

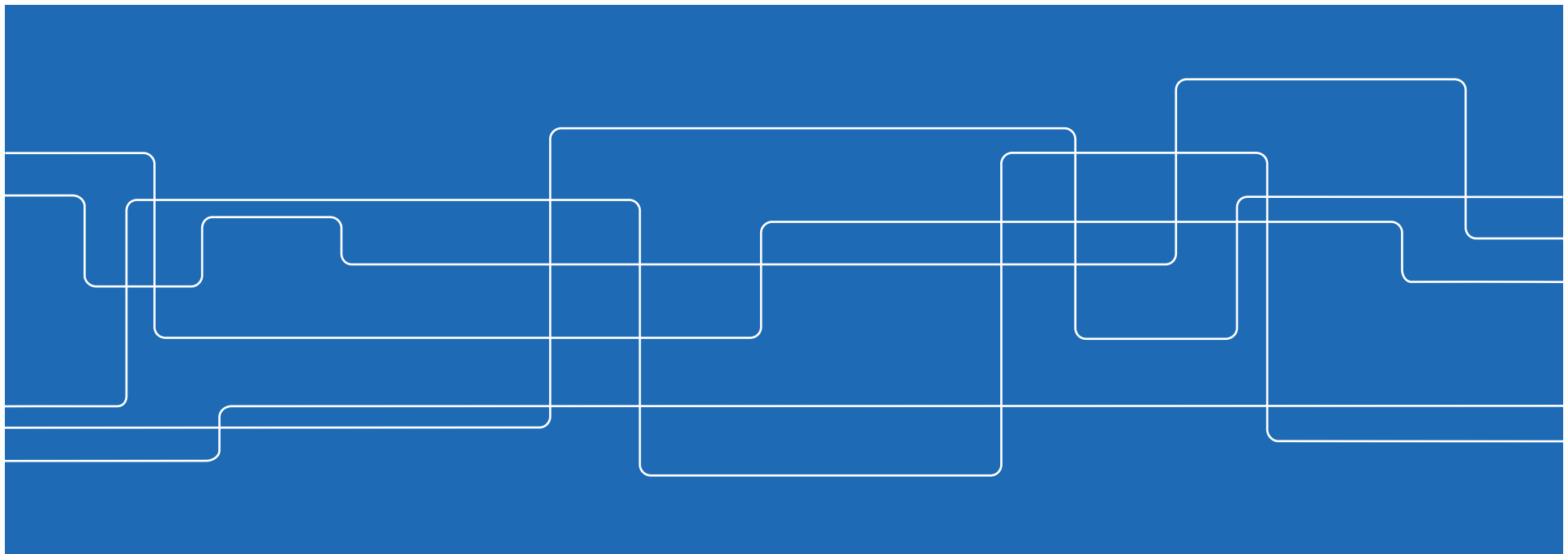


# Open measurements for new applications

*DPSP 2014 Keynote, Copenhagen*

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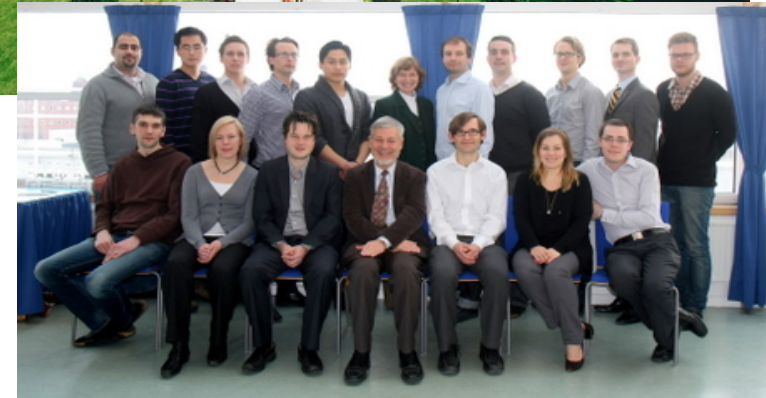
## Aim of this presentation

Discuss the idea of ***Substation Automation Clouds***, de-mystify the term, and present some cases showing that it is actually a good idea and might even be realised in a not too distant future.



# A bit of Background

- KTH – Institute of Technology,
- Established 1827 in Stockholm
- 700 Faculty, 10 PhD students
- M.Sc students
- World ranking
- Focus Areas:
  - Electricity, Energy, Material, ICT & Transportation
- Power system development & Information Exchange
- 3 Senior researchers, 7 PhDs students, 10+ MSc & BSc students
- Courses on Power system communication & control, Distributed control, Computer applications in power systems
- Focus areas:
  - Automation & Distributed control of power systems, Multi-agent applications, Reliability cybersecurity & performance of ICT systems



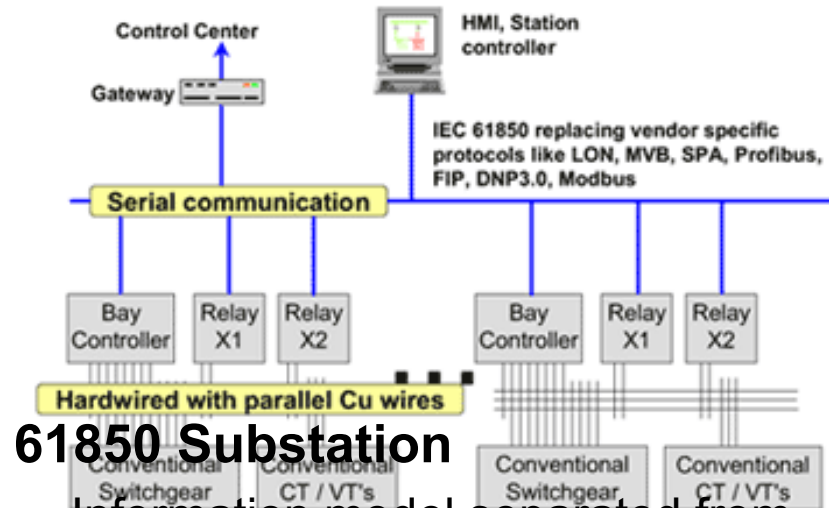


# Outline

1. The 61850 standard for Substation Automation
2. Substation Automation Clouds
3. Some justifiable concerns
4. Some challenging examples
5. Summary



# Substation Automation Development

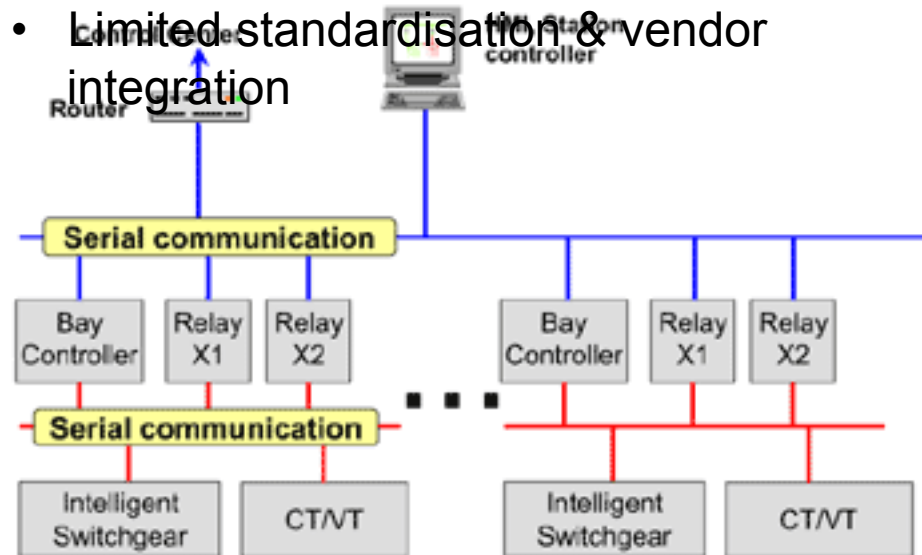


## 61850 Substation

- Information model separated from protocol implementation
- Improved vendor interoperability
- Point to multipoint Measurement access via sampled values (-9-2)
- "Free" allocation of functions to devices.

