# LONG TERM EVOLUTION FOR CONTROL SYSTEM APPLICATIONS IN A SMART GRID CONTEXT

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PER LJUNGBERG
PROGRAM MANAGER
ERICSSON RESEARCH

# THE NETWORKED SOCIETY

- The "smart grid" has come to describe a next-generation electrical power system that is typified by the **increased use of communications and information technology** in the generation, delivery and consumption of electrical energy.
  - http://smartgrid.ieee.org/ieee-smart-grid
- By 2020, we envisage a world with more than 50 billion connected devices. When one person connects their life changes. With everything connected our world changes.

  CEO H.Vestberg
  - http://www.ericsson.com/

# ABSTRACT

- **Long term evolution for control system applications in a**
- **smart grid context**


- Ljungberg Per, Donovan Craig

  Ericsson Research

  164 80 STOCKHOLM
- http://www.ericsson.com



- Long Term Evolution L.T.E., marketed as LTE 4G, is a global standard for wireless
- communication of high-speed data based on the GSM/WCDMA network technologies with
- increased bandwidth and low latency specially designed for machine-2-machine (m2m)
- applications. The success and rapid roll-out of LTE 4G in many countries have lead to an increased
- interest to use this technology for different application domains. In the smart grid context system
- characteristics such as resilience, availability and latency are important factors. In this
- presentation we share our insights on experiments conducted in a virtual smart grid lab
- environment where selected smart grid functions use LTE for distribution automation. The studied
- use-case is Distributed Fault Location Isolation and Service Restoration (FLISR) using a subset
- of IEC 61850 control signaling. Early results demonstrate the technical feasibility of using LTE
- 4G for a wide range of m2m communication needs in a smart grid context.

# MANY NETWORKING TECHNOLOGIES FOR THE SMART GRID (NO SILVER BULLET)

## FIBRE
- 👍 Bandwidth/Latency
- 👎 Cost/Time to deploy

## GPRS
- 👍 Low Cost
- 👎 Bandwidth/high latency

## PLC
- 👍 Physical in place
- 👎 Bandwidth/Attenuation

**KEY CHALLENGE: Seamlessly integrating ICT with the power delivery system**

## 3G
- 👍 Significant bandwidth
- 👎 Limited concurrent nodes

## RF MESH
- 👍 Inexpensive
- 👎 Low power/unlicensed spectrum

## 4G: WIMAX
- 👍 Bandwidth/designed for data
- 👎 Technology orphan

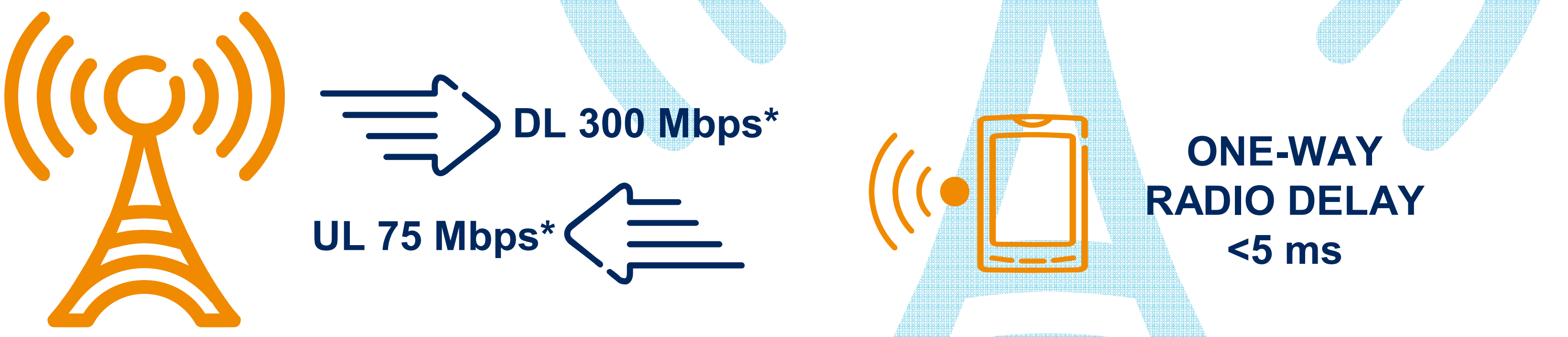
## 4G: LTE
- 👍 Very low latency/quality of service provisioning/secure ecosystem/bandwidth
- 👎 Coverage/spectrum allocation

CAN LTE MEET INDUSTRY REQUIREMENTS?

