MANCHESTER 1824

The University of Manchester

Substation Communication Architectures and Intelligent Solutions

Shangdong Symposium, Jinan **18 May 2015**

Dr. Haiyu Li

Manchester University, UK

In The Same Wavelength Thinking?

Reliability of 0.9999?

Gaps ?

Of course, we can, e.g. data for internet banking more > 0.9999

Private/dedicate networks are good for critical time applications, but far too costly for 0.9999

Main objective:
- Advancing technology to increase services & retain customers

Applications:
- Voice
- Data
- Computers
- Internet

Communication Engineer

Main objective:
- Delivery power reliably and efficiently

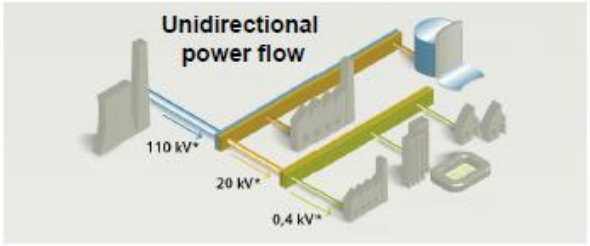
Applications:
- Fast response for P&C, self healing
- Relatively slow response for planning, operation and tele-control, voice, data

Power Engineer

Evolution of Power Grids

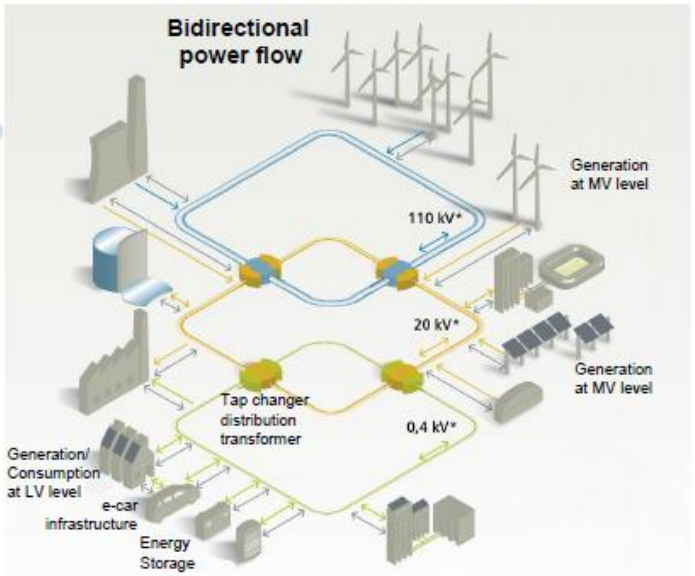
- AC or DC ? -> Reduce loss for efficiency transmission ?
- Integration of low carbon technology (LCTs), -> needs high level of automations and controls for better energy utilisation & efficiency

Today



- ❑ Radial system
- ❑ Simple protection
- ❑ Simple or no automation
- ❑ Simple or no communication

Tomorrow

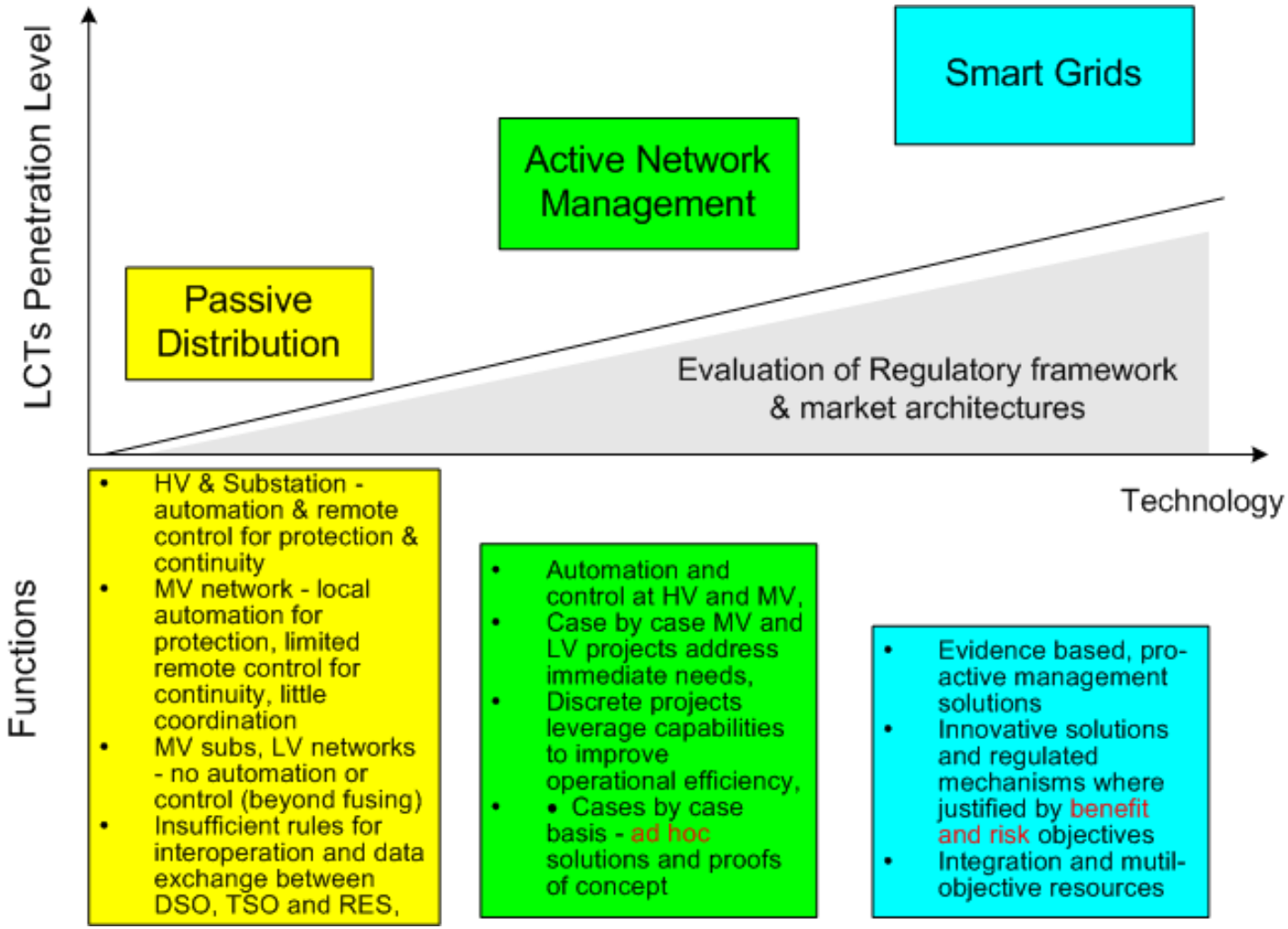


- ❑ Meshed system
- ❑ Adaptive protection
- ❑ High automation degree
- ❑ Bidirectional communication

Smart Grids?