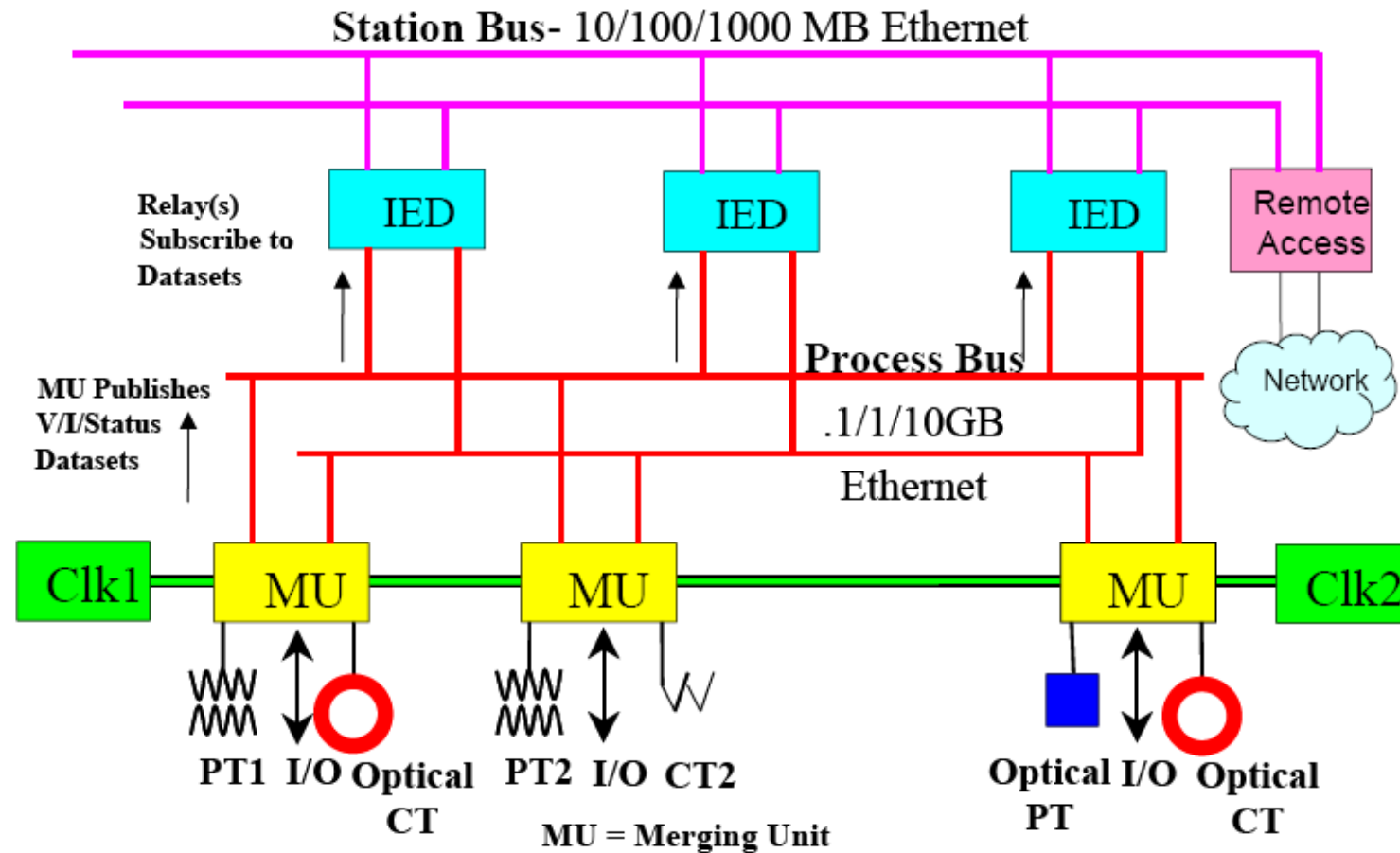
## Traditional Substation

- Functions tied to physical device
- Measurement connection based on point to point links (Copper wires)
- Some buses for relay communication
- Limited standardisation & vendor integration

