
# OpenPMU

Open Source Phasor Measurement Unit

## Experience and Lessons from Operating PMUs in Distribution Networks

**(NASPI Webinar)**

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# Distribution PMUs versus Transmission PMUs

On the face of it, there should be no differences between a PMU in a distribution network and a transmission network, the measurement process is the same...?

Distribution transformer might have:

1) No space for a PMU
2) No telecoms
3) No view of the sky
4) Heavily distorted voltage / current

Depending on the location, distribution PMUs experience widely varying harmonic content throughout the day.

# Distribution PMUs versus Transmission PMUs

The typical transmission PMU likes a warm and cosy 19” rack.

- UPS power
- GPS with clear view of the sky
- Perfect Ethernet / IP telecoms
- Operates with a managed PDC
- Nice and clean voltages / currents

# Distribution PMUs versus Transmission PMUs

**Opinion:**

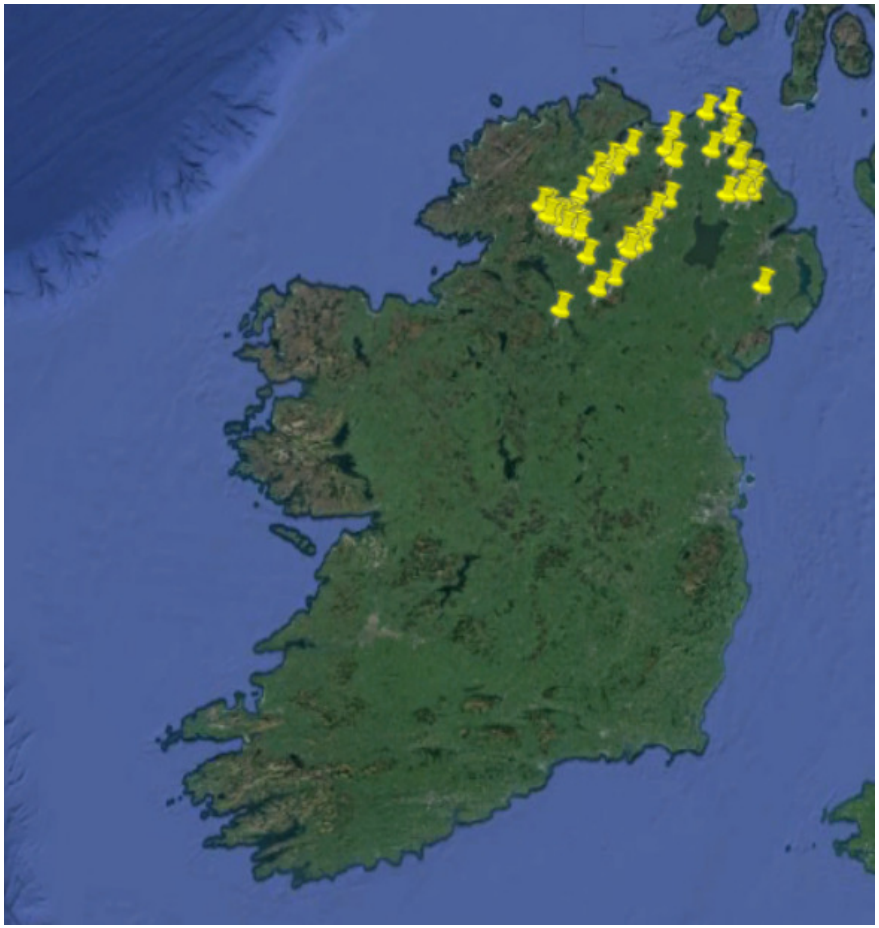
Most PMUs on the market are completely unreliable whenever their power is interrupted or the telecoms are imperfect.


They have such bad security practices, I wouldn't connect them in my home never mind critical national infrastructure (some have hard coded backdoors).

**Solutions:**

1) Patch up the mess we have with VPNs and middleware.
2) Fundamentally rethink the way PMUs communicate with their applications.

# Experiences in Ireland



Yellow pins are wind farms where PMUs may installed.

Many sites are on mountains with limited telecoms service, meaning wireless solutions such as WiMAX are required.

The telecoms are not 100% reliable.

C37.118.2 is insufficient, so the utility has used commercial Historian solution to provide a buffer.