Picture Source: Siemens AG 2013 from IntelliSub Europe, Nov 2013

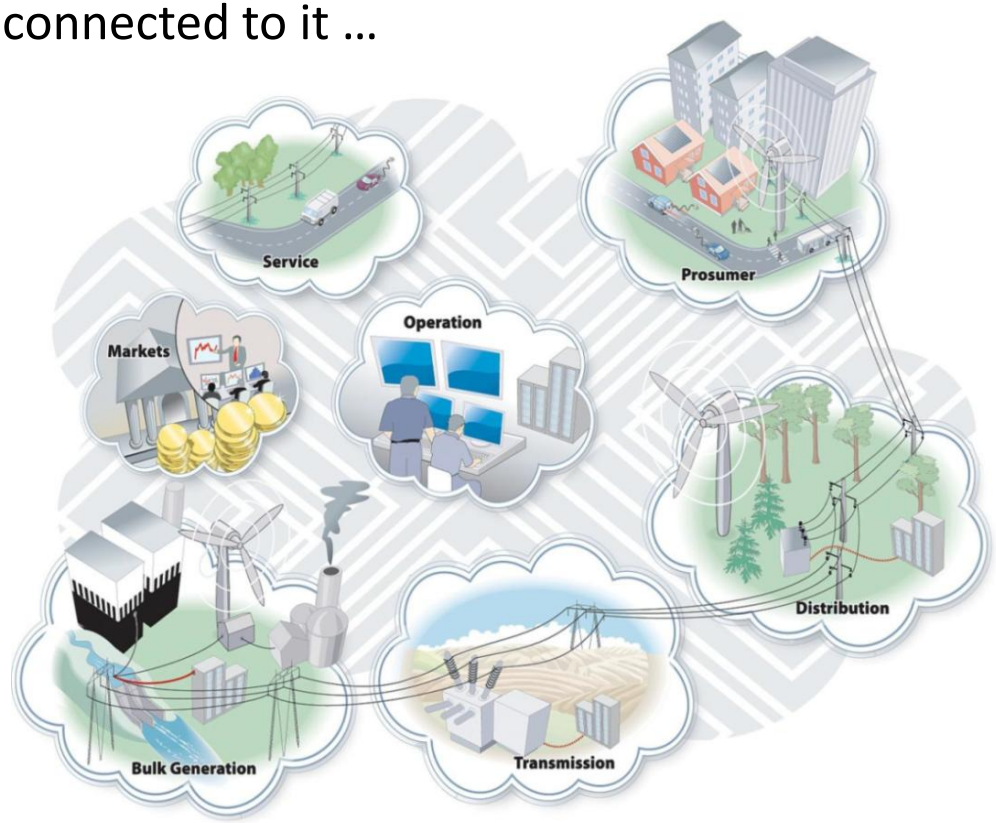
What Smart Grids Can Offer?



Source with editing : IntelliSub Europe, Nov 2013

Smart Grids = ICT + Power ?

The integration of kW/MW and kBit/Mbits to make the electricity networks that can cost efficiently integration of low carbon technology (LCT) as well as actions of all users connected to it …



How?

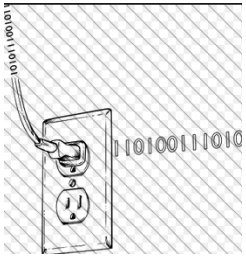
Picture Source: ISGT Europe 2010 Panel Session (PN 1): "Standards for Smart Grid"

Communications and IT Technology

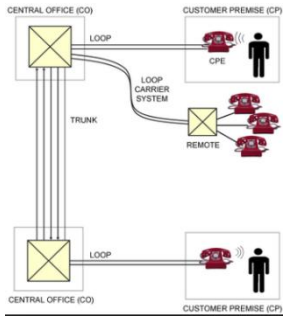
Link/media technology

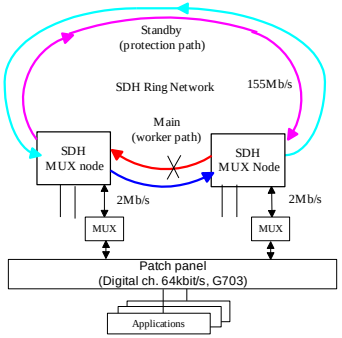


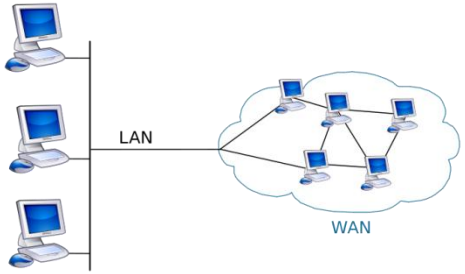




Networks and integration of telecom technology (ICT)







