Introduction – Chris Develder

- Professor at Ghent University since Oct. 2007
  - *Research Interests*: **smart grids** (data analytics; optimization/scheduling algorithms for DSM/DR), **information extraction** (e.g., knowledge base population, relations in news archives); **optical networks** (dimensioning, resilience schemes, ILP)
  - Visiting researcher at UC Davis, CA, USA, Jul-Oct. 2007 (optical grids)
  - Visiting researcher at Columbia Univ., NY, USA, 2013-14 (IE)
- Industry Experience: network planning/design tools
  - OPNET Technologies (now part of Riverbed), 2004-05
- PhD, Ghent University, 2003
  - "Design and analysis of optical packet switching networks"
- More info: http://users.atlantis.ugent.be/cdvelder

C-DAX:
A Cyber-Secure Data and Control Cloud for Power Grids

Chris Develder
Ghent University - iMinds

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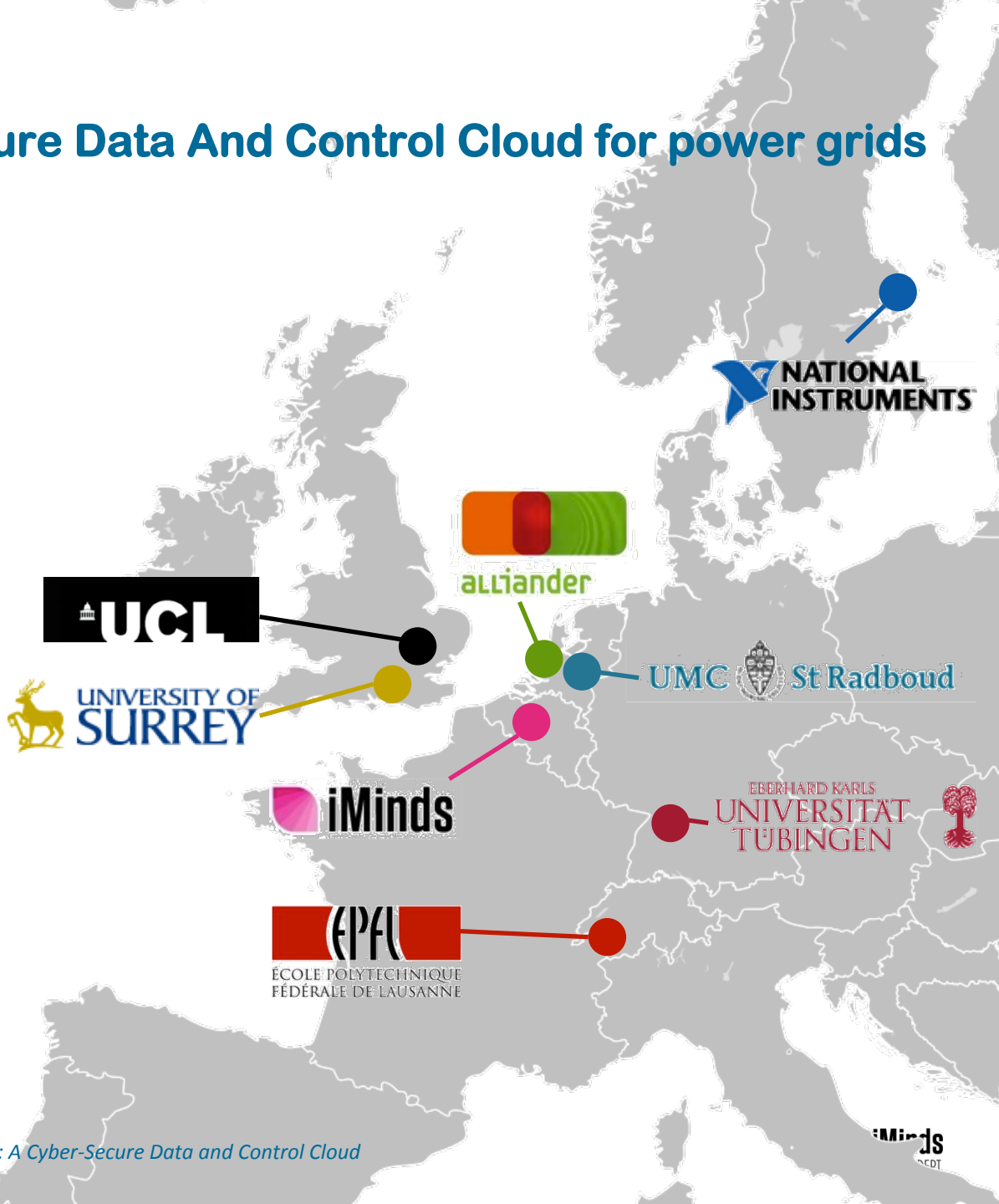
C-DAX
Cyber-secure Data And Control Cloud for power grids

- Project FP7-ICT-2011-8
- Oct. 1, 2012 – Feb. 29, 2016
- Budget: 4.3M EUR
  EU-funding: 2.9M EUR
- More info:
  http://www.cdax.eu