The historian charges per value stored, so much of the synchrophasor data is discarded.

# Experiences in Ireland


The PMU equipment itself is:

1) Complex to configure (can't explain to an electrician over the phone)

2) Unreliable (hardware failures / software corruption)

3) Expensive

**If I knew then what I know now:**

I would never have even tried to get any commercial product to work. At the very minimum, I would have placed a PC adjacent to it to completely handle all Internet telecoms.

# Why build your own PMU?

The reality of PMU ownership

**Bad hardware**

**Bad software**

**Mystery algorithms**

**Poor reliability**

*Don't be fooled by the 5 figure price tag, some PMUs have about $100 of parts.*

*It's not the price that's the problem, it's that they don't work reliably.*

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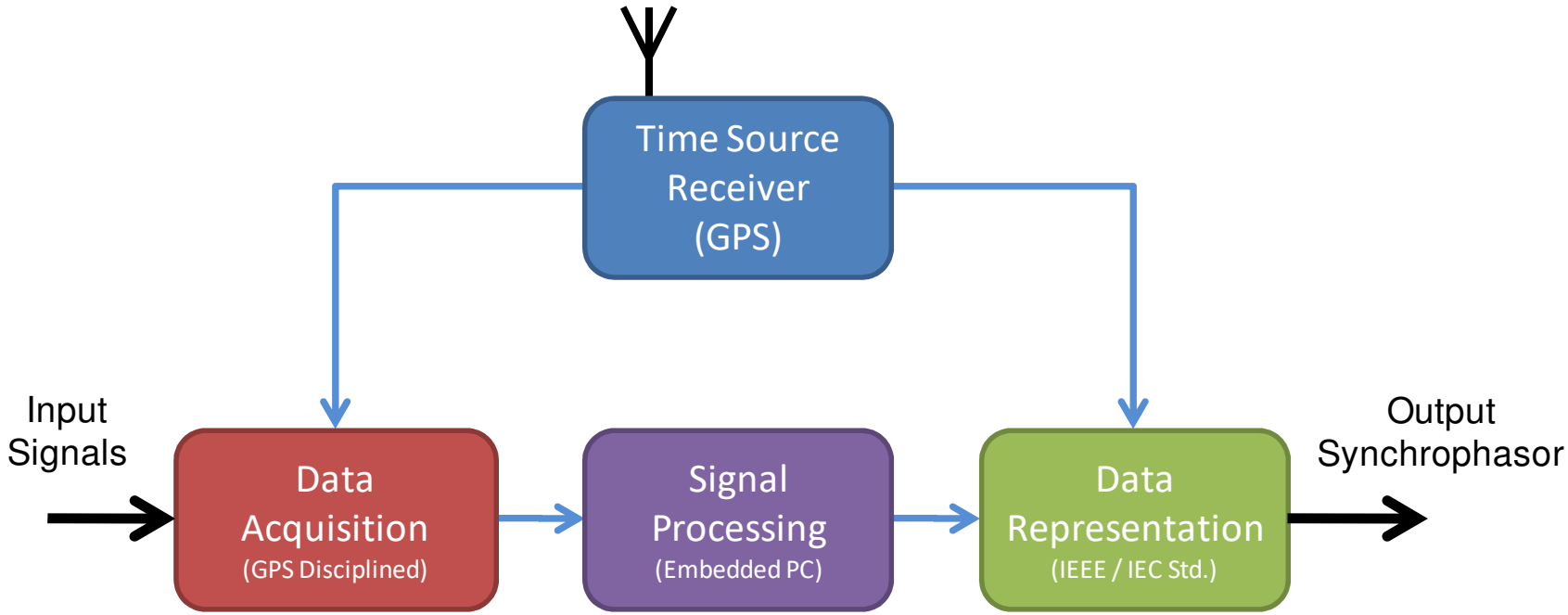
# PMU Basics