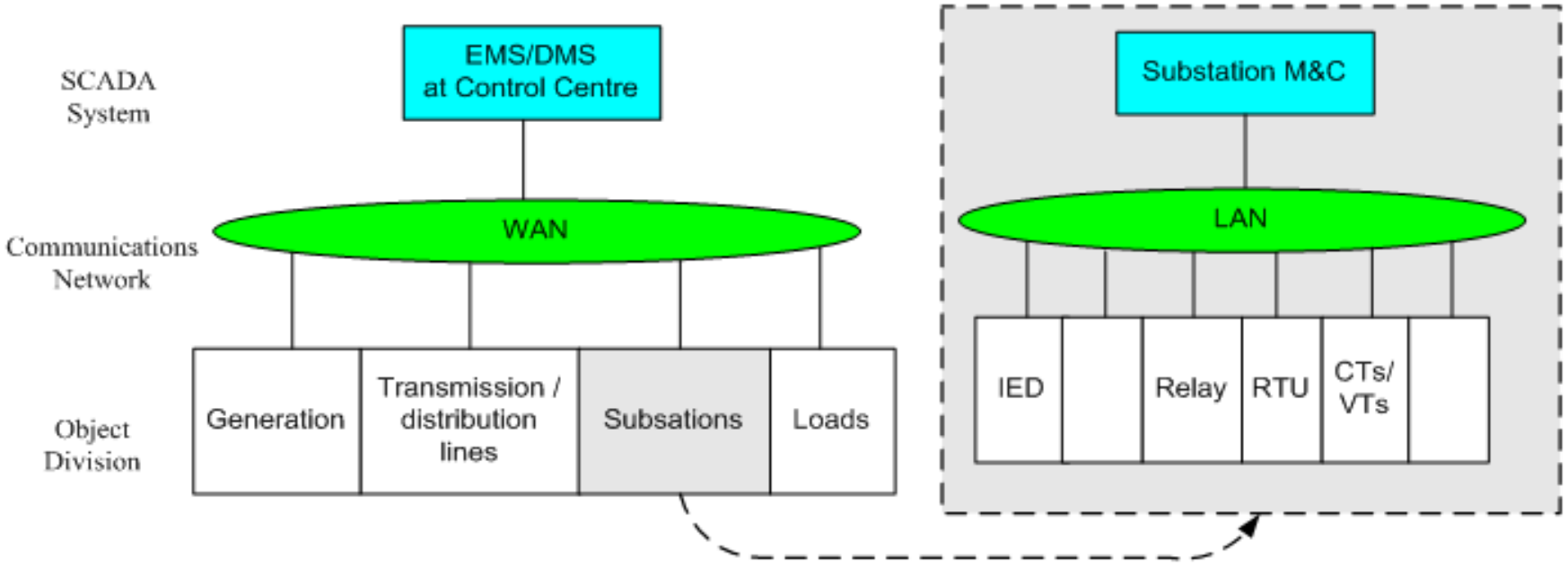
Networking - P to P

Networking - LAN and WAN

Integrated Services

Basic Topology of Power SCADA

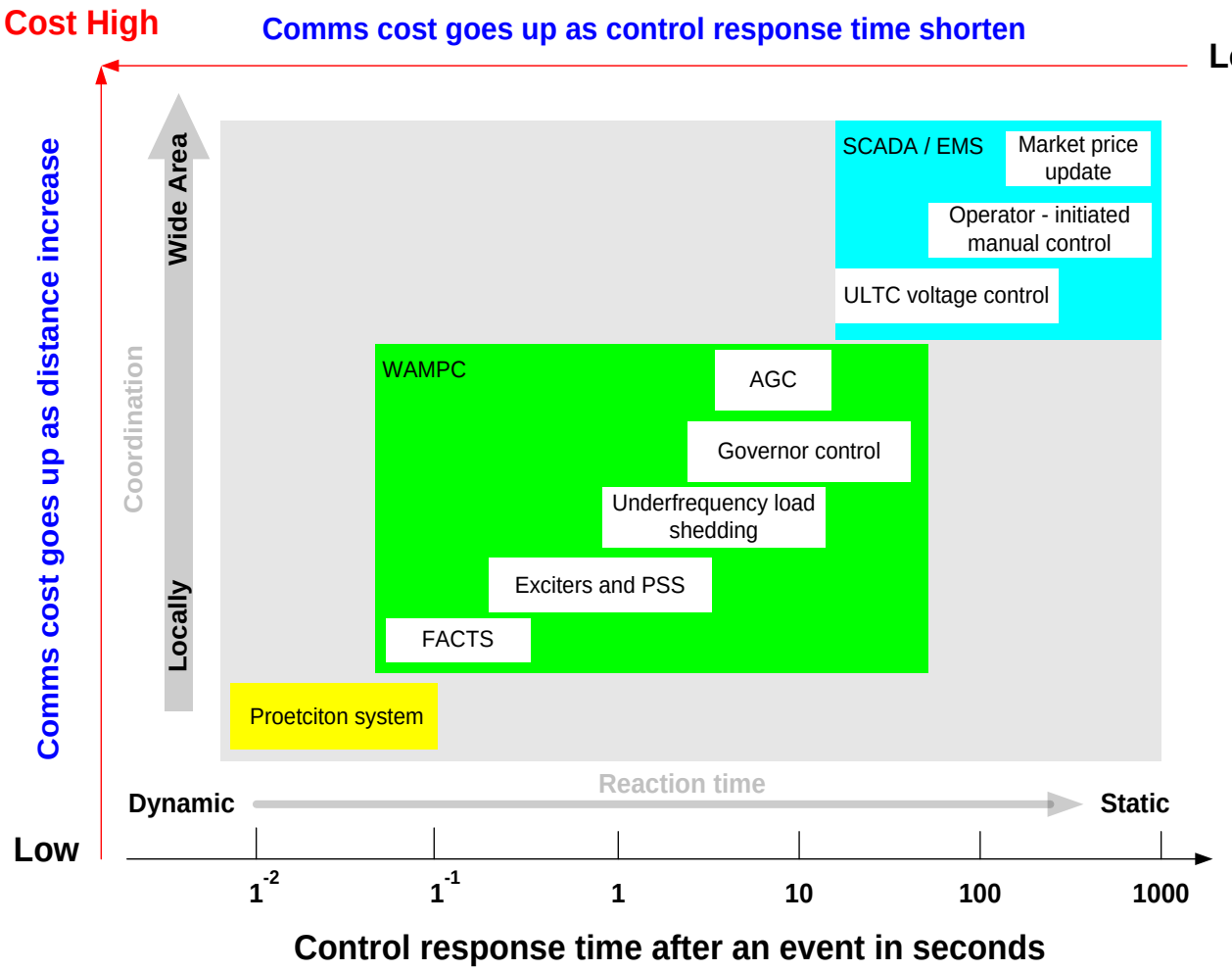
- Different ad-hoc topologies of SCADA systems exist today, but below is the most common topology of SCADA.



- Object Division
- Communications Networks
- SCADA Systems

Latency Times vs Economics

Cost: a function of response time vs the distance of the communication



How much do we need for communication to implement each of these functions?

Affordability for not core business?

Different Business Priority

Telecommunication Operators

Users: Voice and data

Market: Vast – more money

Latency response time:

- Voice - real time < 500ms
- Data - happy with seconds

Transmission Reliability:

- Voice - less importance
- Data - very important

Development Priority

- Connectivity to customers -> i.e. more asset of copper and fibre to reach customers
- Multiple services -> Attracting more customers
- Quality of service -> Retain customers

Power Operators

Users: (i) P&C of power equipment
(ii) Voice and data

Market: Power comms – less money

Latency response time

- Power equipment P&C – Vary from 10th ms to seconds,
- Voice – happy with < 500ms
- Telecontrol & data: happy with seconds

Reliability

- P&C, self healing – extremely important
- Voice & Data - also very important

Development Priority

- Power delivery - reliability
- Power delivery - efficiency
- Power delivery – availability, reduced outages during install/replace

How to Bridge the Gaps?

