(LL)RF and EPICS

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Osprey DCS

Why DCS?

- Why bother with a **D**istributed **C**ontrol **S**ystem?
- Scope and Scale
  - RF >= LLRF
- Integration / Uniformity

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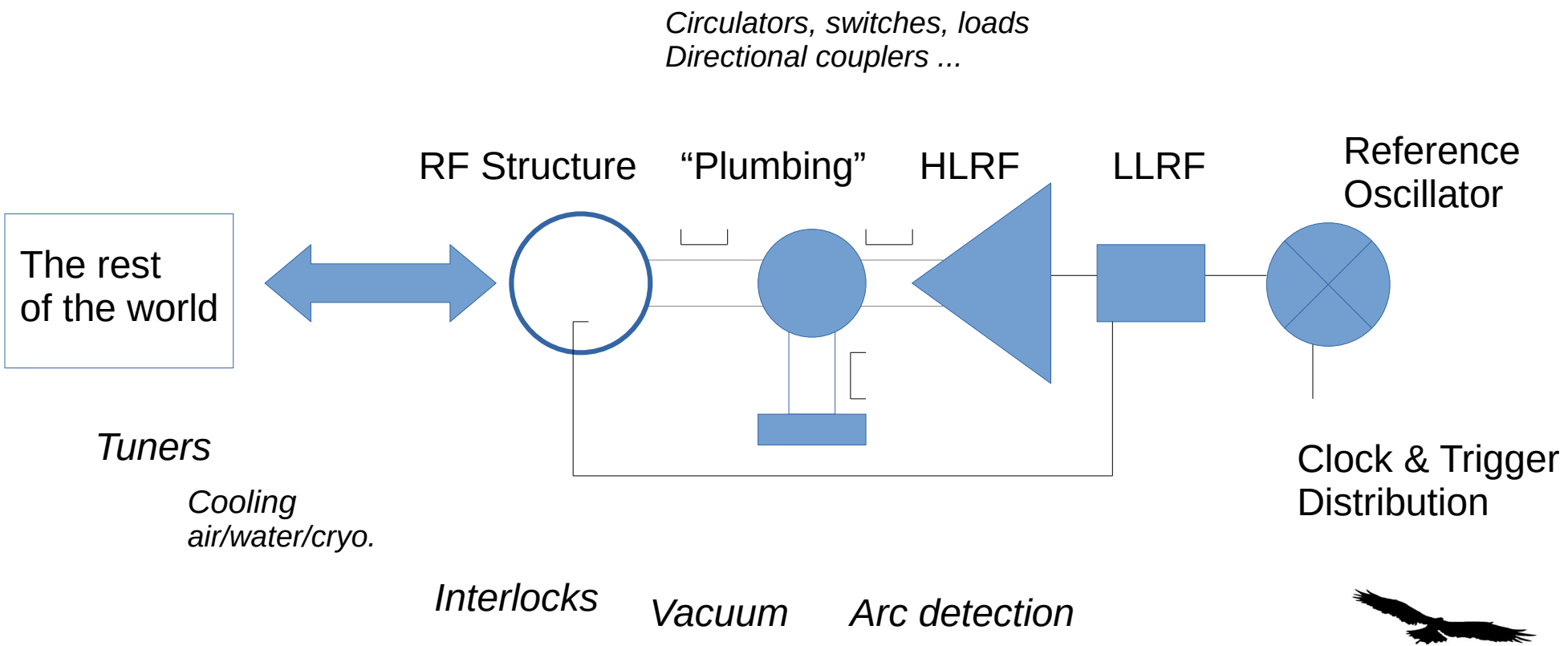
Pieces of an RF System



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The “Slow” Parts

<< 100 Hz

- Personal Safety / Physical access control
  - eg. Door switches
  - Typically high reliability PLC w/ redundant I/O
- Equipment Protection
  - eg. thermal switches
- Cooling
  - Water water everywhere…
  - Sometimes LN_2 and/or He
- Vacuum
  - Pumps, Gauges, RGAs, ...

Sometimes 2x vendors!
Often “one way” communication with DCS

Interlocks!
SCADA

Recommended Reading
Therac 25 Incident

Leveson (1993) "An Investigation of the Therac-25 Accidents".

Insulating vacuum in cavity, wave guide, cavity, ...

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The (maybe) Faster Parts

~1 KHz → ~1 MHz

- RF chain monitoring
  - Directional Couplers
  - Amplitude (and sometimes phase)
- Arc detection
- Cavity tuner
  - Motor / Piezo. actuator(s)

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The Fast Parts

> ~10 MHz

- LLRF
  - …
- Timing
  - Clock & trigger distribution

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What is EPICS

- **E**xperimental **P**hysics and **I**ndustrial **C**ontrol **S**ystem
- Free and Open Source SW Toolkit to build DCS
- Developed since ~1990
- In use at many facilities large and small
  - Particle, Plasma, Telescopes, ...

https://epics-controls.org/ https://epics.anl.gov/

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EPICS is ...