# LTE/4G IN A NUTSHELL

## LTE = LONG TERM EVOLUTION

- A new all IP radios access technology commonly know 4G
- Global standard developed by the 3GPP
- Built for high-speed data communications




* Peak rate LTE Rel.8

Source: [2]

# KEY BENEFITS OF LTE/4G

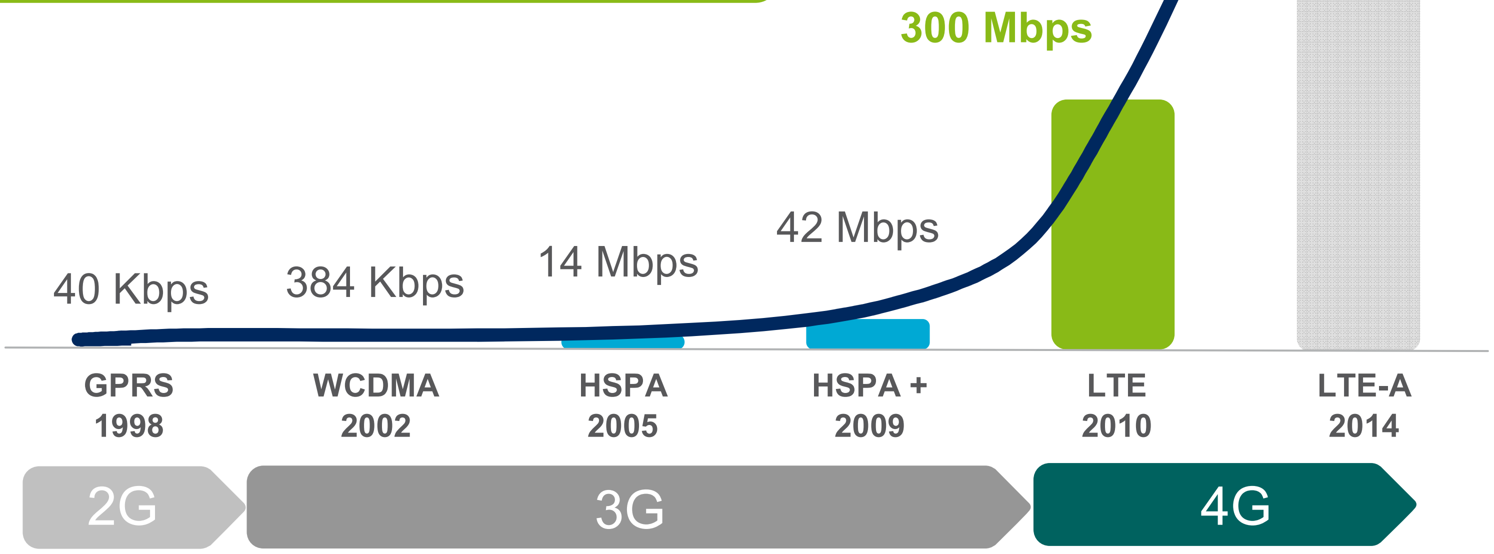
- Global standard and future-proofed technology
- Very low latency
- QoS, policy control, and priority handling
- Secure ecosystem
- Rapid deployment

- Simple IP network architecture
- Self organizing network (plug and play)
- Scalable bandwidth Spectrum Flexibility
- Efficient Multicast / Broadcast
- Multi-antenna support (MIMO)