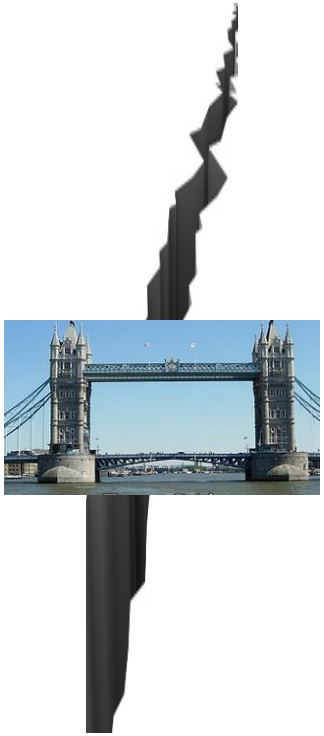
Telecommunication and IT Engineers

Liberal Thinking for Reasons

- Core business – voice and data
- Short life cycle technology
- 21st century communications technology
- BT 21st Century Network, all in one switched packets for voice, video, data

- 21st Century internet technology
- Advanced mobile service from 1G to 4G and 5G on the way

Super confident people, who can delivery 21st ICT for any Smart Grids applications ?



?

How to bridge the gap

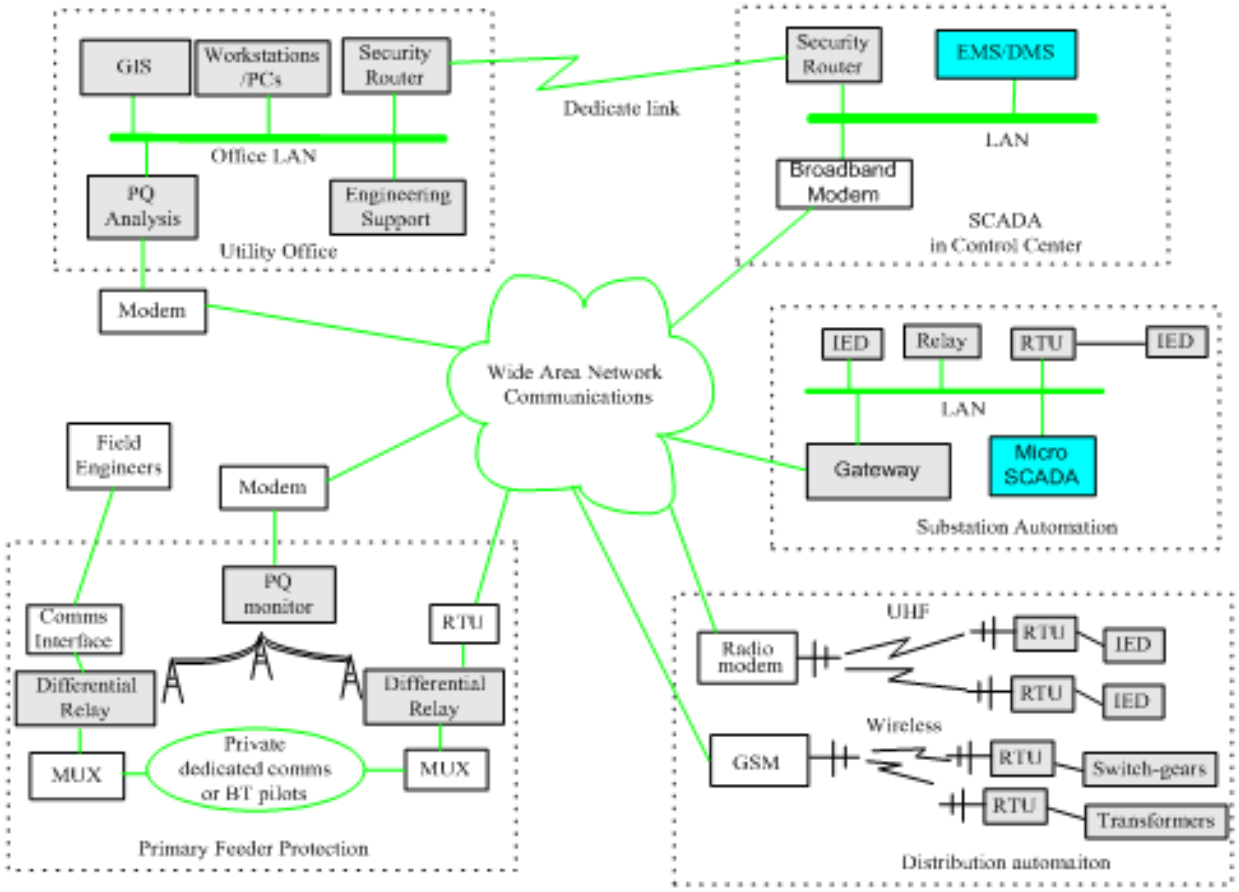
Power Engineers

Conservative Thinking for Reasons

- Core business -> Delivery power & Keep light on
- Main objective -> efficiency, reliability and availability
- Unsure reliability and security of comms cloud / internet,
- too complicate to understand new technology or any needs?
- Impact of short life cycle technology on long life power asset,
- Favour of building private network, but too expensive,
- All in one through a limited super high way comms networks without proper data flow management will make thing worse before getting better