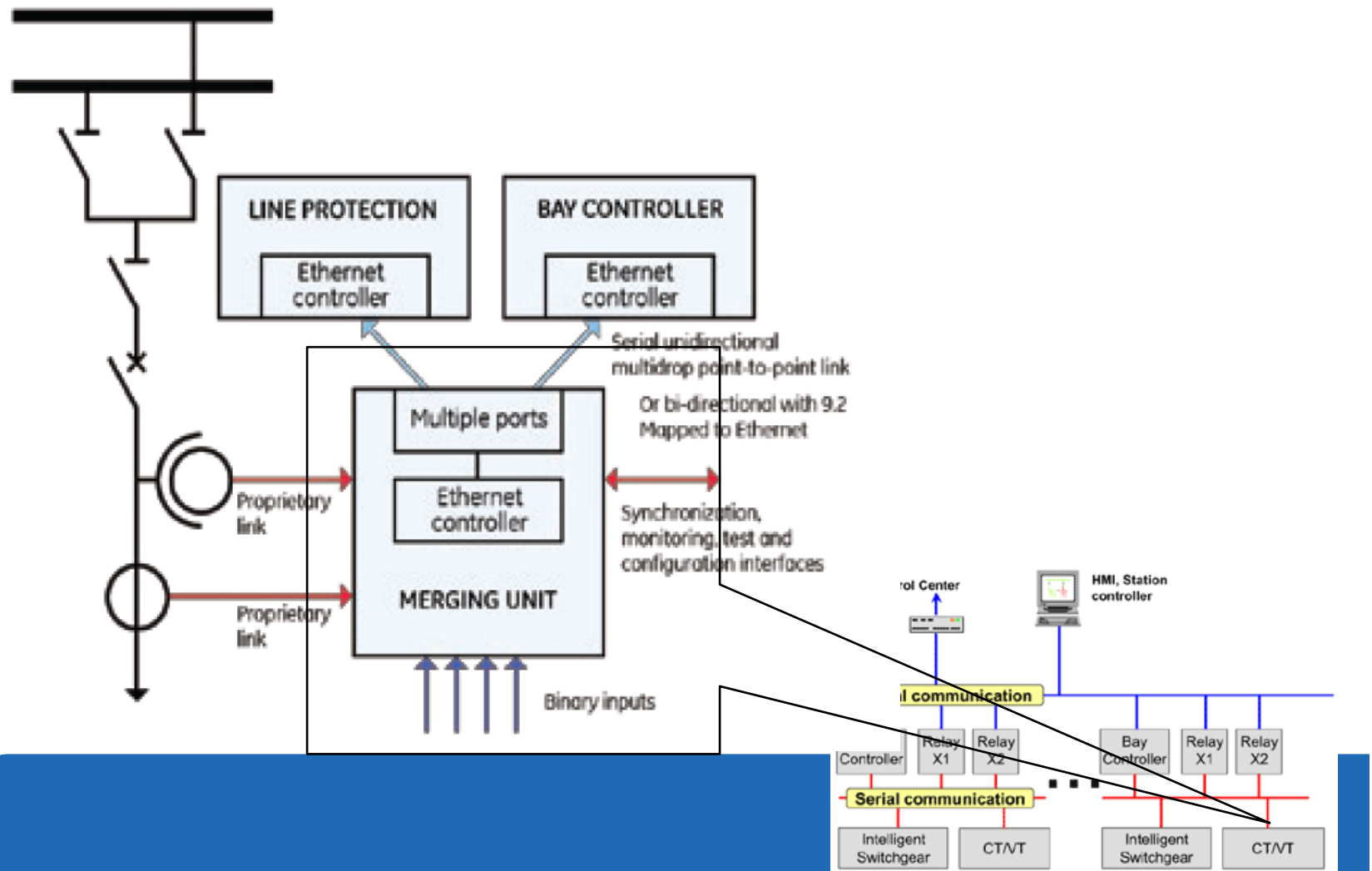




# Substation Automation Architecture



# The Merging Unit





## Try Google:ing "IEC 61850 Stack"

**libIEC61850**

open source library for IEC 61850



Standardisation has opened up a flood of new solutions in the Substation Automation field.

What will this lead to?







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# Substation Automation Clouds

The general idea of "Clouds" is to abstract (hide) the physical details of the implementation and put the focus on the services and functions<sup>1</sup>

In the context of substation automation, this has two implications.

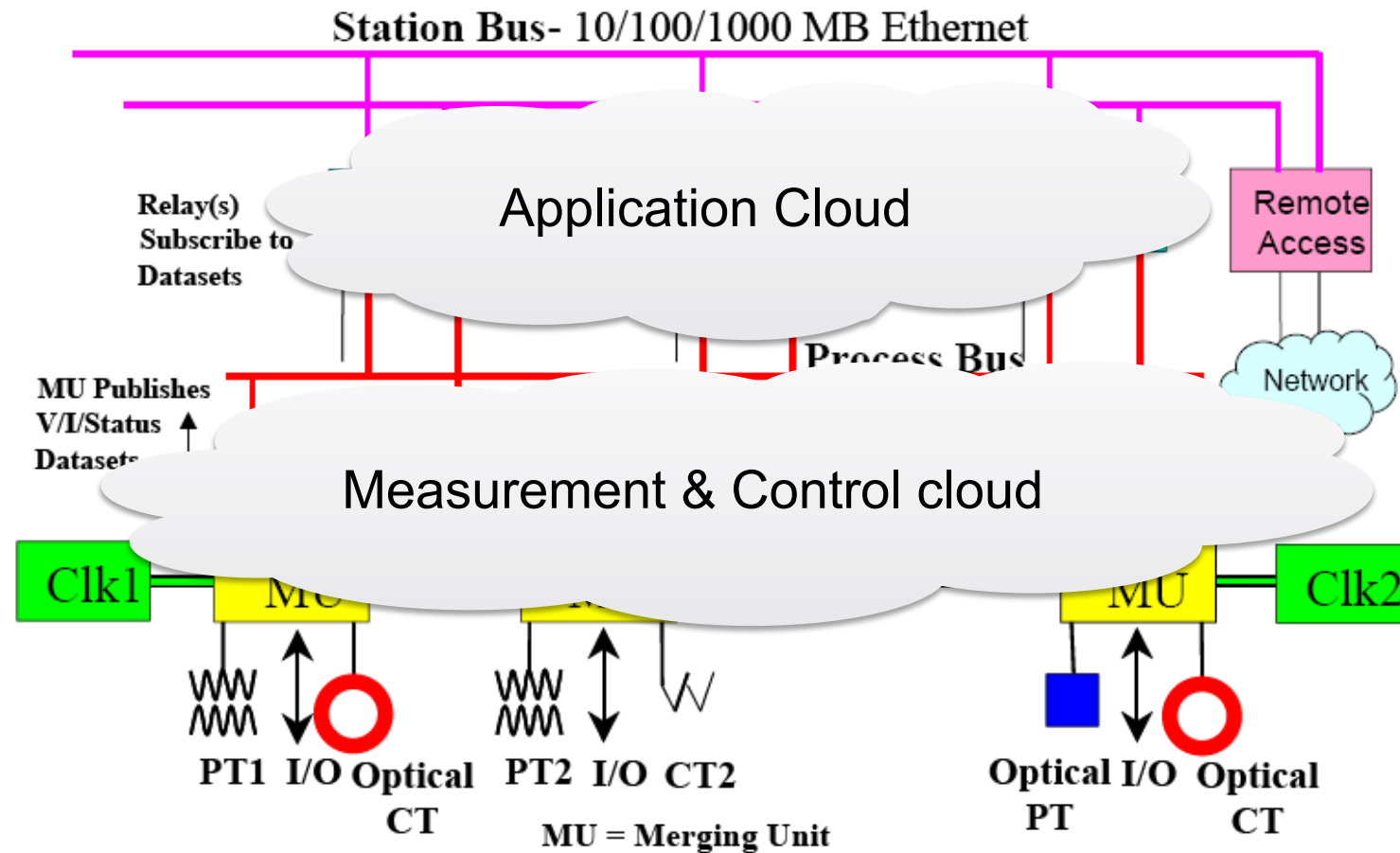
1. Open access to measurements and controls
2. Freedom to allocate functionality across hardware & software platforms

This is strikingly similar to some of the design objectives of IEC 61850

1: Ryan, P.S. ; Falvey, S. ; Merchant, R "When the Cloud Goes Local: The Global Problem with Data Localization". IEEE Computer , Volume:46, Issue: 12, 2013.



# Substation Automation Clouds





# Cloud characteristics

## Measurement & Control cloud

Publish & Subscribe method for communication. (-90-2)

One CT/VT – many IEDs use the data  
Measurement availability across bays, across stations?

## Application Cloud

Application functions located "anywhere"

Proximity for reliability

At a distance for flexibility & backup

Adaptive back-up schemes

Software upgrades "best of breed" without HW update.



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## The voice of reason.....

At this point, some justifiable concerns can (should!) be raised.

- Fancy system architectures will never be as reliable as point to point copper-wire links!
- Allocating functions freely across hardware platforms offers only problems no benefits!
- The communication links will never be fast enough!
- Protection must be stable and reliable – no unnecessary risks
- All the options and flexibility increase the risks for configuration and human errors.
- The Copper wires are already in the ground, if it works do not fix it
- .....