Context & Cause

Challenge

Transition to **active distribution networks:**

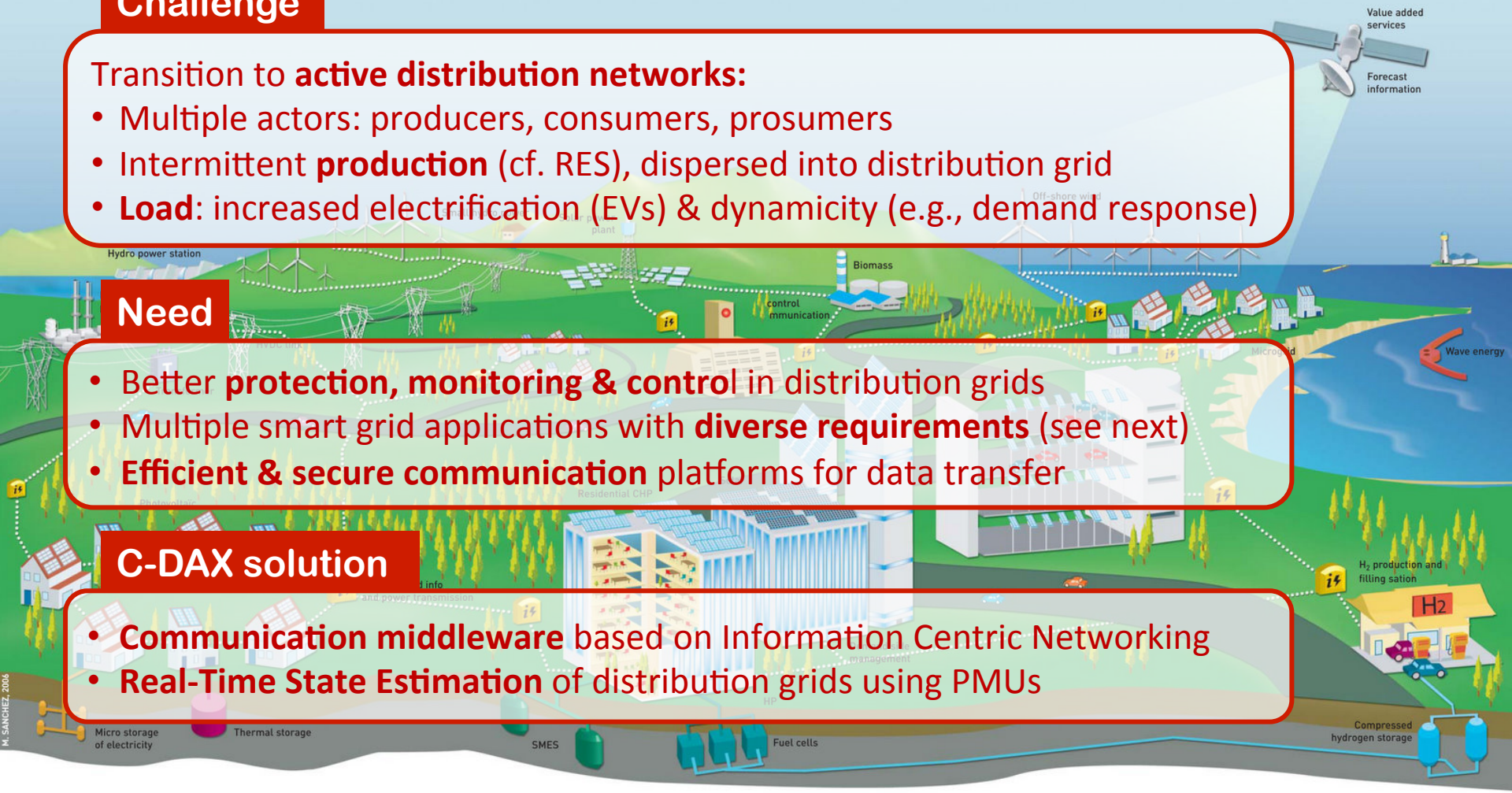
- Multiple actors: producers, consumers, prosumers
- Intermittent **production** (cf. RES), dispersed into distribution grid
- **Load**: increased electrification (EVs) & dynamicity (e.g., demand response)

Need

- Better **protection, monitoring & control** in distribution grids
- Multiple smart grid applications with **diverse requirements** (see next)
- **Efficient & secure communication** platforms for data transfer

C-DAX solution

- **Communication middleware** based on Information Centric Networking
- **Real-Time State Estimation** of distribution grids using PMUs



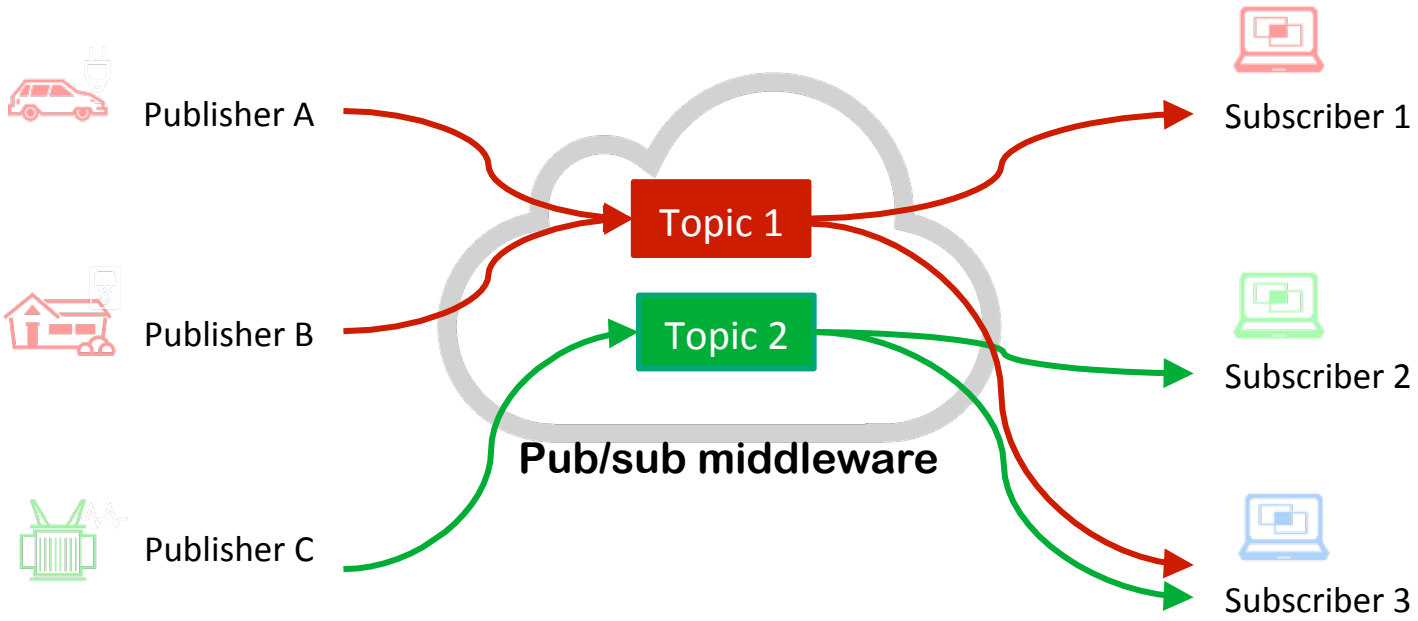
Smart grid communication pattern variation