Ad-Hoc Communications Today

Ad-hoc communication technology everywhere



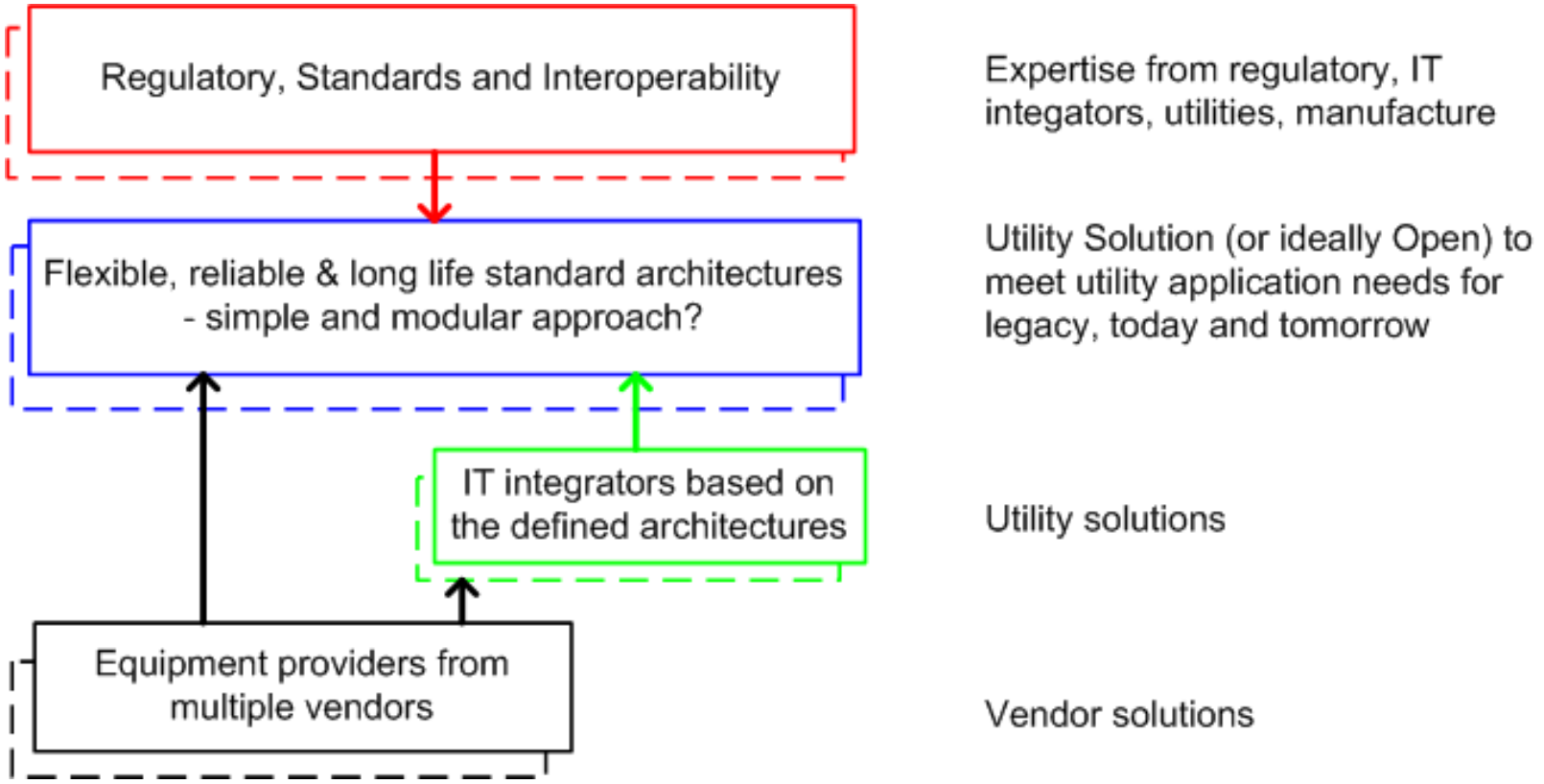
(i) Enterprise & office users, (ii) EMS/DMS center, (iii) P&C, (iv) substation and distribution automations

Definition of Roles for Simplicity

Assumption:

- To make collaboration efforts, need to define clear rules and roles for the simplicity

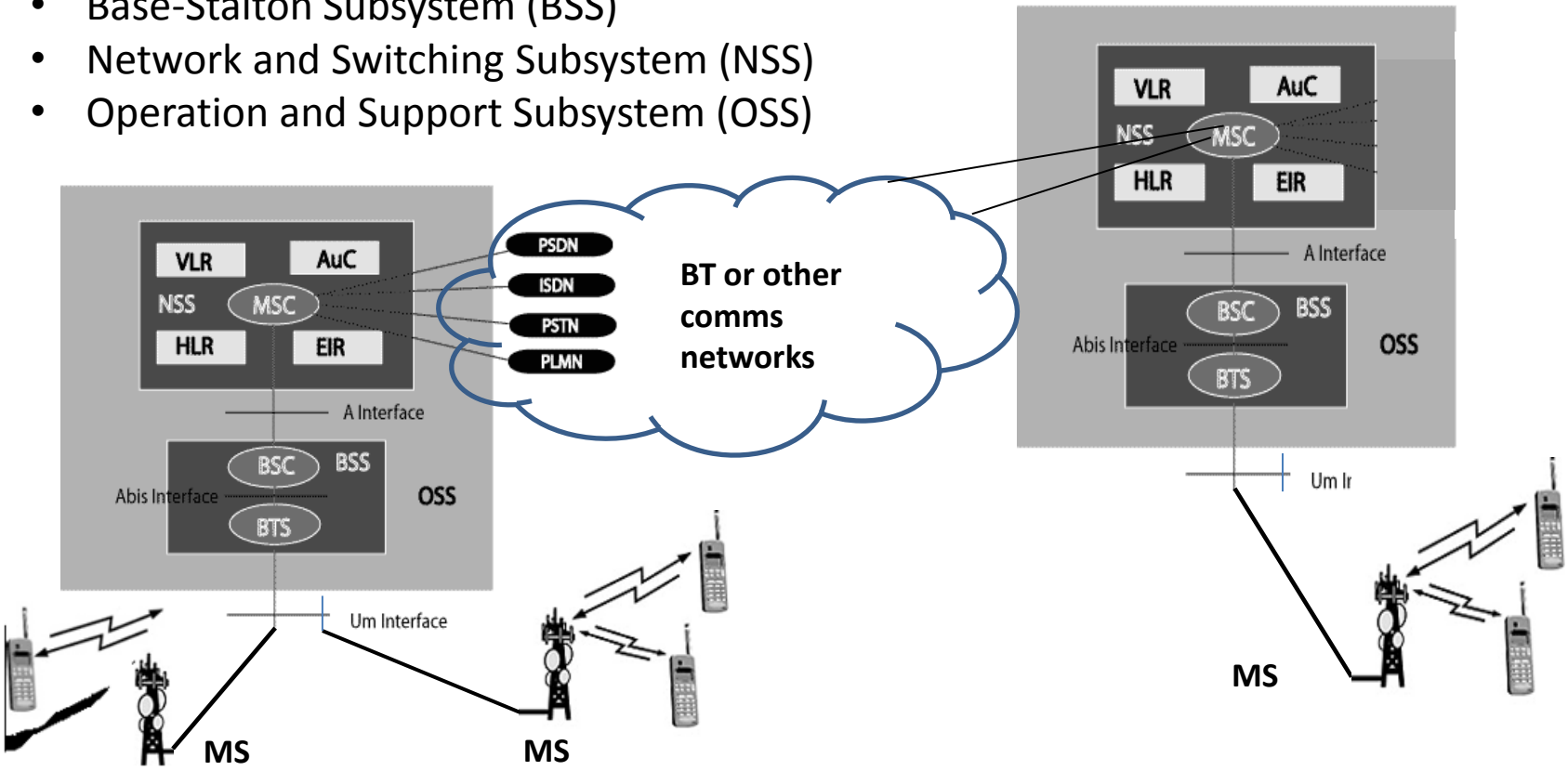
Proposed framework



GSM – Example

GSM architecture - Open and defined by the European Telecom Standard Institute (ETSI)