## Then again.....

- Software has a much shorter life-cycle than hardware which is shorter than primary equipment - The three must be separated to enable flexibility & upgradeability
- The core value of a protection system is in the software - Focus development on software, and not hardware
- The "flood gates" have been opened, cheaper solutions will appear as a consequence of the open standards.
- There are actually a quite a few examples of developments in this direction.



## So, who is right?

There are some **Technical requirements** that must be fulfilled, for example reliability, performance, stability,...

There are some **Business requirements** that cannot be ignored. Cost & risk versus benefit

There are a lot of **Human requirements** that must be challenged!

.....some of them may be right.





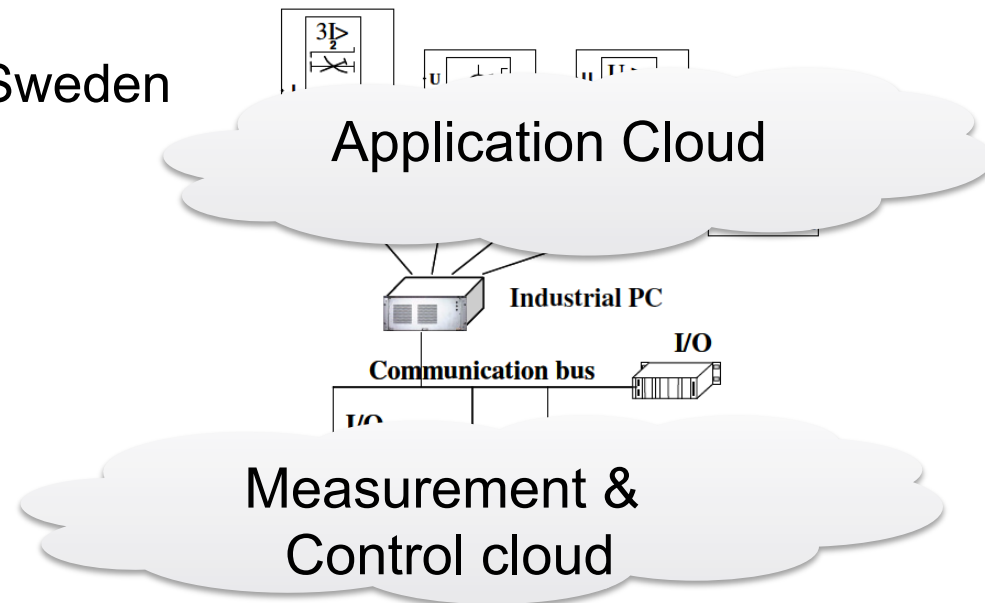
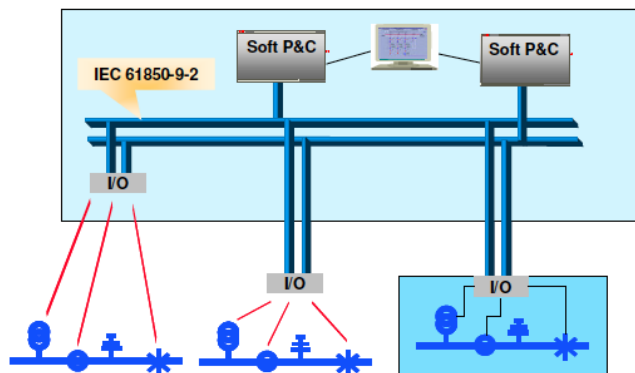
# Outline

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# Vattenfall Soft protection & control (2010)

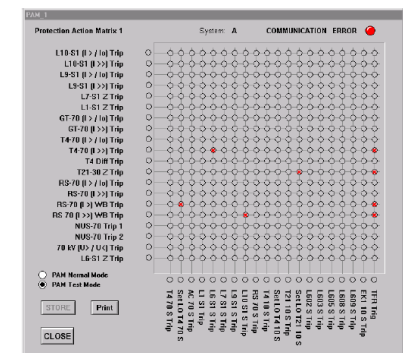
Ulricehamn 130/40 kV station in Sweden



Remote I/O communicating via 61850-9-2

All functions realised in two redundant central real-time PCs

Configuration of functions for tripping via User Interface

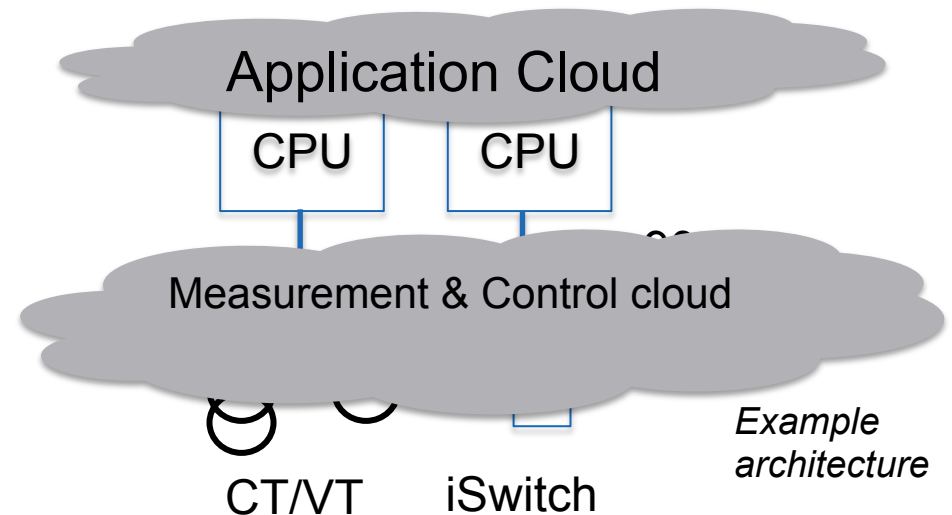


Johnsson, A. ; Söderström, J.E. ; Norberg, P. ; Fogelberg, A.  
Standard platform for integrated soft protection and control  
Innovative Smart Grid Technologies Conference Europe (ISGT Europe), 2010 IEEE PES



