimensions
    - Messages trigged by the same event but with different contents.
    - Messages contain partially redundant information.
- Removing the redundancy can effectively reduce the signaling overhead and mitigate the congestion.

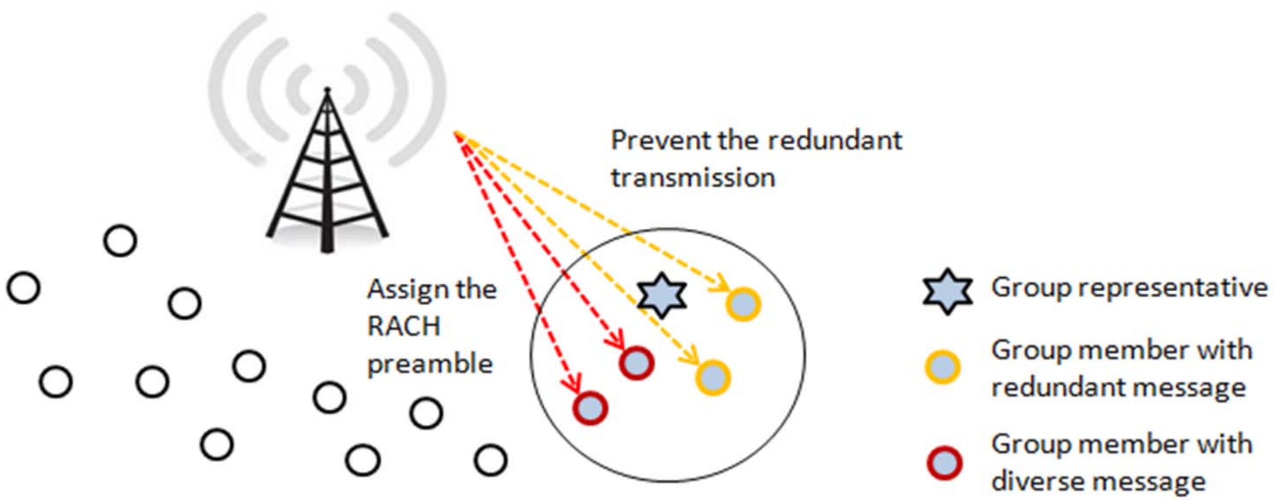
A Unified Concept to Exploit/Remove the Redundancy



- **Scheme 1:** Inhibition of fully redundant messages
- **Scheme 2:** Coordination and scheduling of RACH resources
- **Scheme 3:** Cross-device compression of messages

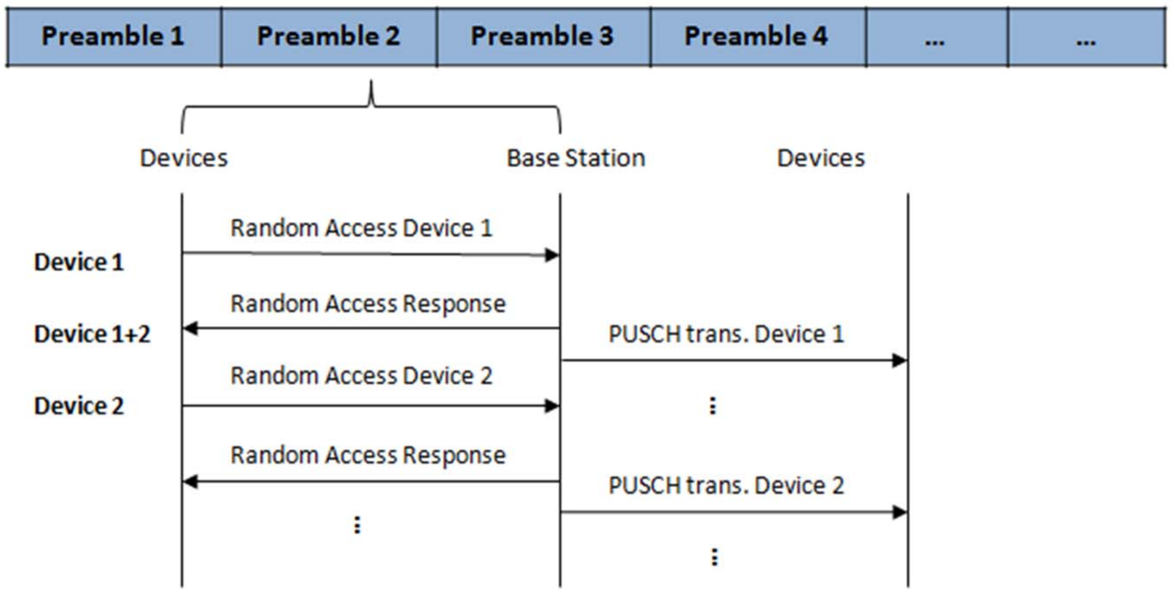
Scheme 1: Inhibition of Fully Redundant Messages