- Mobile staiton (MS)
- Base-Staiton Subsystem (BSS)
- Network and Switching Subsystem (NSS)
- Operation and Support Subsystem (OSS)



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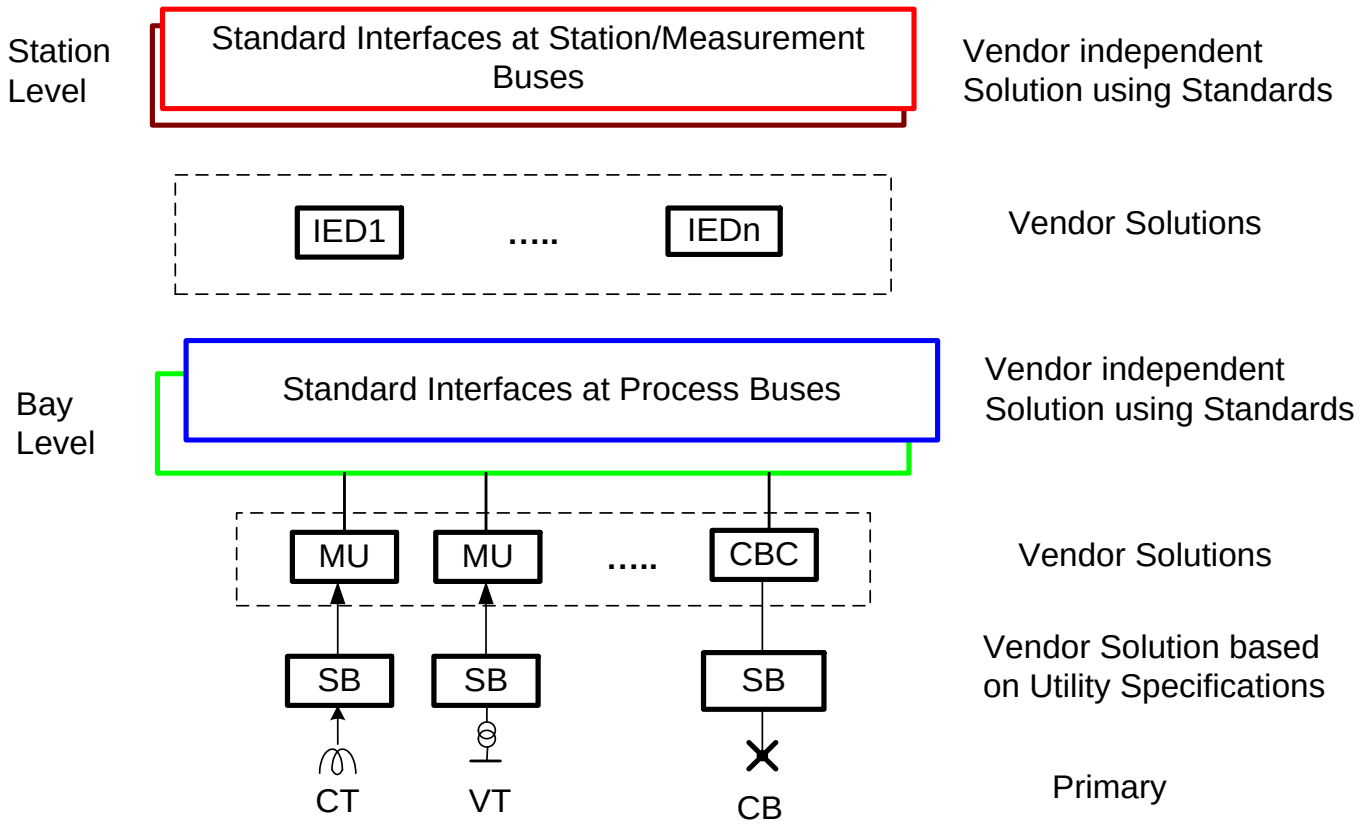
UK NG AS3 Project

- **Since April 2008, Manchester has completed design of digital substation architecture based on IEC61850 for NG AS3 Project**

Key elements	Aims & Benefits
IEC61850 Station Bus	➢ Vender Interoperability (Bay) for future sub extension
Standard Bay Solutions	➢ Re-use of proven designs to reduce risk, cost & delivery time,
IEC61850 Process Bus	➢ Plug & Play" install/replace to reduce system access ➢ Vender Interoperability & Inter-changeability (MUs & IEDs) to efficiently manage obsolescence & cut PDSA cost ➢ Fibre optical connections to reduce EMC requirements
Standard I/O Interface Using switch box	➢ long-lasting/future proof ➢ Enabling pre-outage installations to reduce outage period