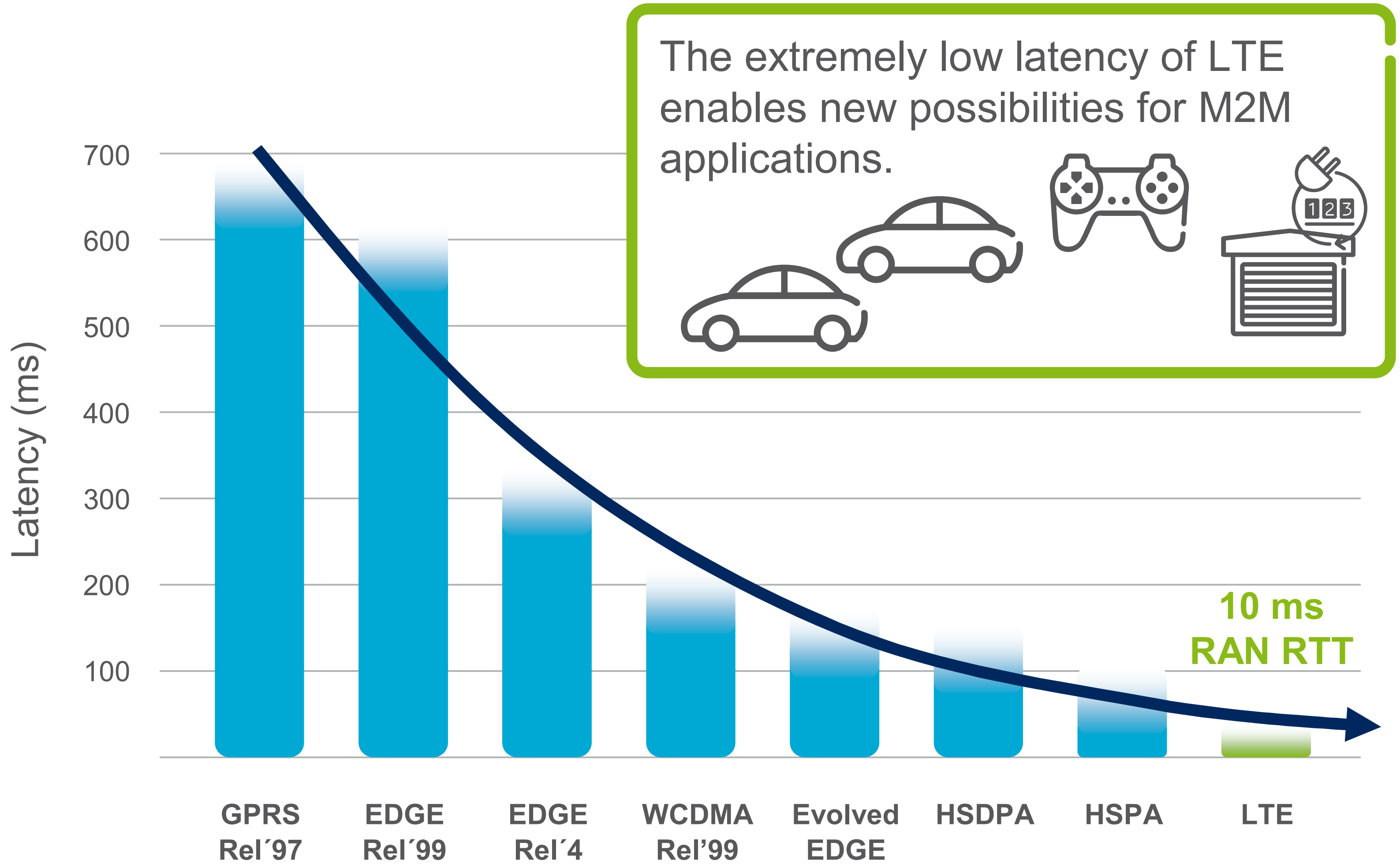
# BANDWIDTH COMPARISON

## PEAK RATE

The extremely high throughput of LTE enables new possibilities for M2M applications.

# LATENCY COMPARISON



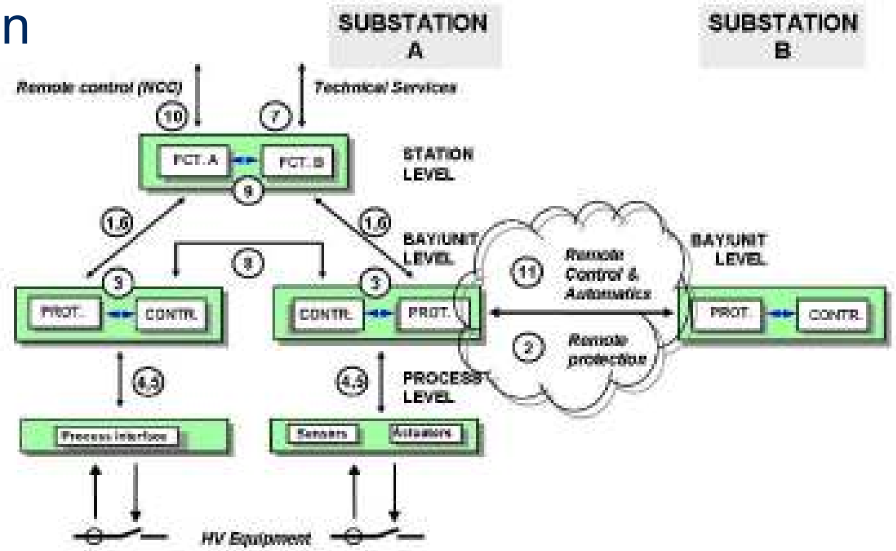
# EIT ICT LAB RESEARCH INTO LTE FOR DISTRIBUTION AUTOMATION

- A proof-of-concept demonstrator for distribution automation using LTE technology.
- The objective was to evaluate an existing LTE operator network using COTS products for latency, reliability, availability and security.
- Value #1 – Cost-effective and rapid connectivity
  - Wireless connectivity can provide cost-effective and rapid implementation for bringing grid assets online, especially legacy assets.
- Value #2 – Redundant Communication
  - Independent and redundant communication channels will be needed to increase reliability and resilience in the smart grid.