- The base station broadcasts relevant information, including:
  - Received messages sent by some correlated/associated devices, in order to prevent redundant message transmissions
  - Assignment and scheduling of RACH resources for expected diverse messages



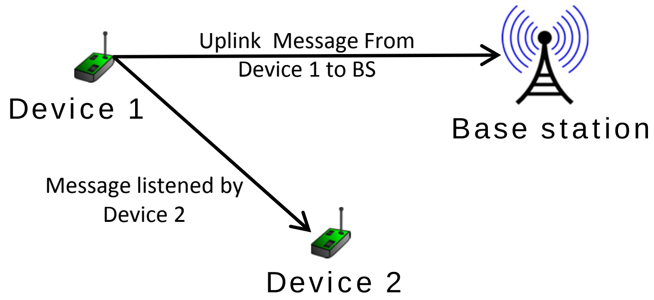
Scheme 2: Coordination and Scheduling of RACH Resources

- Event-dependant diverse messages are expected by the network during the congestion period.
- Assignment and scheduling of RACH resources (e.g., preamble sequences) for these transmissions.
- Following the priority order, the expected diverse messages can be sent in the manner of consecutive transmissions, i.e., one device will reuse the RACH resource if it is freed by the previous user.

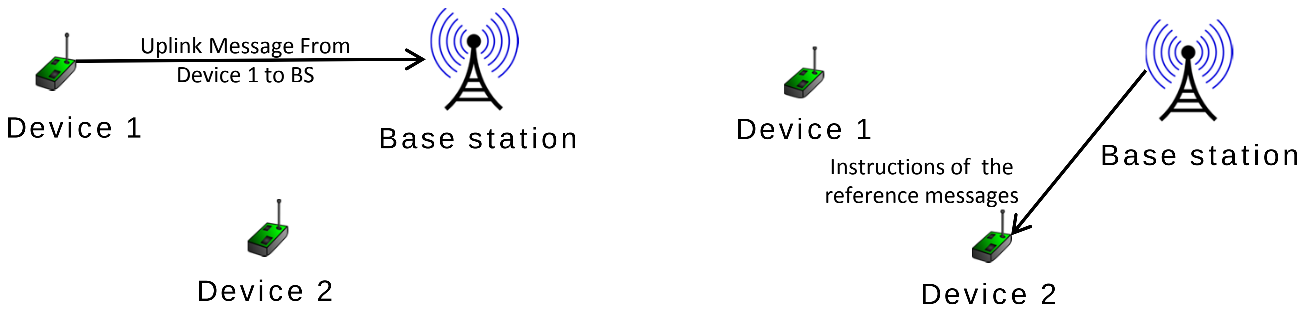


Scheme 3: Cross-Device Compression - Uplink

- The device stores the uplink signalling messages from other devices sent in the recent past.
  - Approach 1: The device listens directly from the uplink channel of the proximate devices