- Collaboration of many laboratories, companies, and organizations
- Software ecosystem
- Network protocol(s)
- Conventions
- Your friendly local controls group

Drivers for lots of common hardware!

… also uncommon ...

https://epics-controls.org/

https://epics.anl.gov/

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Jargon...

- EPICS ...
- PV – Process Variable. *Addressable unit of data*
- CA / PVA – Network protocols
- IOC – Input/Output Controller *Most common type of server*
- Record – Data structure in an IOC *Often for each I/O point*
- (Record) Field – Part of such a data structure

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PV is ...

- Process Variable *name*
  - Address string used by CA and PVA protocols
- Unique within facility (or at least a network)
- …
- Often cryptic
- Hiding among many many others

CA / PVA are ...

- Network protocols
  - Channel Access protocol (designed circa 1980)
  - PV Access protocol (designed circa 2010)
- Get / Put / RPC (pva only)
- Publish / subscribe
  - Data rate driven by IOC / hardware
  - Zero updates → ~0 bandwidth (only periodic keepalive)
- Multiplex
  - eg. 1000 subscriptions over one socket

CLI tools
cainfo / pvinfo
caget / pvget
caput / pvput
camonitor / pvmonitor
/ pvcall

PVA adds extendable
Data types

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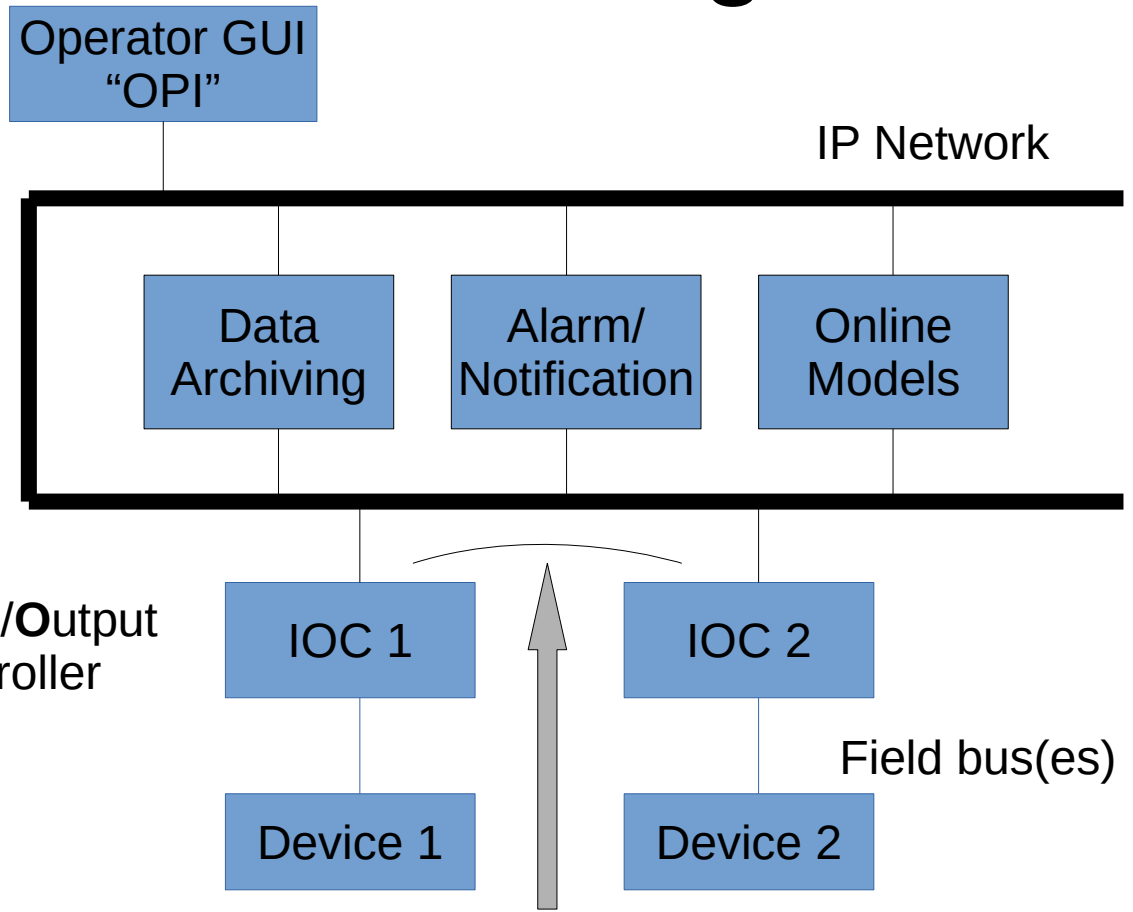
IOC is ...