# REQUIREMENTS FROM STANDARDS

› IEC 61850 for Substation Automation

SA case toughest for: Availability
Latency
Reliability
Integrity




PROTECTION

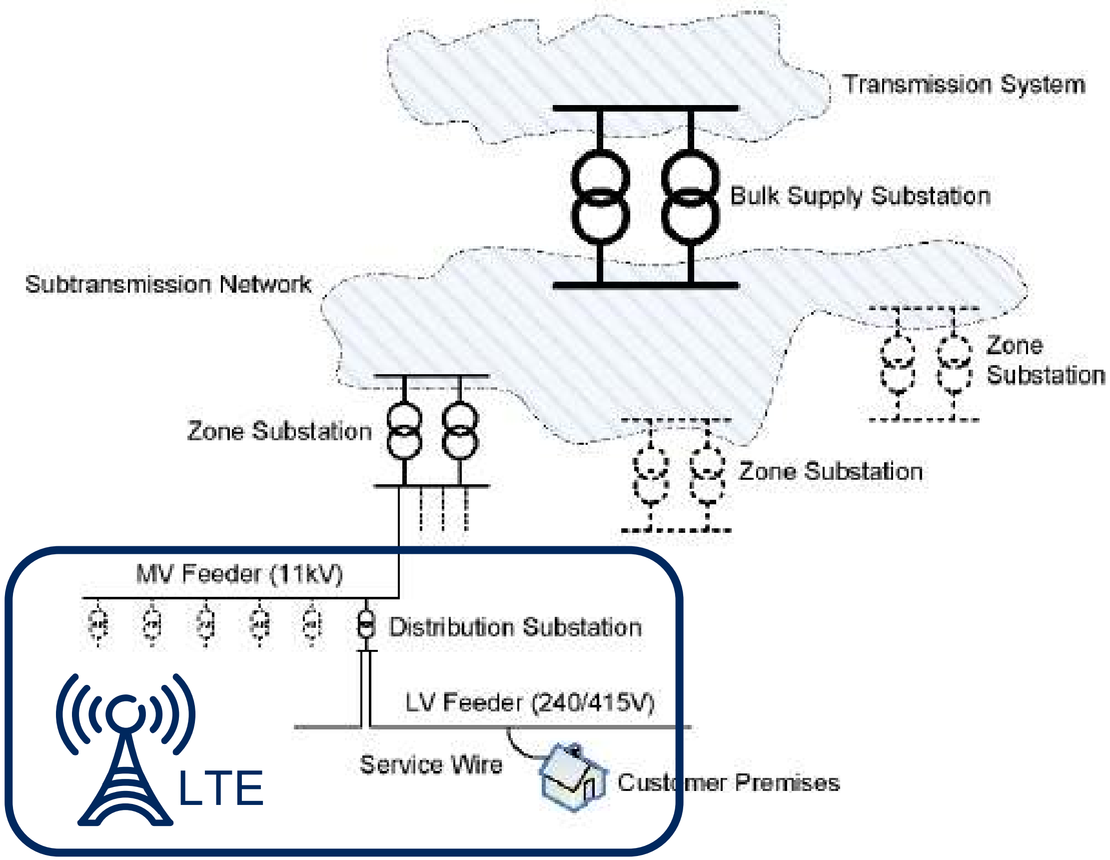
AUTOMATION

| TYPE | PERFORMANCE CLASS | REQUIREMENT DESCRIPTION | CLASS | TRANSFER TIME (ms) | INTERFACE |
|---|---|---|---|---|---|
| 1A | P1 | Transmission time <1/4 of a cycle | TT6 | ≤3 | 3,5,8 |
| 1A | P2 | Transmission time ~1/2cycle | TT5 | ≤10 | 2,3,11 |
| 1B | P3 | Transmission time ~cycle | TT4 | ≤20 | 2,3,8,11 |
| 2 | P4 | Less demanding automation functions | TT3 | ≤100 | 2,3,8,9,11 |

Source: [3]