- **1-to-1**: e.g., control messages for specific assets
- **1-to-M**:
  - *Broadcast*: e.g., energy offers in demand response schemes
  - *Anycast*: e.g., offer for voltage regulation by any suitable subset of EVs located in a certain area
- **M-to-1**: e.g., energy consumption reports in demand response or smart metering
- **M-to-N**: e.g., multiple charging offers from different charging stations to multiple EVs
- **Asynchronous** communication in dynamic scenarios:
  e.g., EVs come and go, retrieve/deliver data while connected to the network

ICN = Information Centric Networks

- Alternative for point-to-point networks
  - Explicit point-to-point connections from producer to predefined consumers → need to know/config all IPs
- ICN paradigm = based on **topic** rather than IP address
  - Consumers "pull" or "subscribe to" the data "topics"
  - Agnostic of who produced and when/where info is stored
  - Decoupling of producers/consumers
- Advantages:
  - Inherent **security**: hosts do not know each other's locations
  - Overlay network **management**:
    - Management of IP connections, optimal placement of the data within the cloud, resilience …
    - In-network management and processing (e.g., caching, aggregation, filtering, rate adaptation, traffic engineering …)

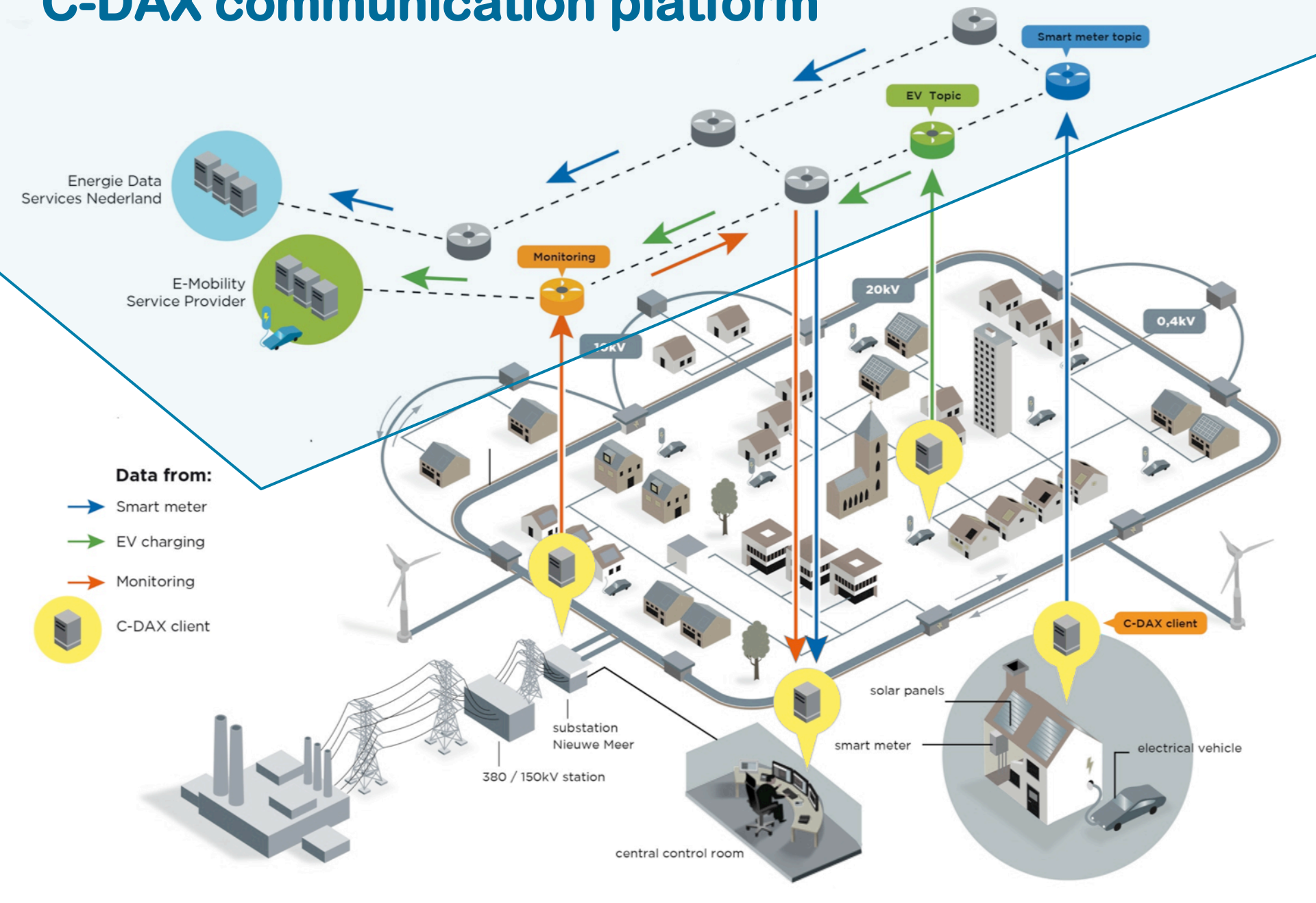
Topic-based communication



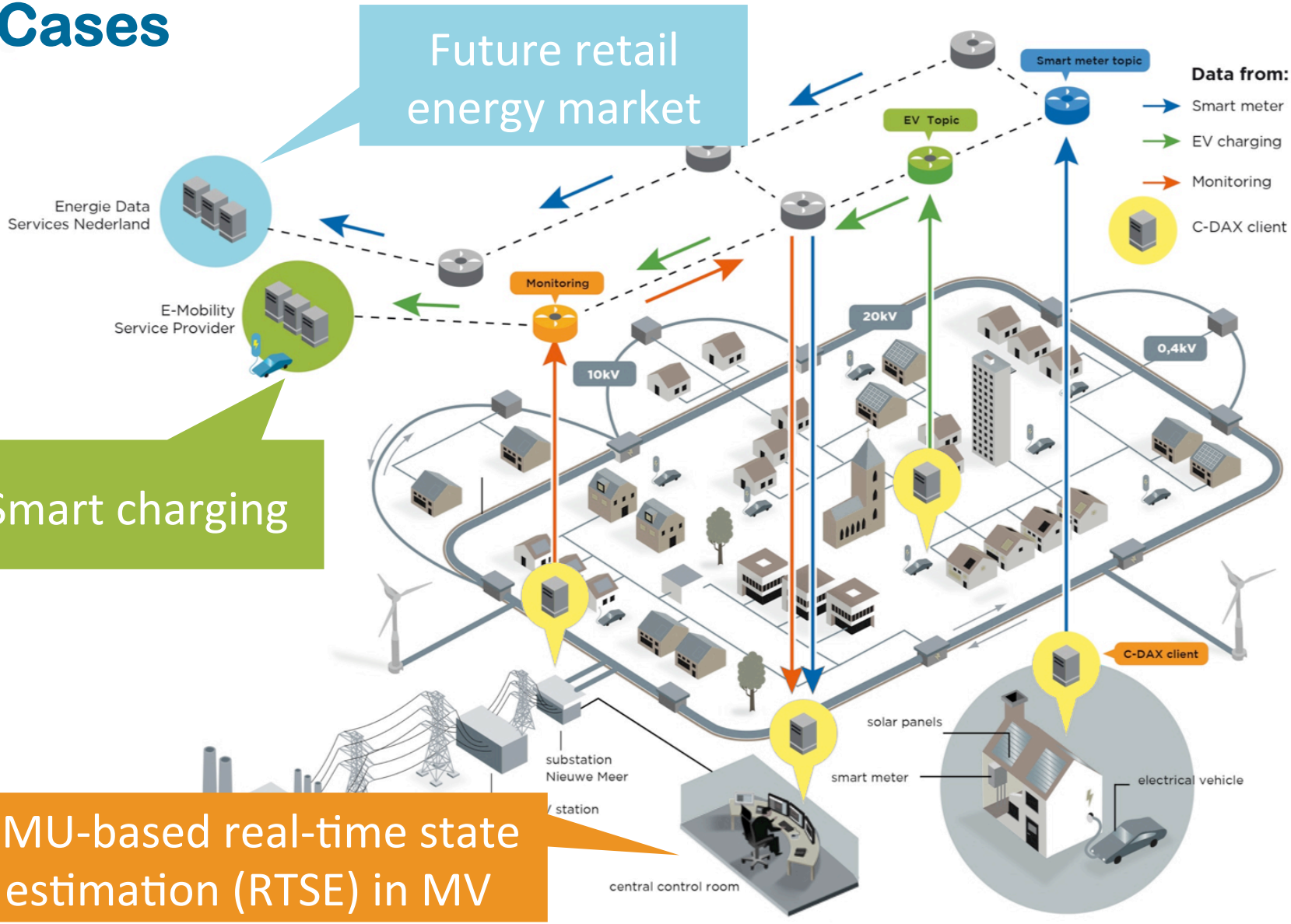
Benefits of decoupling publishers and subscribers

- Communication partners do not need to know each other
- Asynchronous communication possible
- Facilitating extensibility, management and configurability