**Analogue**
Voltages
Currents

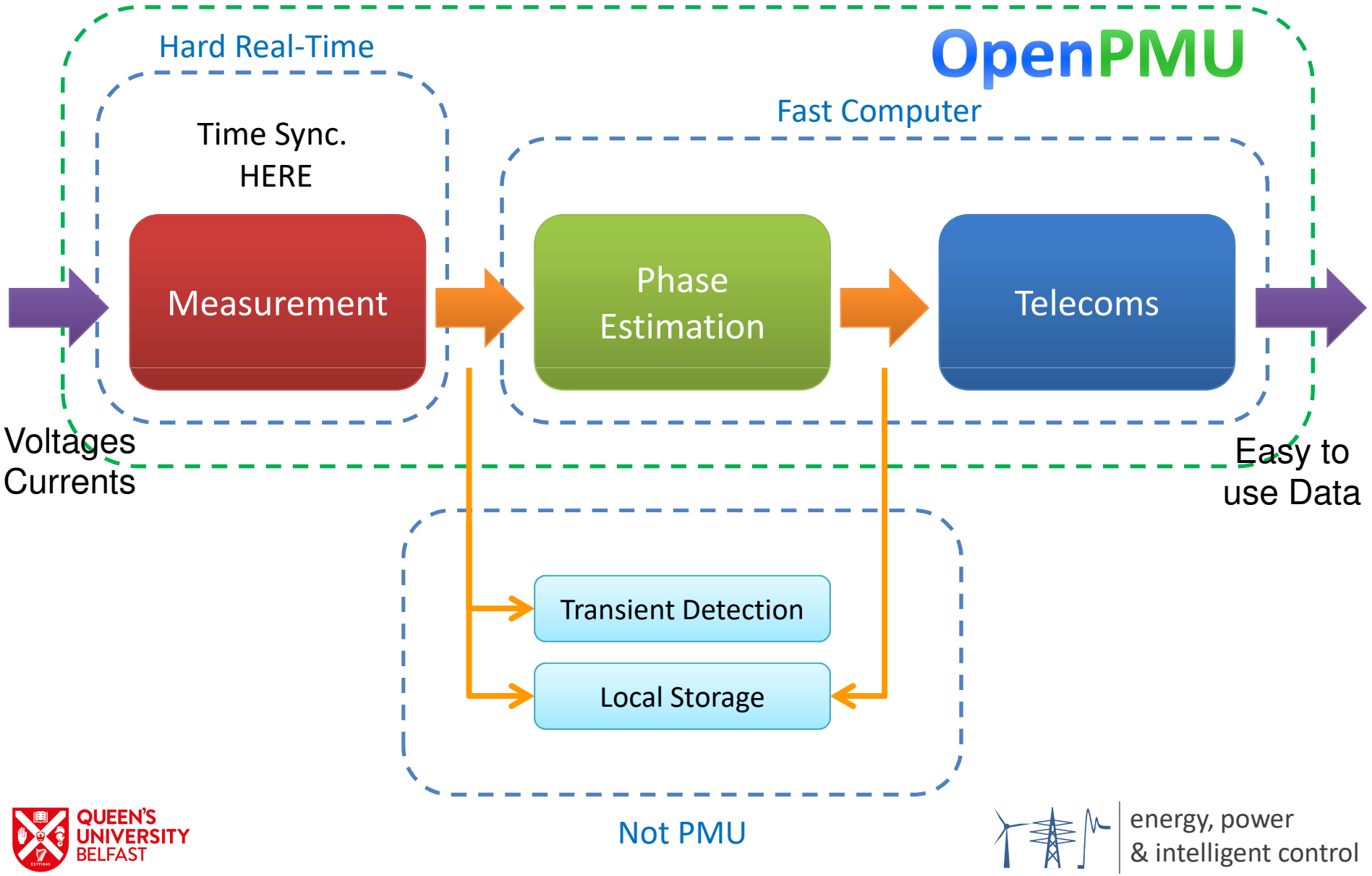
**Numerical**
Voltages
Currents
(Time coded)