# USE CASE FOR LTE APPLICATION: BACKGROUND

› Typical residential electricity supply structure

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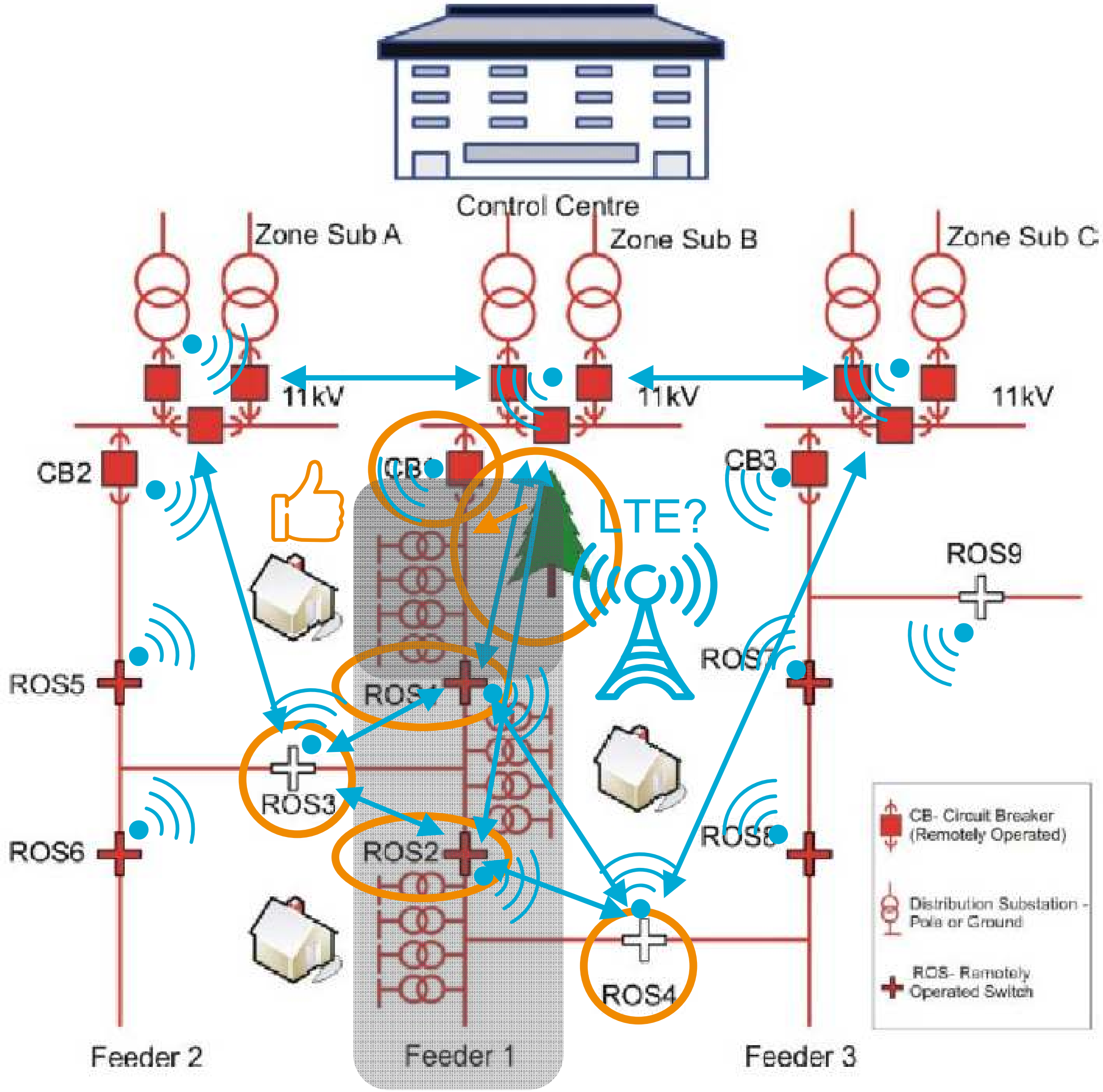
# USE CASE: DISTRIBUTED FLISR

- Distributed Fault Location Isolation & Service Restoration (FLISR)

- IEC 61850
  - Latency 20 - 100 ms
    fast – slow automation

- Sequence of events
  - Tree falls on Feeder 1
  - CB1 trips – Feeder 1 down
  - Reconfiguration decision made
  - ROS1 and ROS2 open
  - ROS3 and ROS4 close
  - Fault isolated between CB1 and ROS1