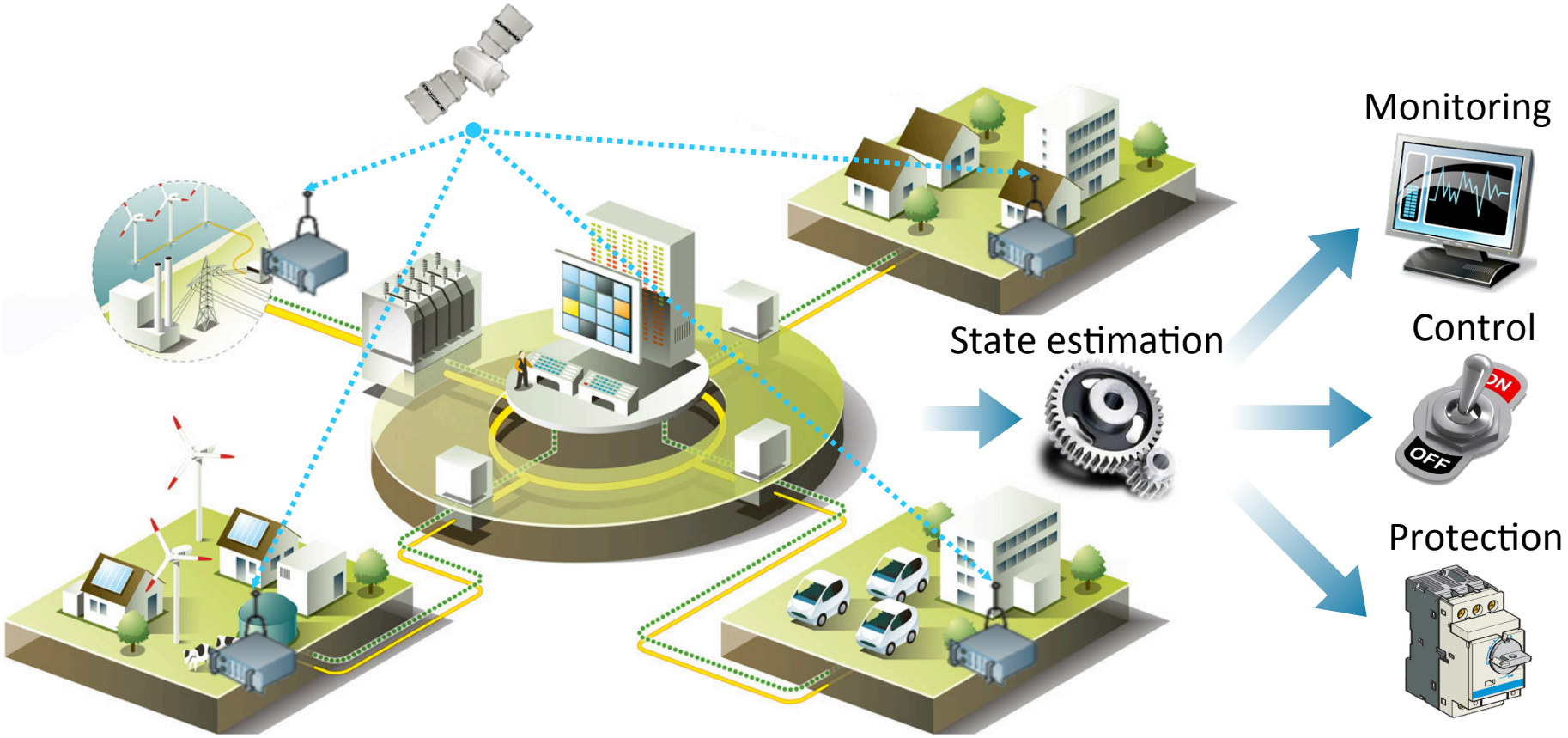
C-DAX communication platform



Use Cases


Future retail energy market
Smart charging
PMU-based real-time state estimation (RTSE) in MV
Energie Data Services Nederland
E-Mobility Service Provider
Smart meter topic
EV Topic
Monitoring
Data from:
Smart meter
EV charging
Monitoring
C-DAX client
20kV
10kV
0,4kV
C-DAX client
solar panels
smart meter
electrical vehicle
substation Nieuwe Meer
central control room

Use Case: Real-time state-estimation of ADNs



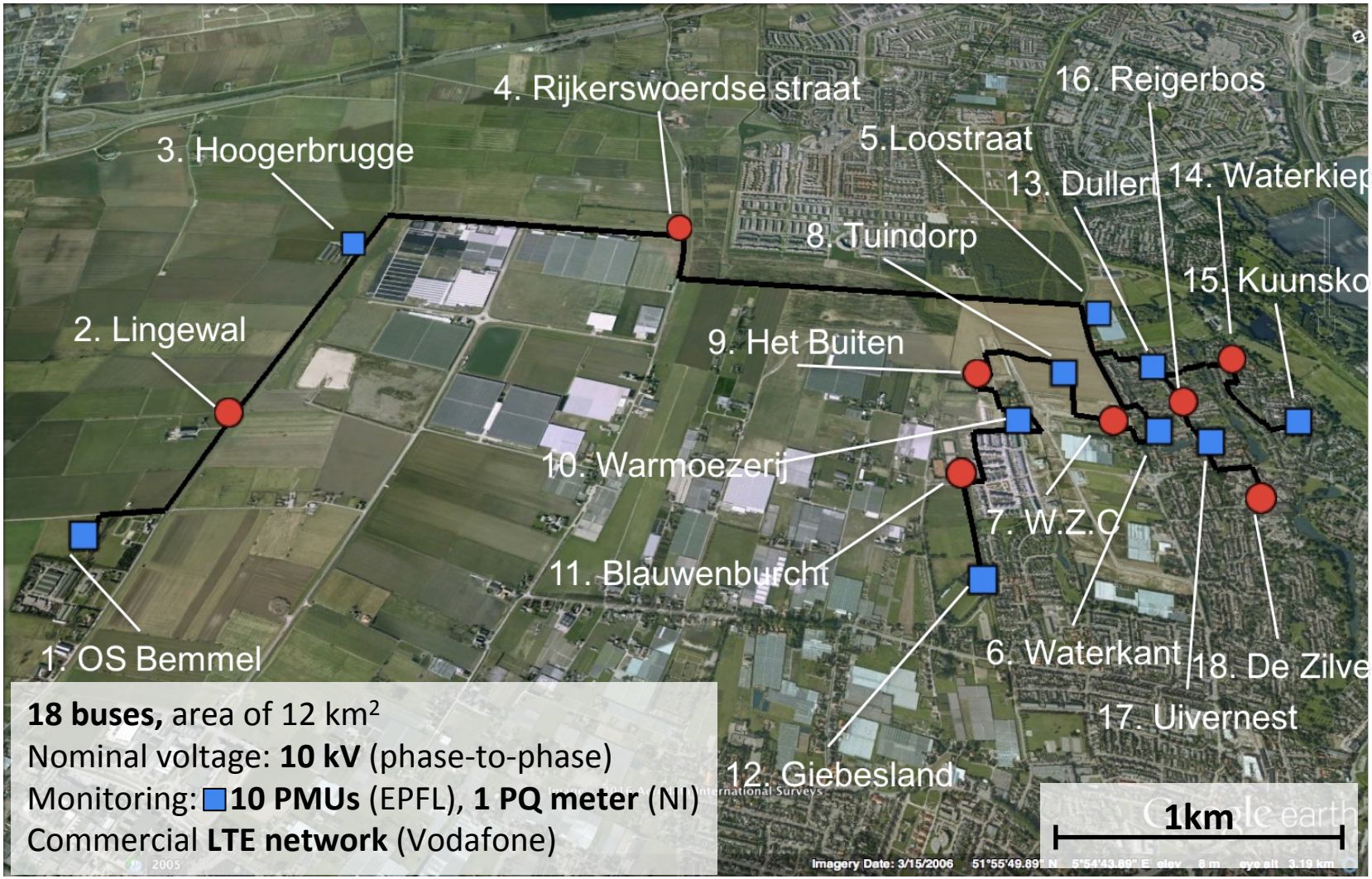
Network in ***normal*** operation:

- Congestion management
- Optimal V/P control
- Optimal dispatch of DER

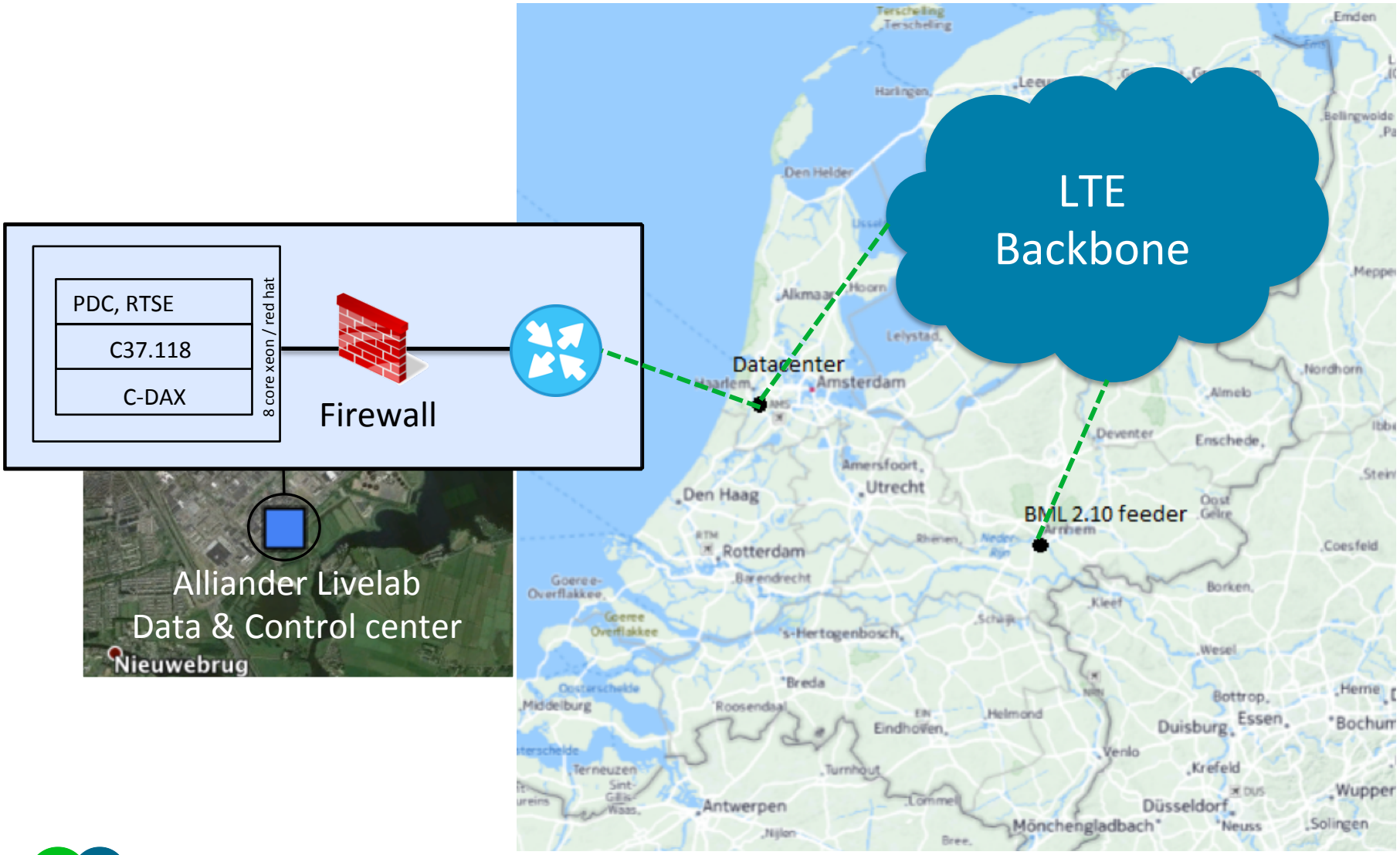
Network in ***emergency*** conditions:

- Islanding detection
- Fault identification
- Fault location

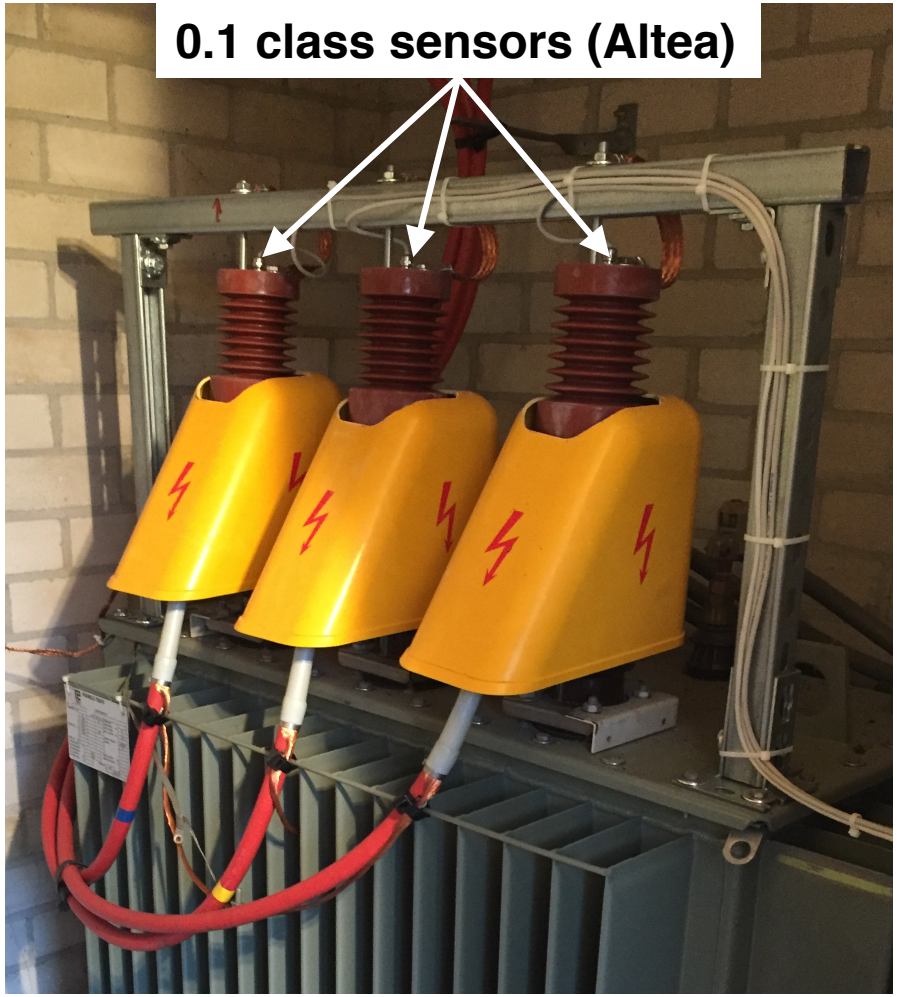
Field trial setup: Feeder of Alliander (Arnhem, NL)



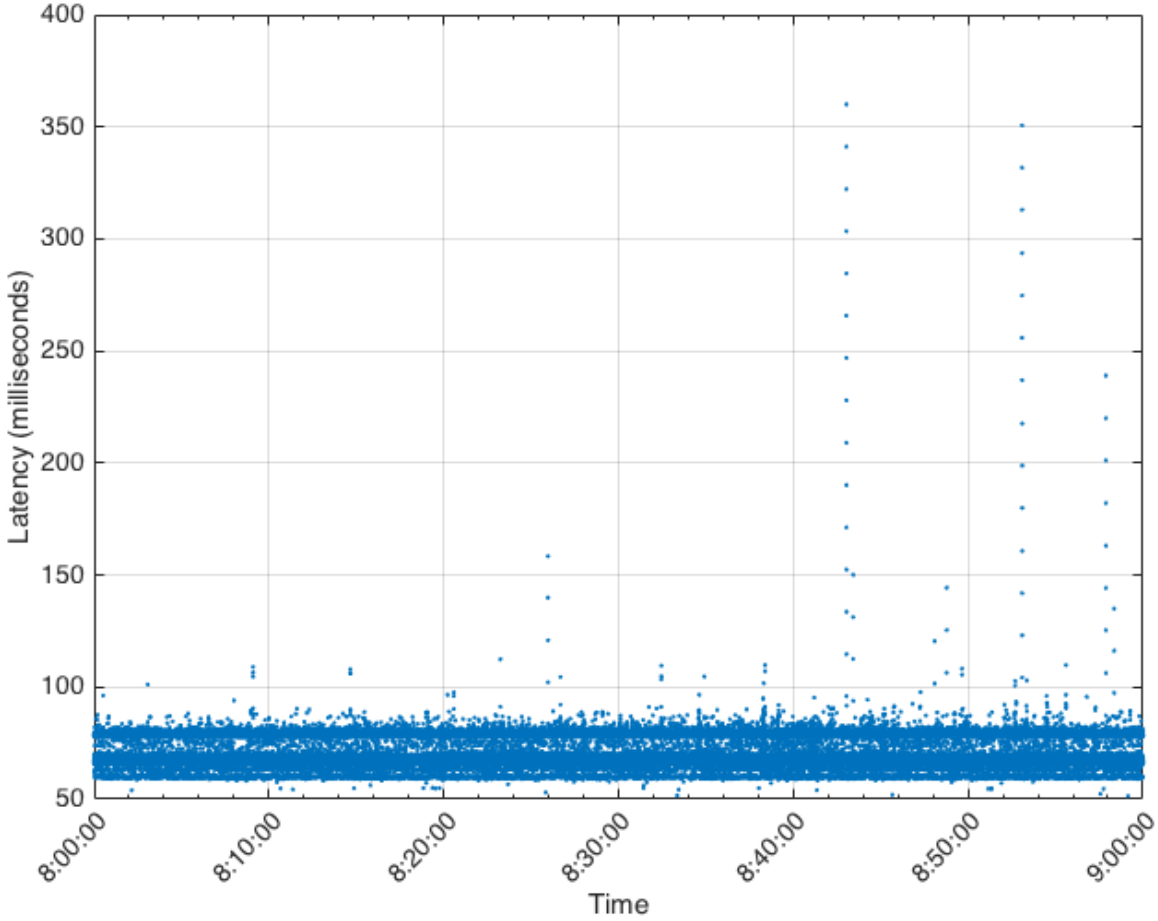
Field trial setup: Alliander data center