Architecture Design Criteria

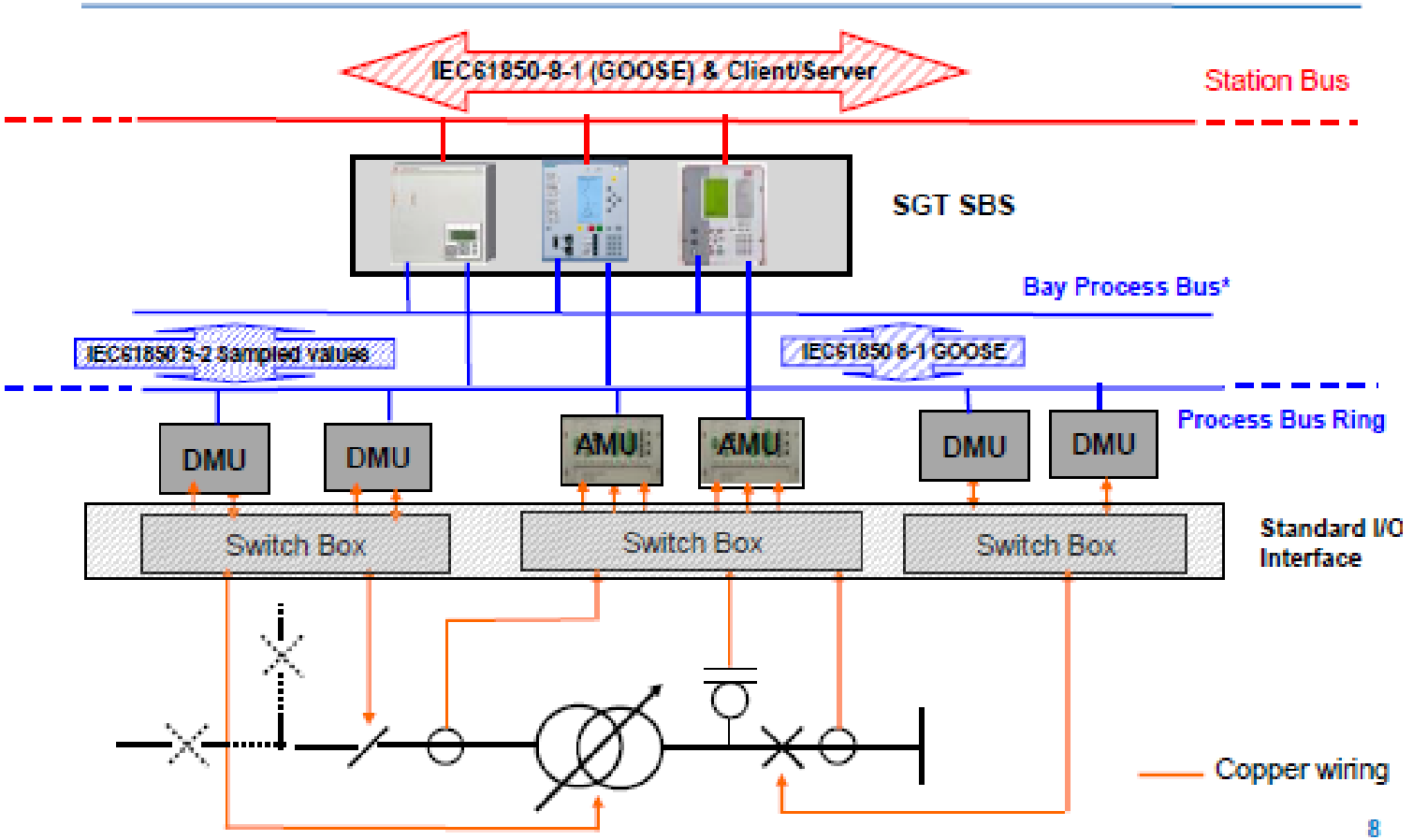
- **Standards Available: IEC61850 (sub), IEC60870 -part 5 (telecontrol), ….**
- **Design Architectures by Utilities or International Standard Organisations -> Open**



IED: Intelligent Electronic Device, MU: Merging Unit, CBC: Circuit Breaker Circuit, SB: Switch Box,

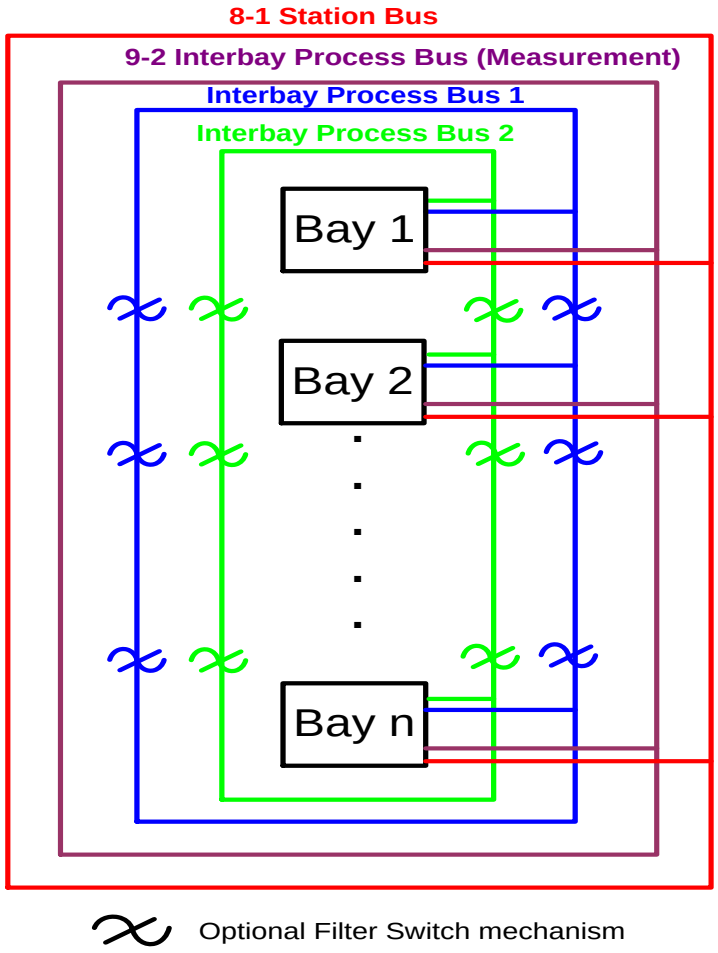
Bay View Down to Equip & Wire

Super Grid Transformer (SGT) Bay



Generic Process Bus Architecture

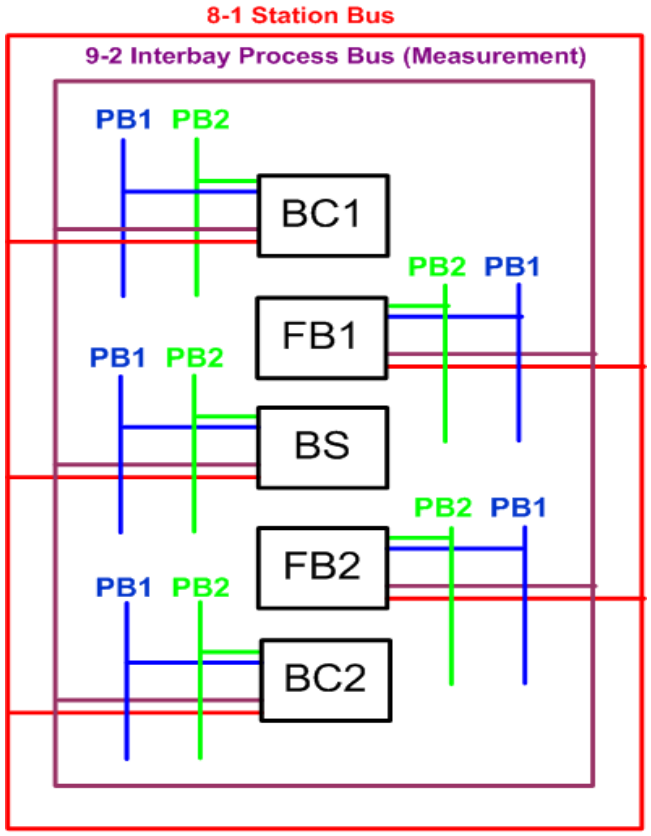
High level view of the concept for bays to connect network