**Communication required to all distributed devices**

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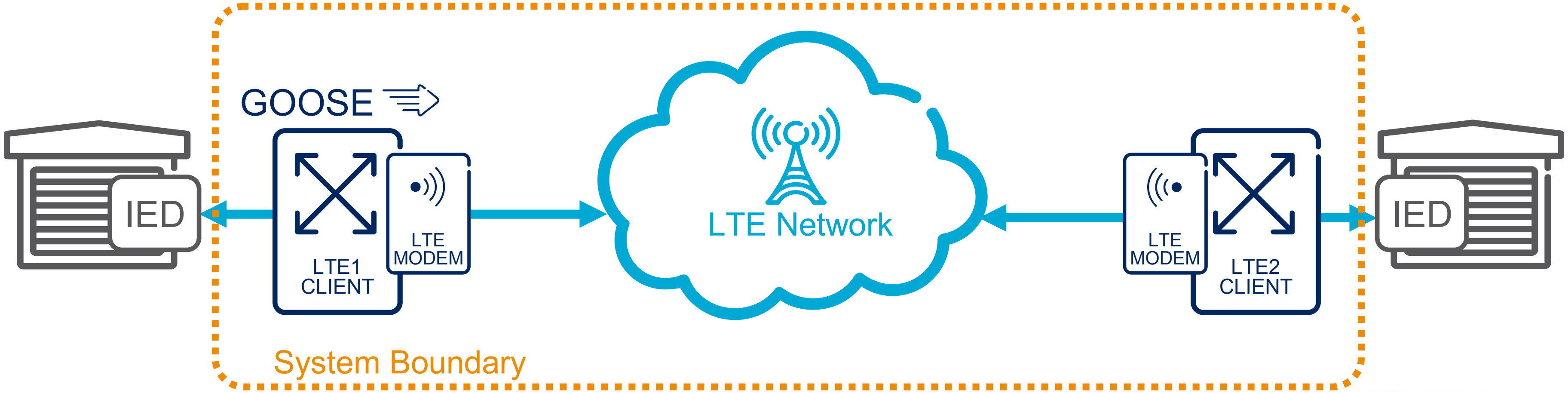
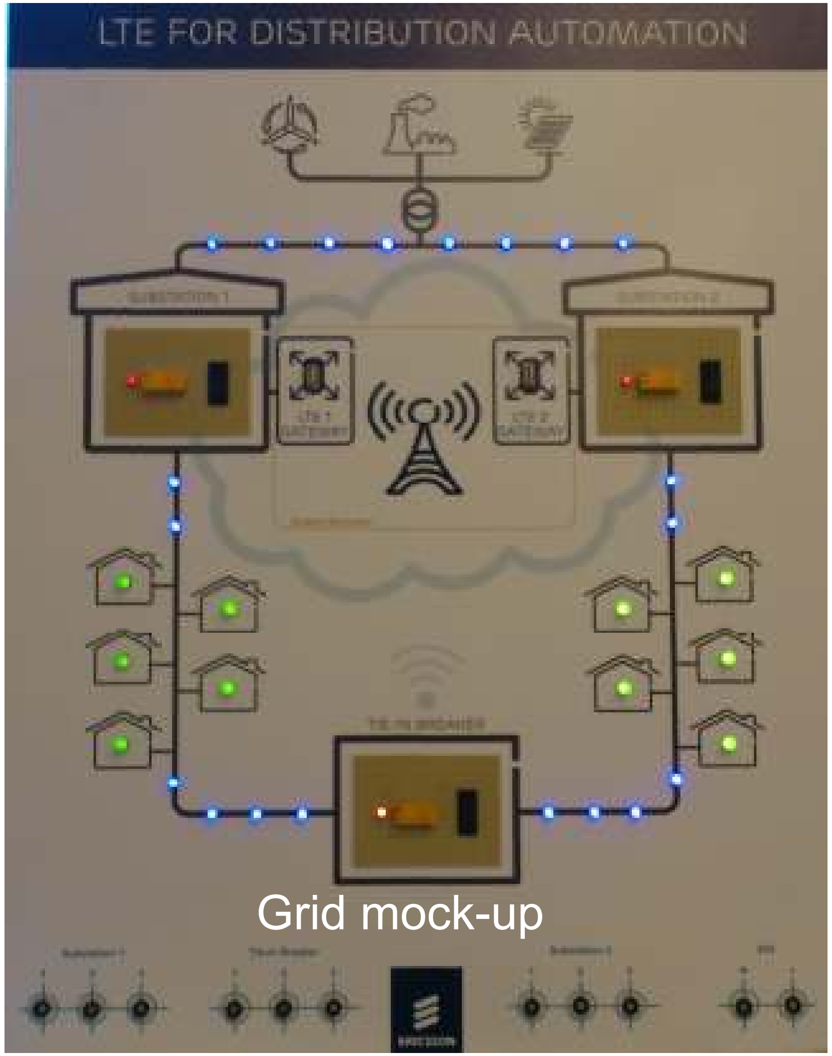
# PROOF-OF-CONCEPT SOLUTION

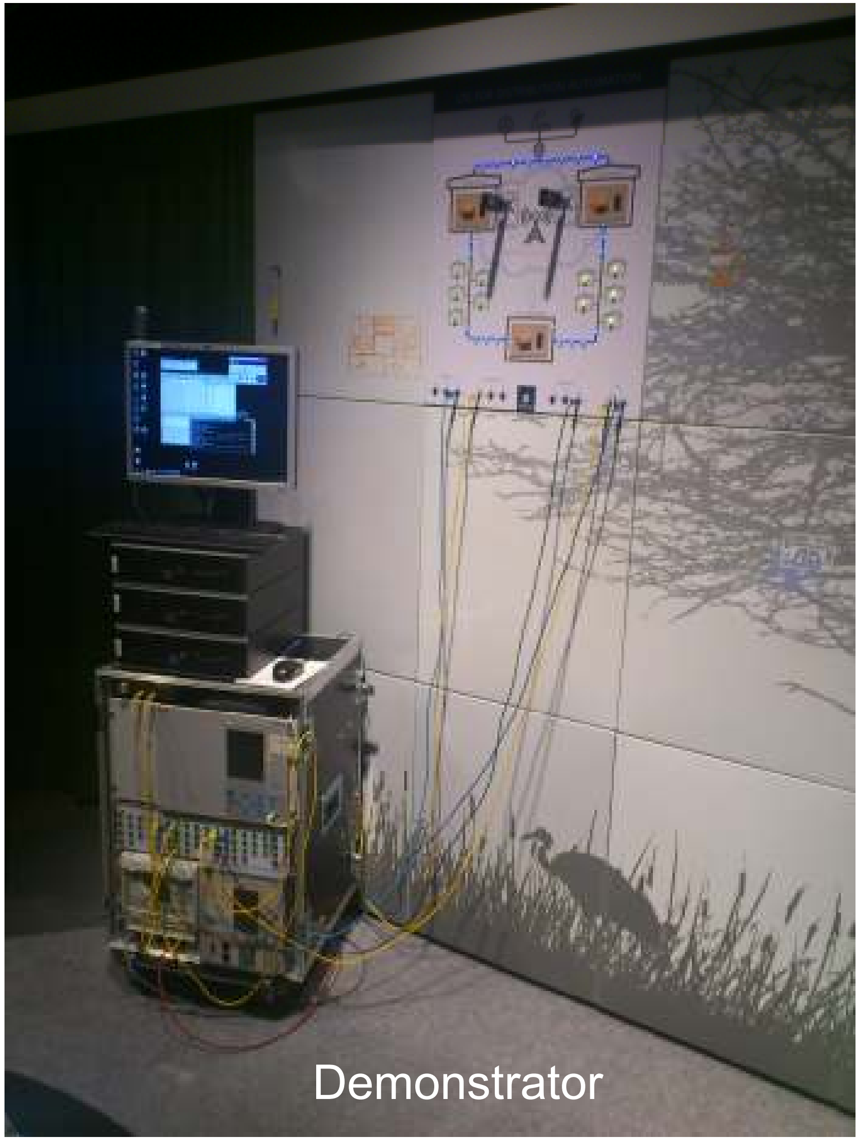
IEC 61850 GOOSE protocol over IP using multi-vendor intelligent electronic devices (IEDs)