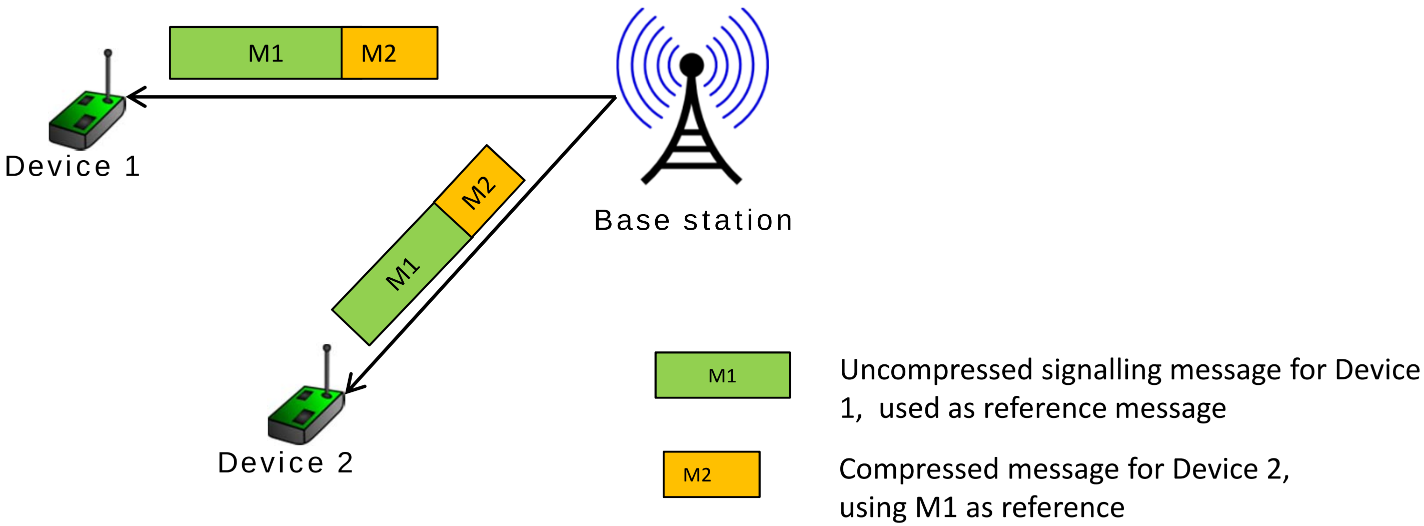
  - Approach 2: BS broadcasts representative uplink messages in the past