Substation setup



Synchrophasor data latencies (4G network)



Mean	Stdev	Max	Min	Data Loss (%)
70.9 ms	8.1 ms	770.5 ms	49.2 ms	0.0053

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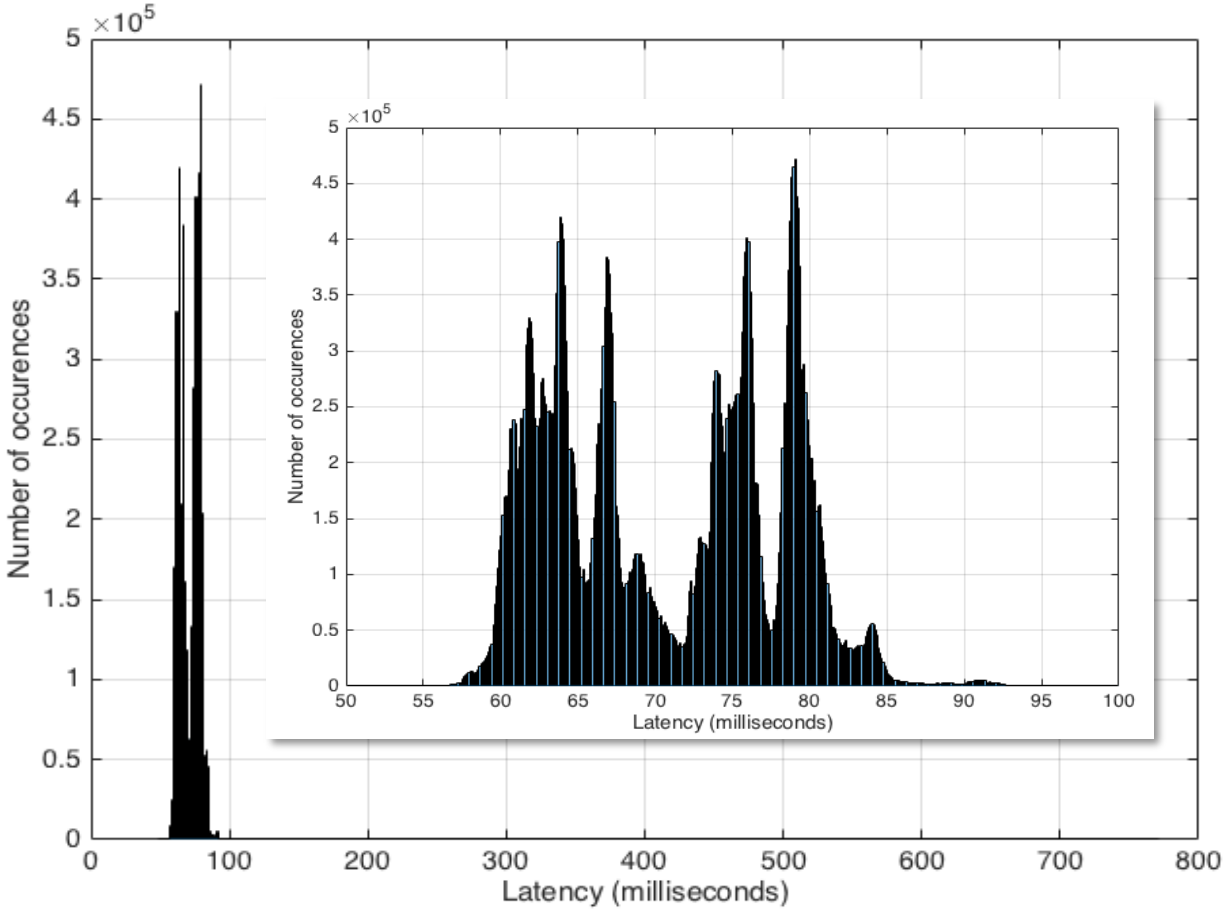

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C-DAX benefits for utilities

- **Single communication platform** for all applications
  - No duplicate investments, better resource utilization
  - Support for streaming, query and point-to-point communication
- Secure and reliable grid operations: **secure, timely and resilient** delivery
  - E.g., support for low latency RTSE application
- **Scalable** platform, supporting a growing number of active power grid assests (flexible loads, EVs, distributed energy sources)
  - Plug-and-play addition of entities (publishers, subscriber) and applications (topics)
  - Support for existing smart grid protocols (e.g., integration of IEEE C37.118)

Q&A

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