# LTE/4G DEMONSTRATOR



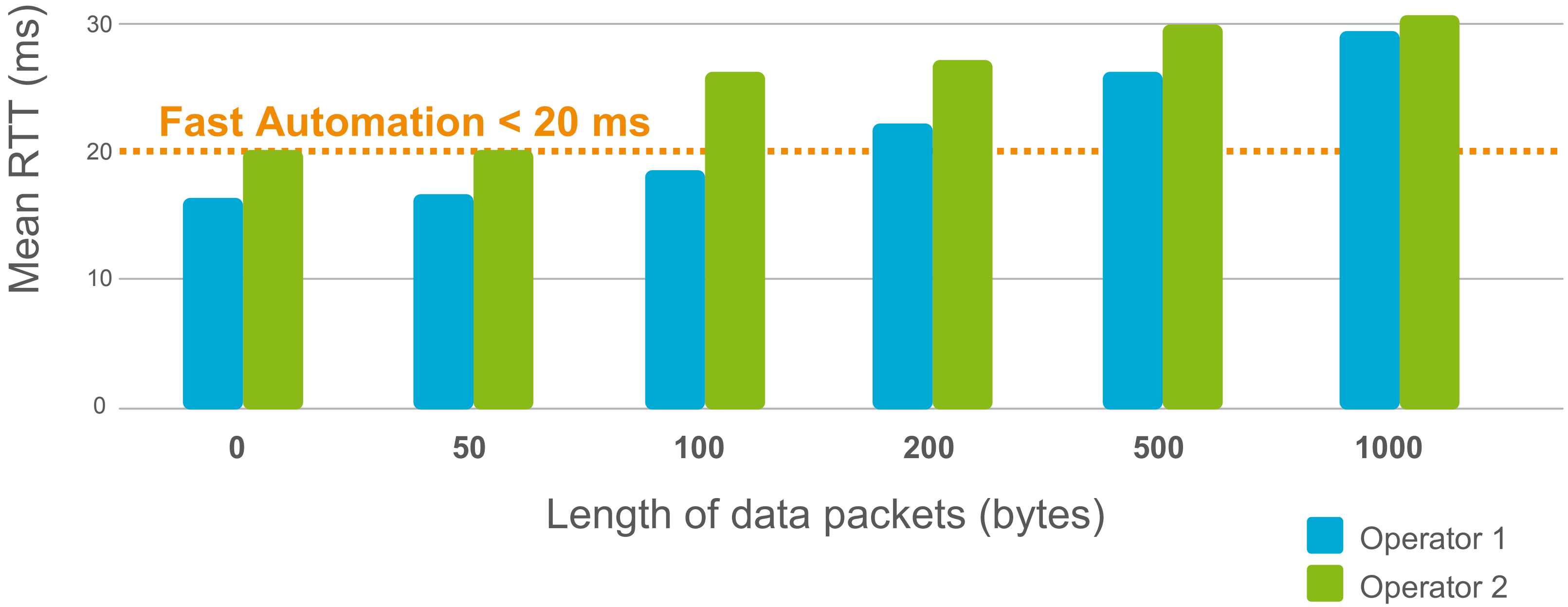

Grid mock-up



Demonstrator

# LATENCY EVALUATION

Latency evaluation showing round trip times (RTT) through two **Operator LTE networks** for different packet sizes.
Note: Standard network with no optimization for M2M traffic.