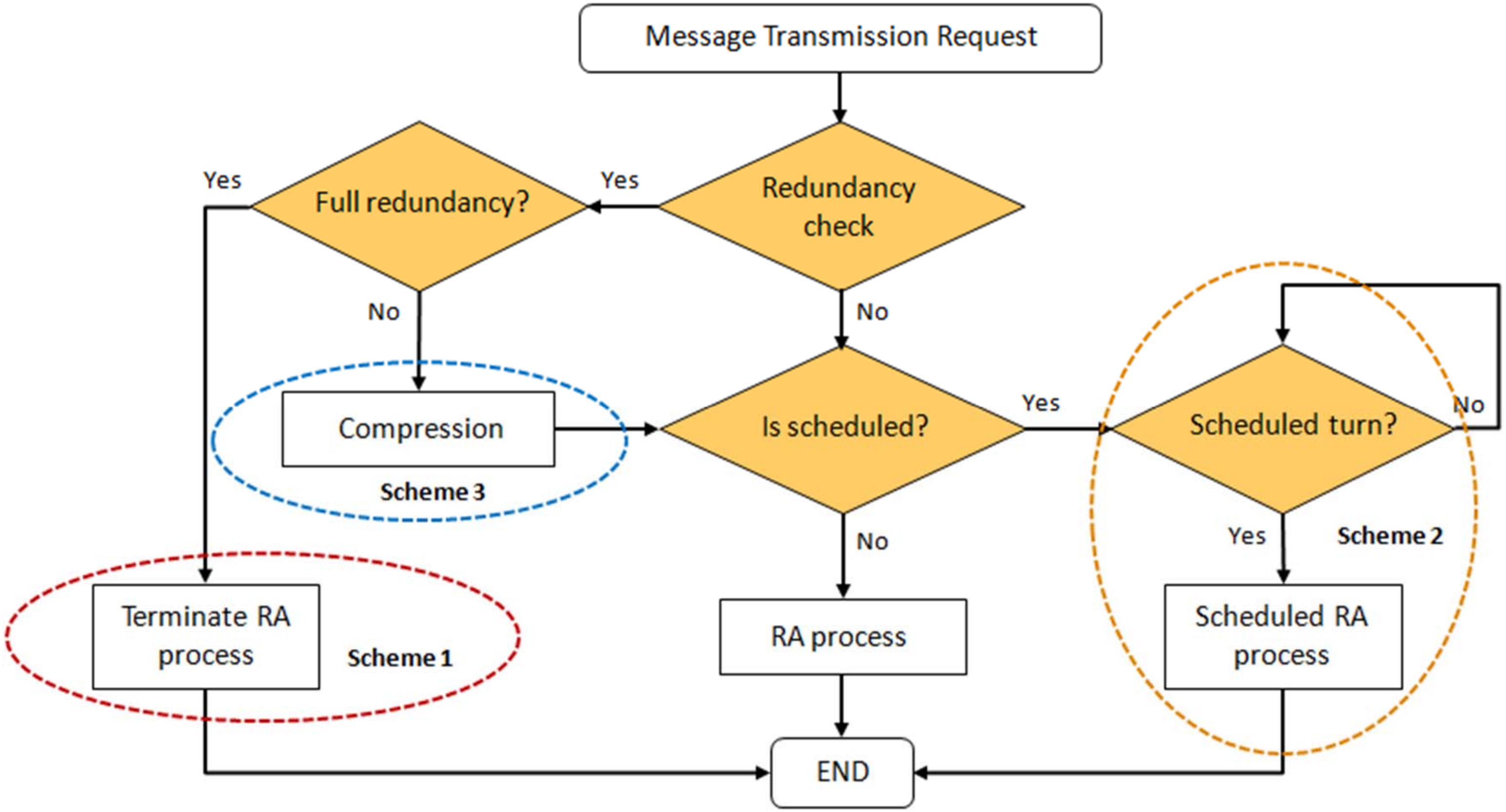
- The new signalling message of the device then can be compressed based on the signalling messages sent by associated devices.

Scheme 3: Cross-Device Compression - Downlink

- The base station broadcasts some uncompressed and associated signaling messages, which are marked as reference.
- The reference messages will be stored at the base station and at all proximate devices.