**Estimated**
Phasors
(with Time Code)

**Application**
Hard Drive of
Perpetual Storage

Thorp , Phadke, Karimi 1985

# The OpenPMU Modular Design Philosophy

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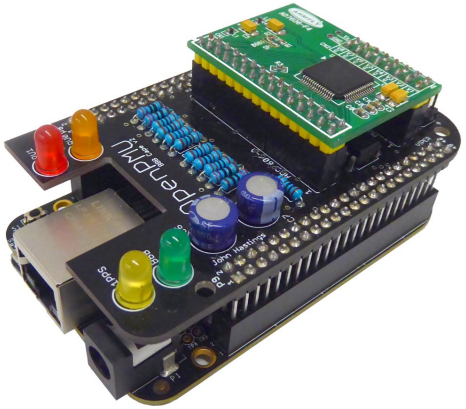
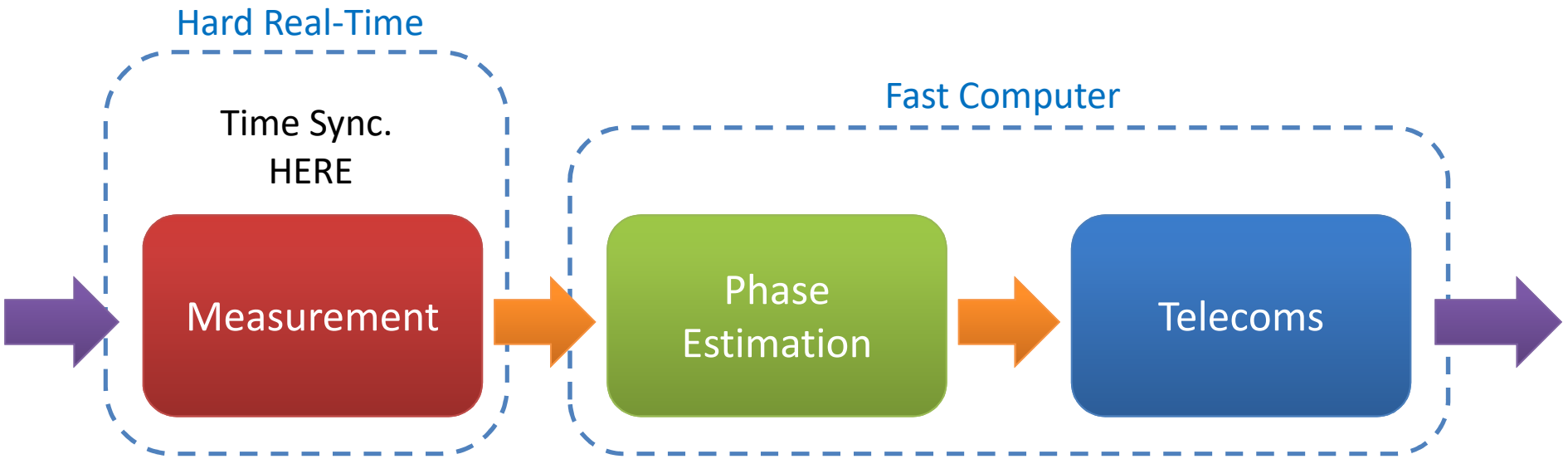
# The OpenPMU Modular Design Philosophy



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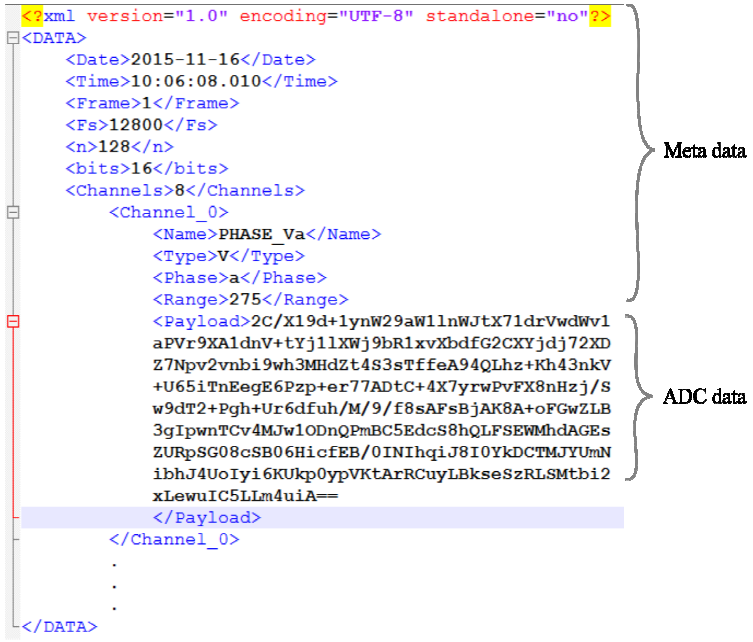
# Benefits of Modularisation

Modules have a defined interface and are hot swappable. IP is used for inter module communication.