# Centralised protection, XUJI China (2012)

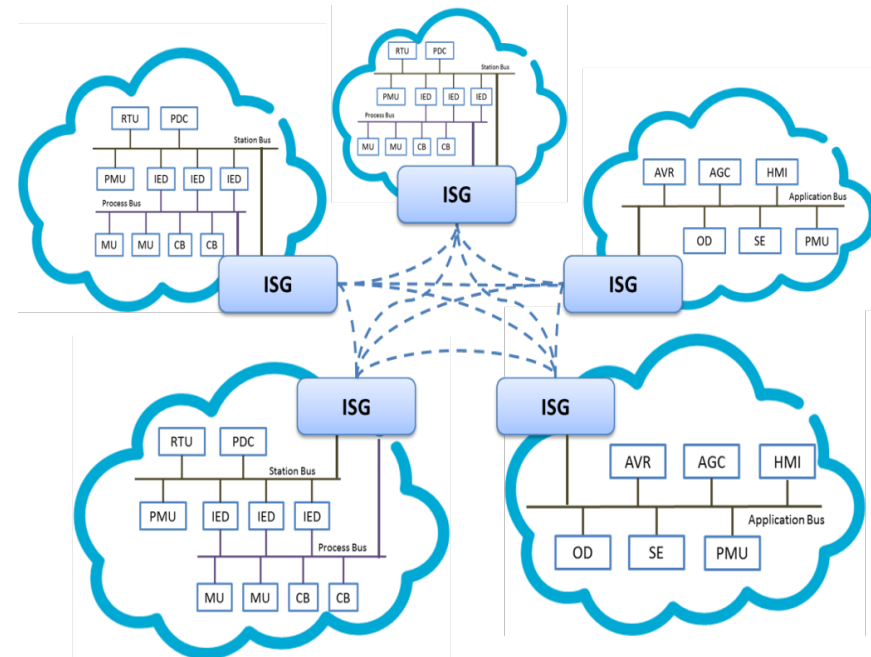
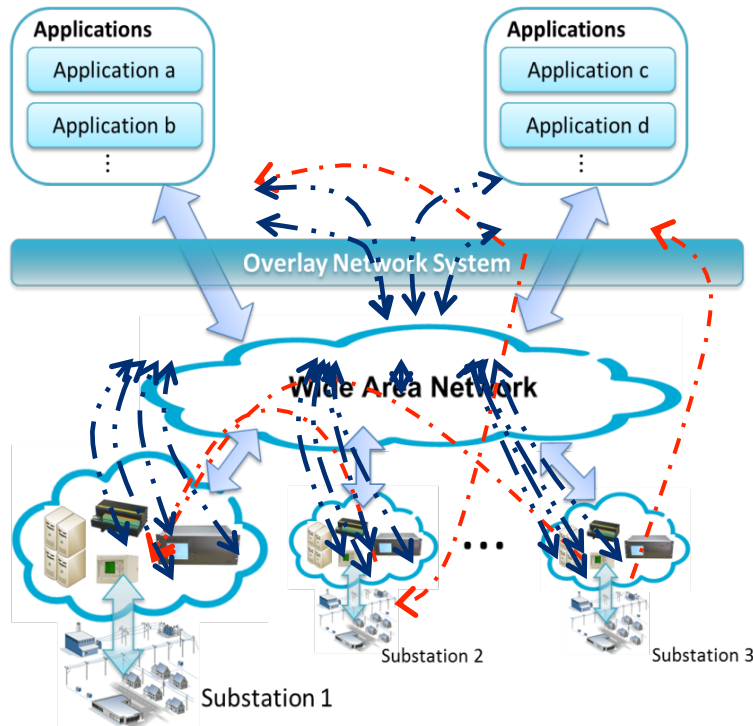
220kV substation in Chaoyang City China, equipment by XUJI  
Centralized protection system, using non-conventional CT/VT



Courtesy: Zhanpeng Shi, ABB Substation Automation Products, Västerås

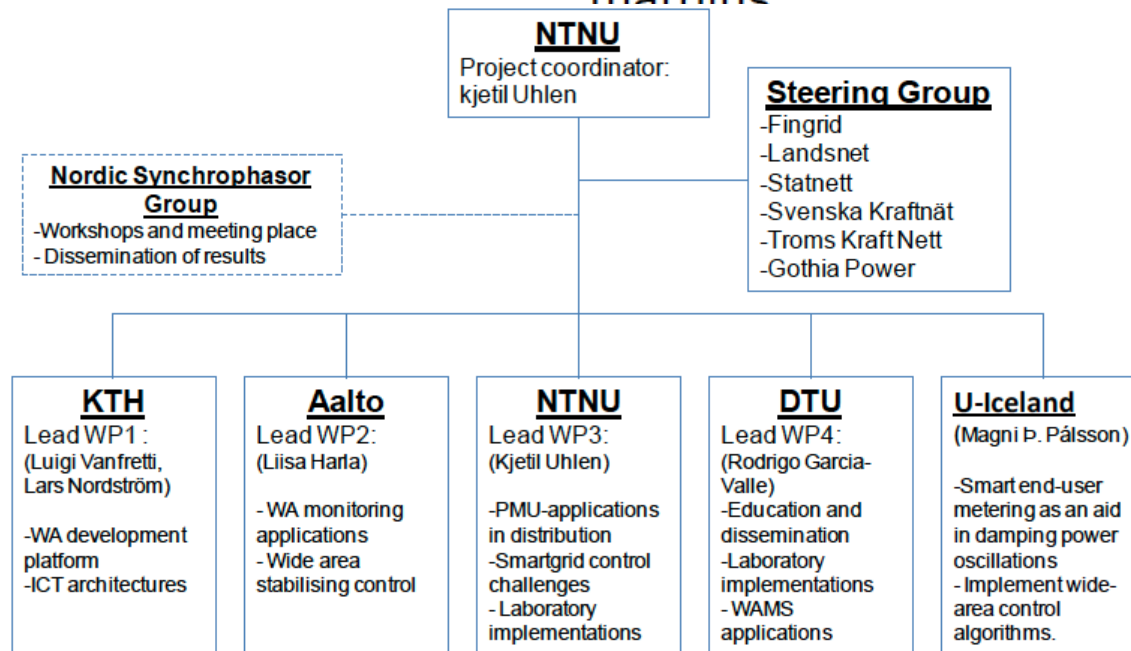
## Stretching the limits even further?

# Peer-to-Peer Architecture





- Develop innovative applications that will enable operation and control of the Nordic power grid more reliably and with better information about security margins



firm comprised by a power  
ware and hardware labs),  
ed software.

interfaces allowing PMU-  
ment, and implementation.