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# DISTRIBUTION ASSETS
## SWEDEN



# KEY LEARNINGS

## 1. M2M OPTIMIZATION

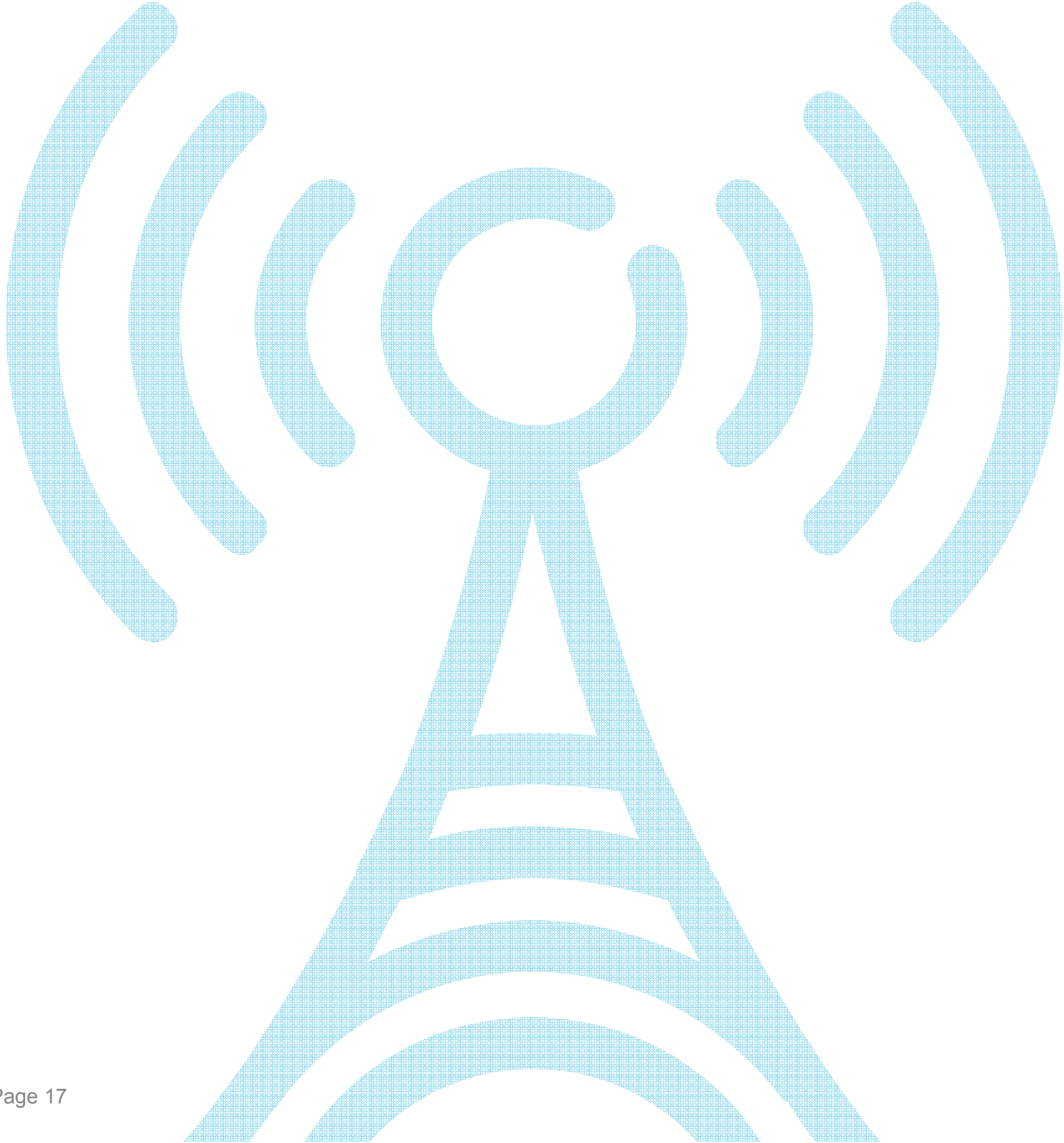
- Smart grid data traffic characteristics are not the same as smart phones, therefore the LTE network needs to be optimized for M2M data flows.

## 2. QUALITY OF SERVICE

- Tailor-made QoS is required to ensure priority in network at all times for mission-critical messages.

## 3. SECURITY

- End-2-end security over and above LTE security features must be considered.



# NEXT STEPS

- › Stockholm Royal Seaport
  Smart Grid Pilot for experimental data to validate FLISR use-cases
- › A Virtual Laboratory for Micro-Grid Information and Communication Infrastructures is established by EIT ICT lab /Smart Energy Systems
  - – Publication Oct 2012: 2012 3rd IEEE PES Innovative Smart Grid Technologies Europe (ISGT Europe) Article Title: A Virtual Laboratory for Micro-Grid Information and Communication Infrastructures.

# CONCLUSION

- Standardized wireless technology allows a rapid introduction of advanced smart grid functions.
- LTE/4G has been demonstrated to satisfy stringent requirements on the network communication infrastructure for distribution automation.
- Continued research on suitability of LTE/4G will be done in the virtual smart grid lab.

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[4] Higgins, N., V. Vyatkin, N. Nair and K. Schwarz. Distributed Power System Automation With IEC 61850, IEC 61499, and Intelligent Control. IEEE Transactions on Systems, Man, and Cybernetics—Part C: Applications and Reviews, Vol. 41, p.81-92, No. 1, January 2011 [4] Cheng, P. et al. Feasibility study of Applying LTE to Smart Grid. IEEE First International Workshop on Smart Grid Modelling and Simulation (SGMS) at IEEE SmartGridComm 2011.

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