- Based on gold rules,
- R&D on reliability assessment & whole life value,
- Clear and better data flow management, e.g. 9-2 (SV), 8-1(GOSSE) to Ethernet, 8-1 (GOOSE) to MMS, Client-Server, GSSE,

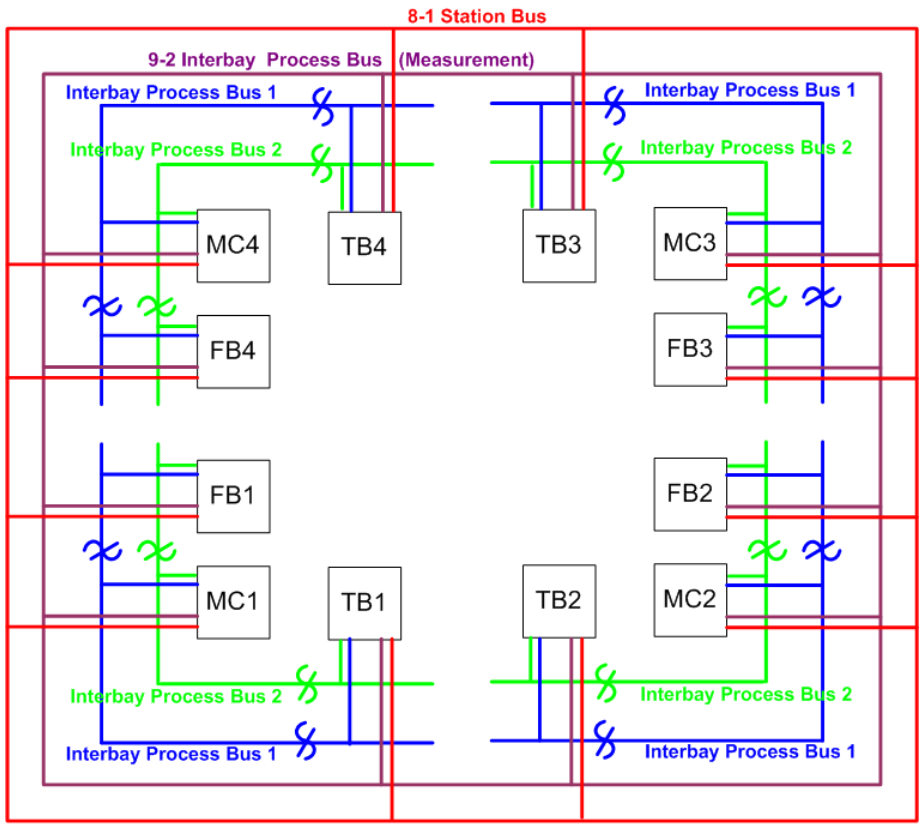
Architecture Applications

Double Busbar sub Architecture



BC: Bus Coupler Bay FB: Feeder Bay
BS: Bus Section Bay PB: Bay Process Bus

Mesh Corner sub architecture

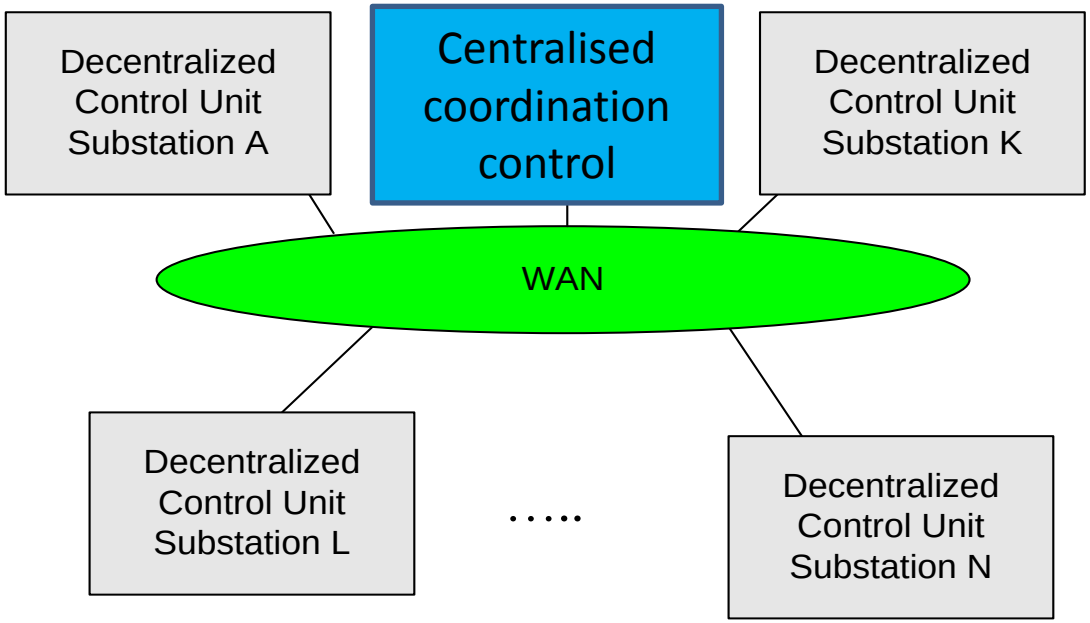


Filter Switch mechanism (Optional) MC: Mesh Corner Bay FB: Feeder Bay TB: Transformer Bay

Why Intelligence?

- Since exiting WAN/Internet has difficulty to meet the fast time response applications, e.g. P&C, some critical self heating functions due to longer latency for reliable and very secure links
- Since private/dedicate links or WAN are to expensive to implement, operation and maintain, especially to DSO due to too many lines and substations

Proposed architecture: Local intelligence + Centralized co-ordination



Conclusions

(1) Flexible and long life architecture & simplified interface

- Concern impact of short life of comms asset (5-10Years) on long life power asset (40-50years)
- Concern the impact of introducing new smart grid technology on longer power outages to install/replace
- Not a single organise can do everything, even it can, it will prevent innovation & multiple vendor solutions
- Expensive post delivery support (obsolescence parts/ spares, fast technology change, shortage of knowledge & expertise)

(2) Local intelligence & centralised coordination architecture

- Everywhere super highway or high speed comms is expensive,
- Short time latency requirement (< 20ms?) by main protection and control.

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Thank You!

Questions?

Dr Haiyu Li (Manchester University)

haiyu.li@manchester.ac.uk

Tel: +44-161-3064694, mob: +44 7775024526