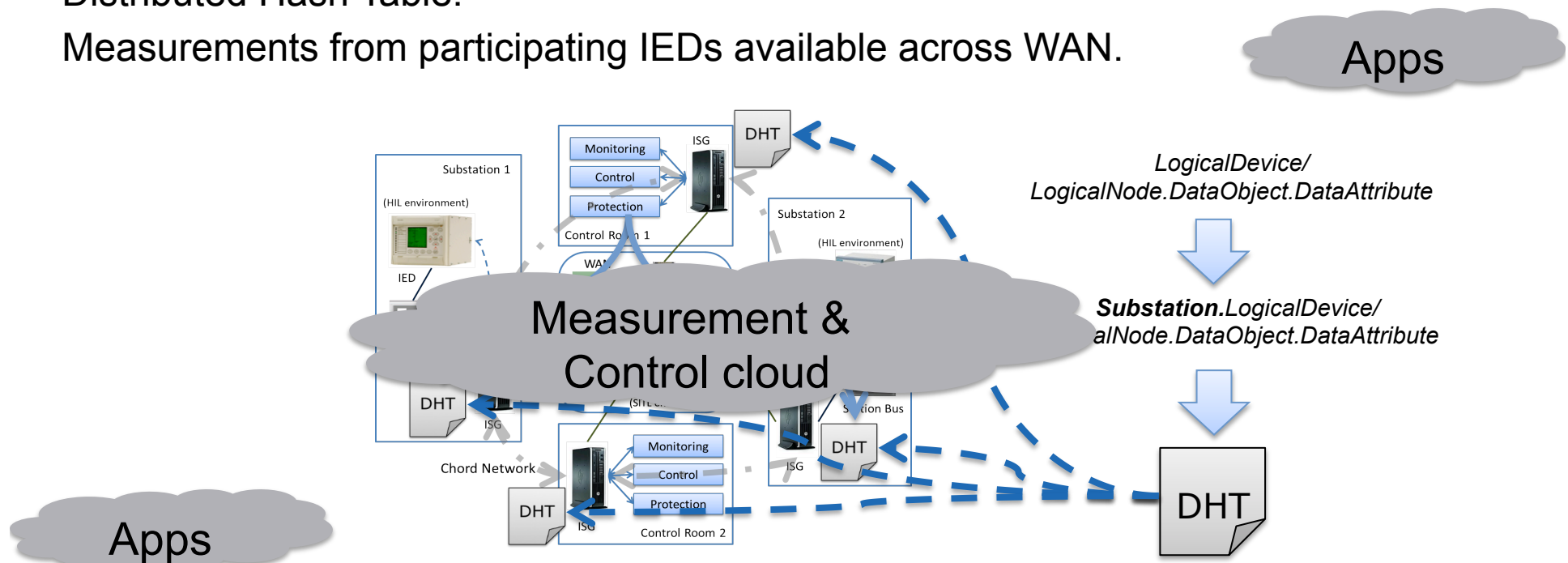
## Finding the data

# DHT for 61850 access across WANs

Available measurements (Logical Nodes) at a participating IED is registered in Peer to Peer network

Local Substation router (Intelligent Gateway) shares data, look-up made via Distributed Hash Table.

Measurements from participating IEDs available across WAN.



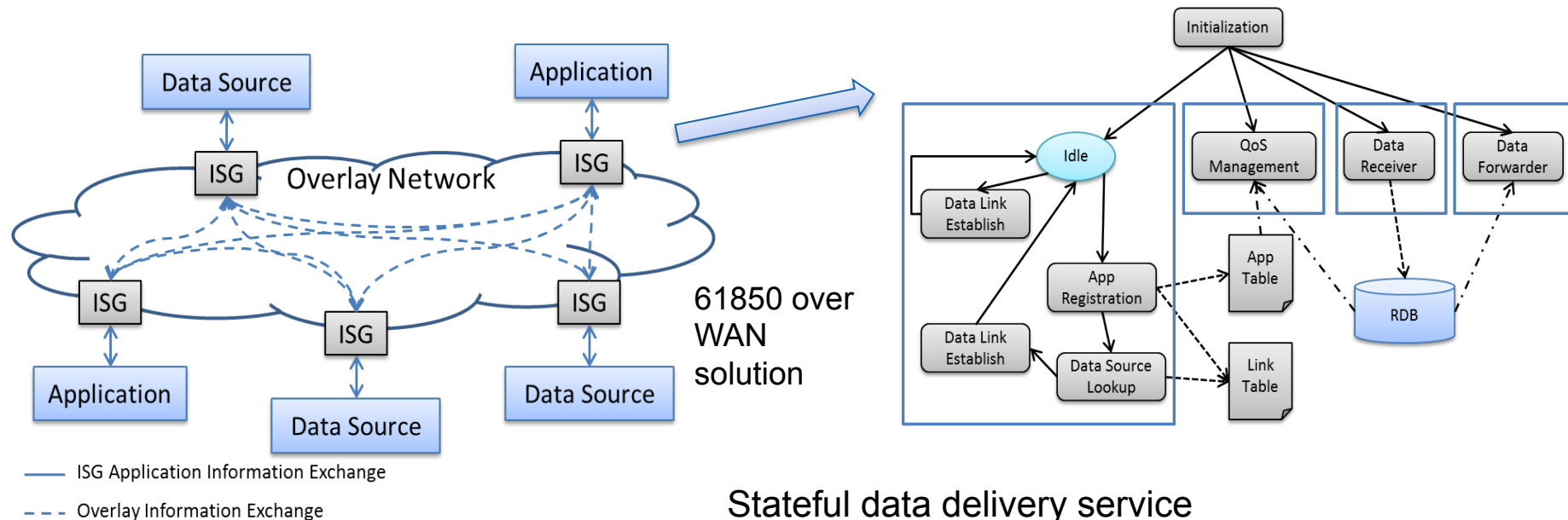
Yiming, W, A. Saleem, Nordström L.

IEC61850 Logical Node Lookup Service Using Distributed Hash Table Innovative Smart Grid Technologies Conference Europe, 2014 IEEE PES