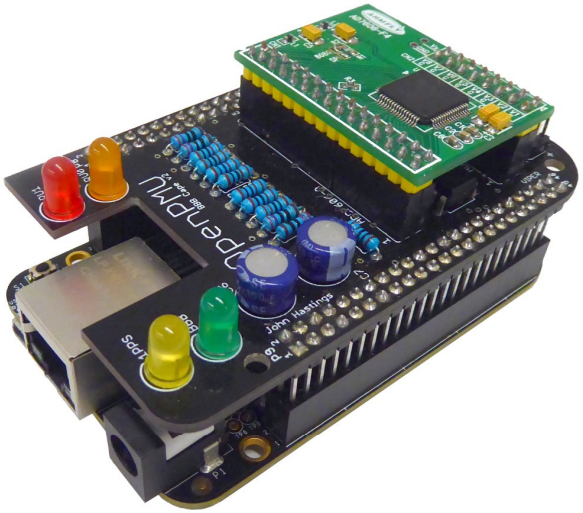
For example, a phase estimation algorithm can be swapped with no impact on the ADC or the Telecoms.

Sampled Values can come from hardware or simulation.

Software can run on anything from Raspberry Pi to Amazon Web Services.



# Phasor Estimation



11 Mbps

Sampled Data

Synchrophasors

100 kbps

```
{
        "utc":1489527568.02,
        "freq":50.0169,
        "pmuid":"QUB020",
        "phasors":[
                {“id”:“Va”, “mag”:230, “ang”:0}
        ]
}
```

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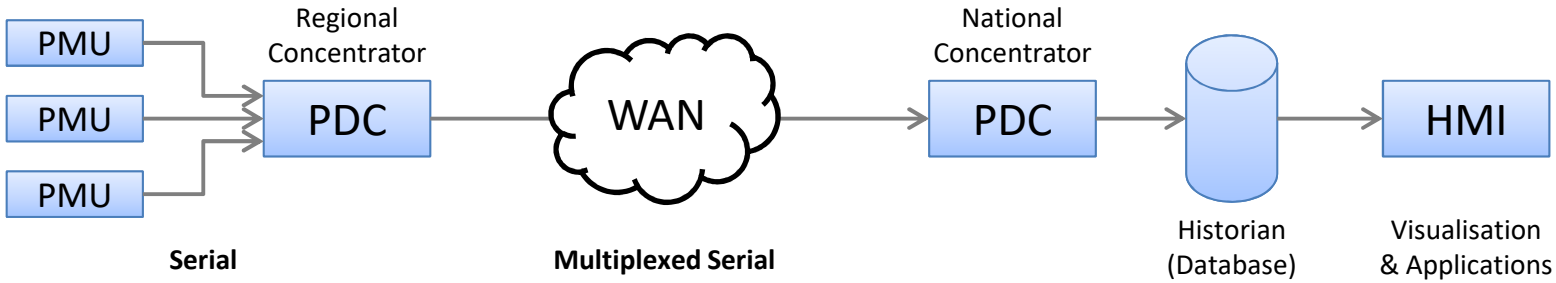
# PMU Telecoms



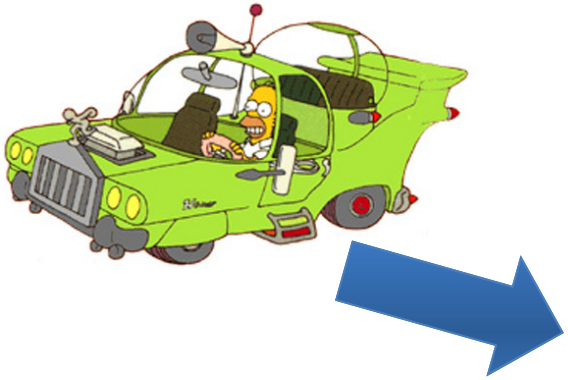

C37.118.2 is really a serial protocol.

Data from more than one PMU is multiplexed in PDCs. PDCs are really multiplexers. This makes for a complex design when there are a large number of PMUs.

There are no intrinsic reliability or security mechanisms.

The historian isn't particularly accessible or user friendly.

# First PMU in a DeLorean!




"Where we're going, we don't need.... PDCs!"

"Historians are going to change!"

~ Dr Luigi McFly