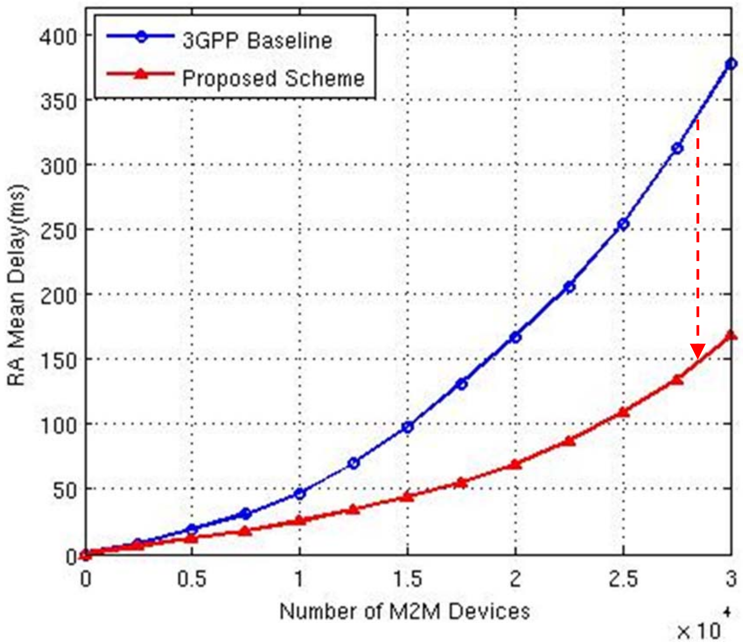


Flow Chart

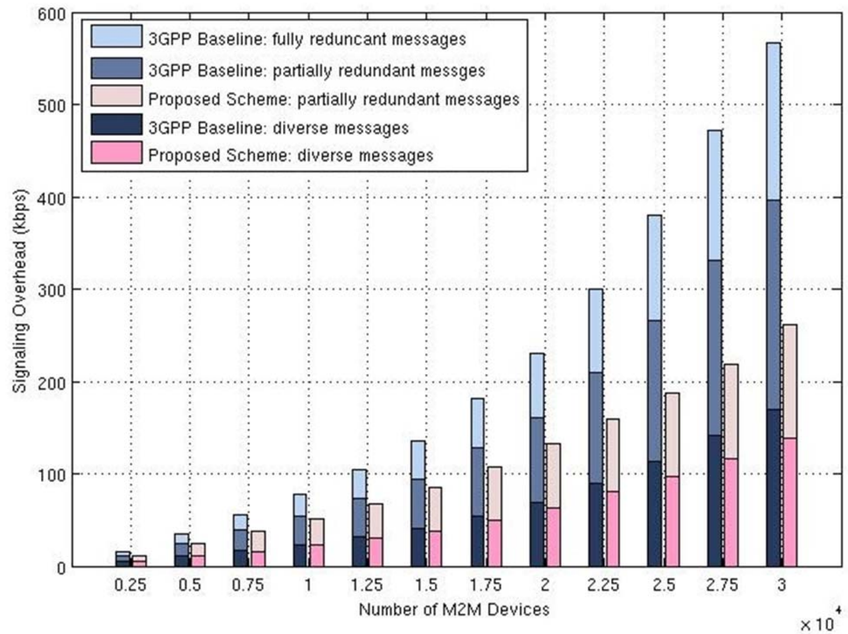

Message Transmission Request
Redundancy check
Yes
Full redundancy?
Yes
No
No
Compression
Scheme 3
Is scheduled?
Yes
Scheduled turn?
No
Yes
Scheme 2
No
Terminate RA process
Scheme 1
RA process
Scheduled RA process
END

Simulation Results

Random Access Mean Delay



UL Signaling Overhead



Conclusions

- A high redundancy in the transmitted messages can be observed when massive numbers of M2M devices attempt to access the network, which may arouse potential congestion in the signaling channels.
- The proposed scheme exploits the bursty nature of the MTC traffic and effectively removes the redundancy in the transmitted messages by either suppressing or compressing the messages with redundant content.
- Furthermore, some of the event-dependent messages are scheduled and transmitted in a coordinated manner.
- Simulation results show that the proposed scheme yields significant reduction in the signaling overhead as well as the average random access delay, thus effectively mitigates the congestion in the signaling channels and helps support of massive connectivity in the 5G network.

Thank you

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References

[1] Yunyan Chang, Chan Zhou, Oemer Bulakci, "Coordinated Random Access Management for Network Overload Avoidance in Cellular Machine-to-Machine Communications", 20th European Wireless Conference 2014, May 2014.

[2] Chan Zhou, Egon Schulz , "Cross-Device Signaling Channel for Cellular Machine-Type Services", VTC 2014 fall , Vancouver, Canada.

[3] 3GPP Std, *TR 37.868, Rev. V11.0.0, Study on RAN Improvements for Machine-Type Communications*, Sep. 2011.

Backup: Simulation Parameters

Parameter	Setting
Carrier Frequency	2 GHz
Cell Bandwidth	10 Mhz
PRACH Configuration Index	6
Total Number of Preambles	54
Maximum Number of Preamble Transmission	10
Number of UL Grants per RAR	3
Number of CCEs allocated for PDCCH	16
Number of CCEs per PDCCH	4
RA Response Window Size	5 subframes
MAC Contention Resolution Timer	48 subframes
Maximum Number of HARQ TX for Msg3 and Msg4 (non-adaptive HARQ)	5

Traffic Model	Performance measures	Number of MTC devices per cell		
		5000	10000	30000
1	Collision Probability	0.01%	0.03%	0.24%
	Access Success Probability	100%	100%	100%
2	Collision Probability	0.59%	10.21%	52.12%
	Access Success Probability	99.95%	82.93%	22.94%