# Getting the data securely across Stateful Data Delivery Service

- Application interface – Stateful Data Delivery Service



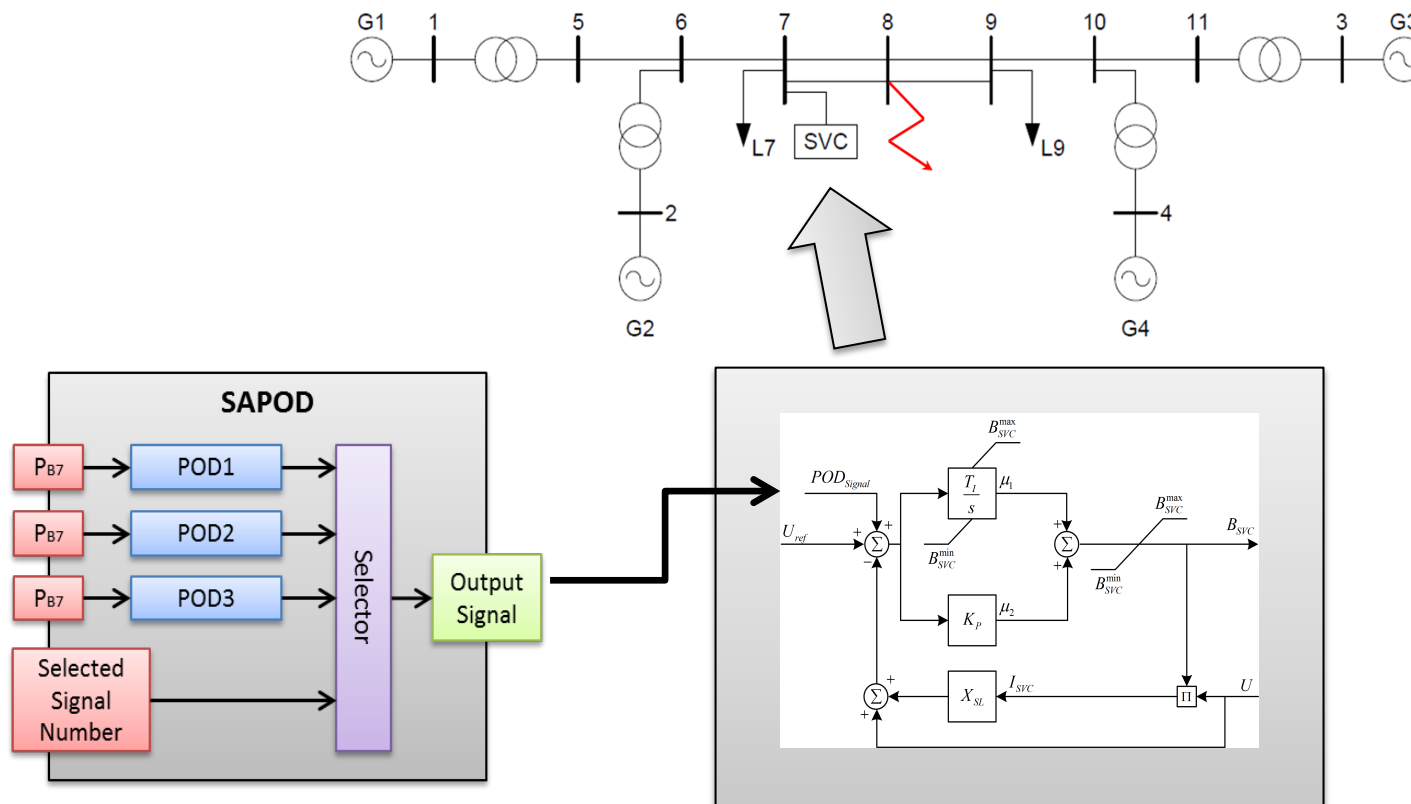
## Stateful data delivery service

- Application QoS requirement register
- QoS online monitoring
- QoS guarantee to the application



# Stateful Data Delivery Service

- Application interface – Stateful Data Delivery Service

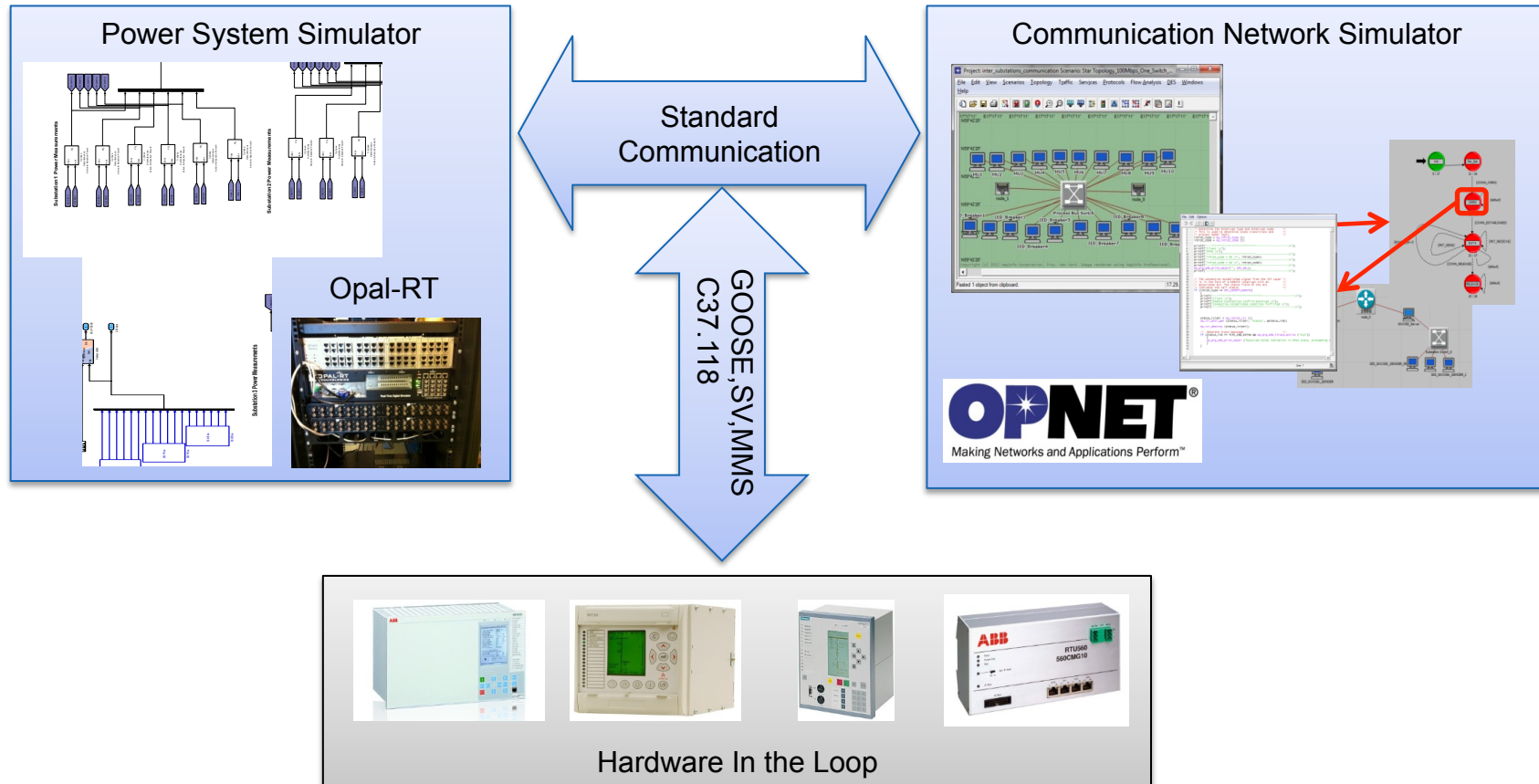


Yiming, W, Babazadeh B., Nordström L. "Stateful Datadelivery service for Wide Area monitoring adn control applications" Submitted to ToSG – Workshop on Trustworthiness of the Smartgrid,, Atlanta, Georgia, USA June 2014.





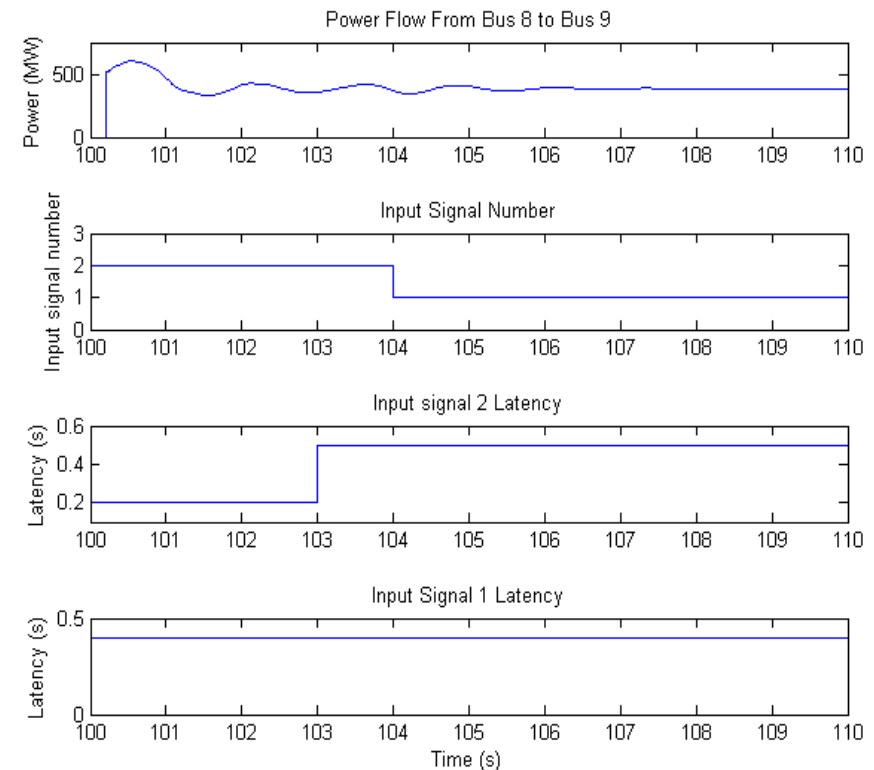
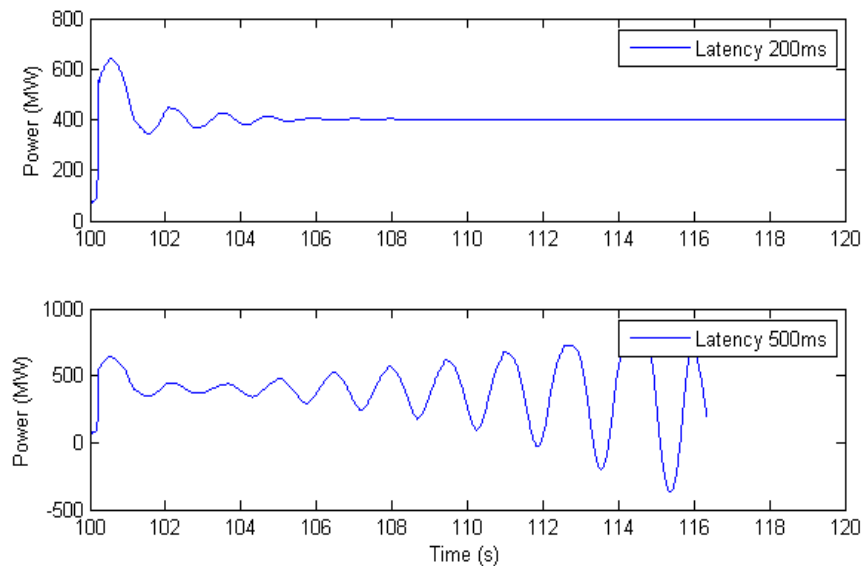
# Laboratory Test platform





# Managing system stability

- SDDS reaction to communication latency increase





## Summary

Substation Automation Clouds is of course a buzzword

Development towards more open systems is speeding up thanks to the 61850 standard

Justifiable concerns can still be raised, some technical, some business, some human

The human requirements must be challenged via R&D&D



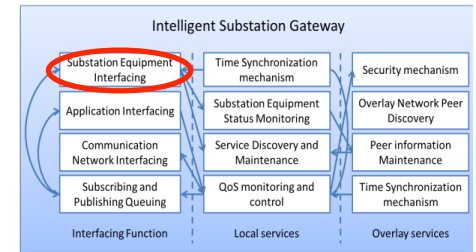
**Thank you**  
**Questions & Comments**

[larsno@kth.se](mailto:larsno@kth.se)

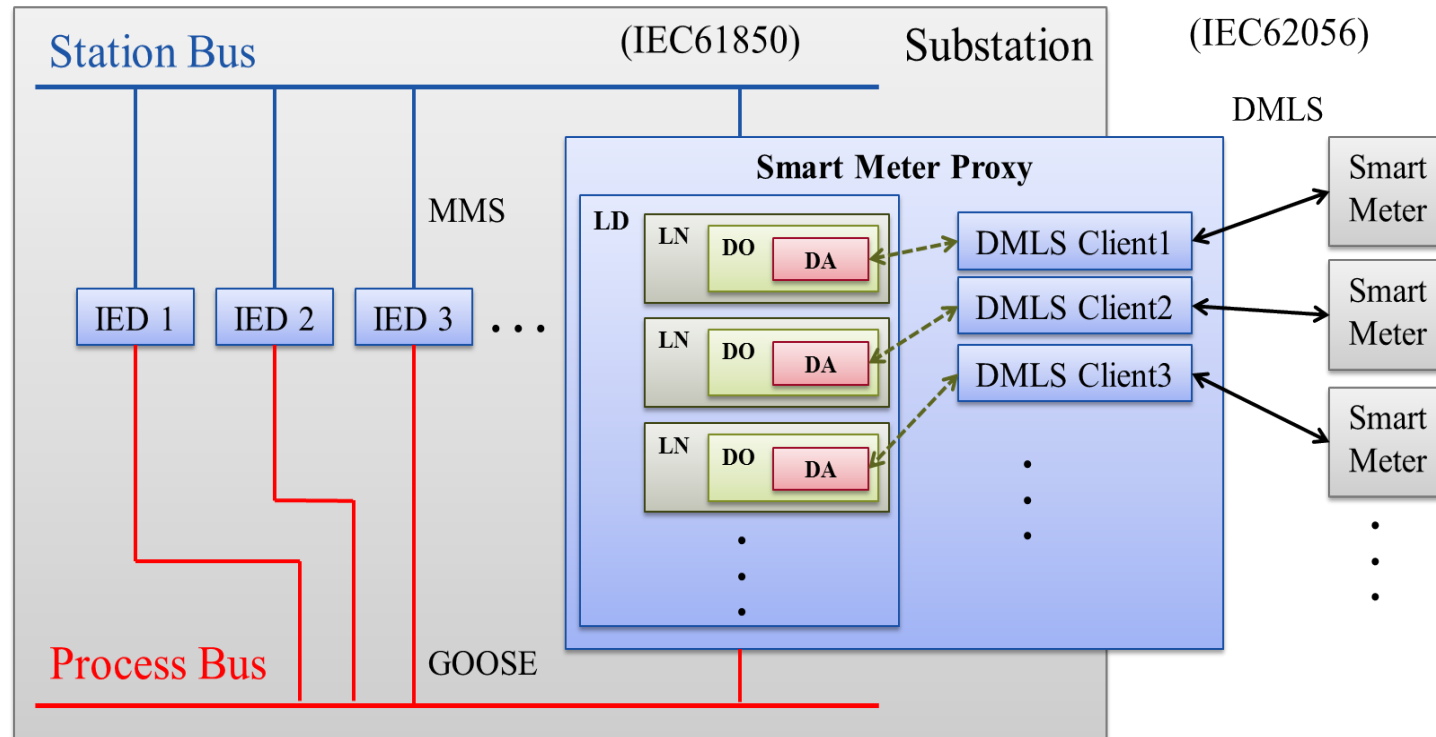


# Ongoing Work - Development

## IEC61850 interface – Smart Meter Data Sharing



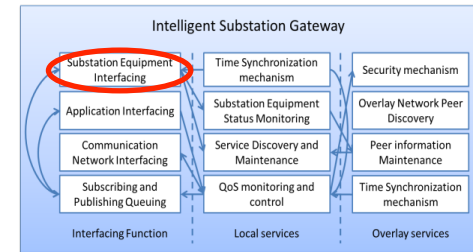
- Stateful Data Delivery Service
- Smart Meter Data Sharing
- IEC61850 mapping to IEC6056





# Achieved so far - Scientific

## IEC61850 interface – GOOSE across WAN



- GOOSE across WAN
- DHT for Logical Node Lookup Service
- IEC61850 for MAS Application
- IEC61850 Substation case study