- Input / Output Controller
  - An OS process
  - Sometimes the host computer
- Modular / (mostly) dynamic data processing engine
- Interact with “device”s
- CA/PVA Network server
- CA/PVA Network client
  - An IOC can easily talk to other IOCs!

EPICS Logical Components



Many components are both network client and server

eg. Archiver stores and retrieves
eg. Slow control loop between IOCs

Field bus(es) RS232, PCI/VME, Ethernet, ...

Easy for IOCs to talk to each other!

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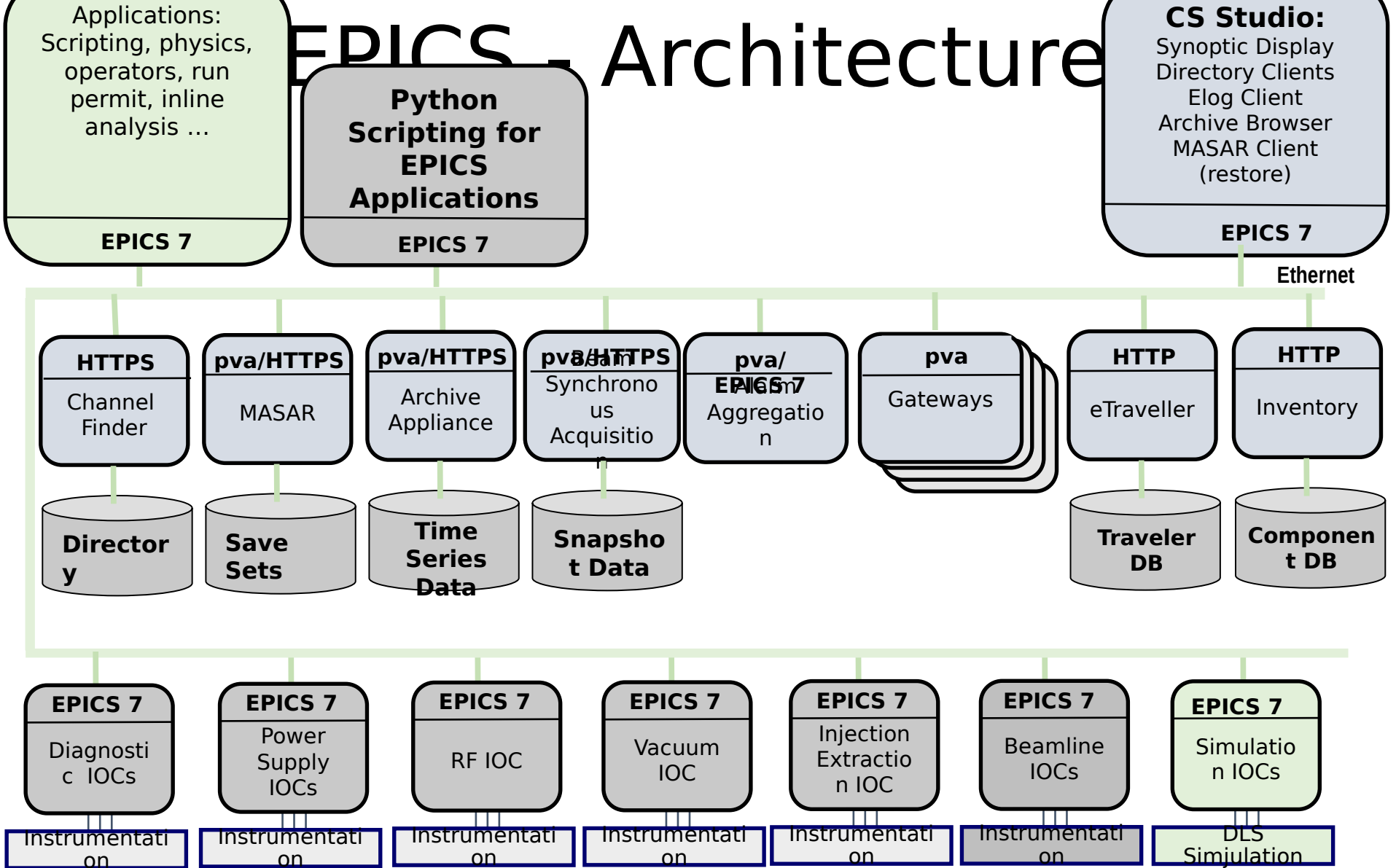
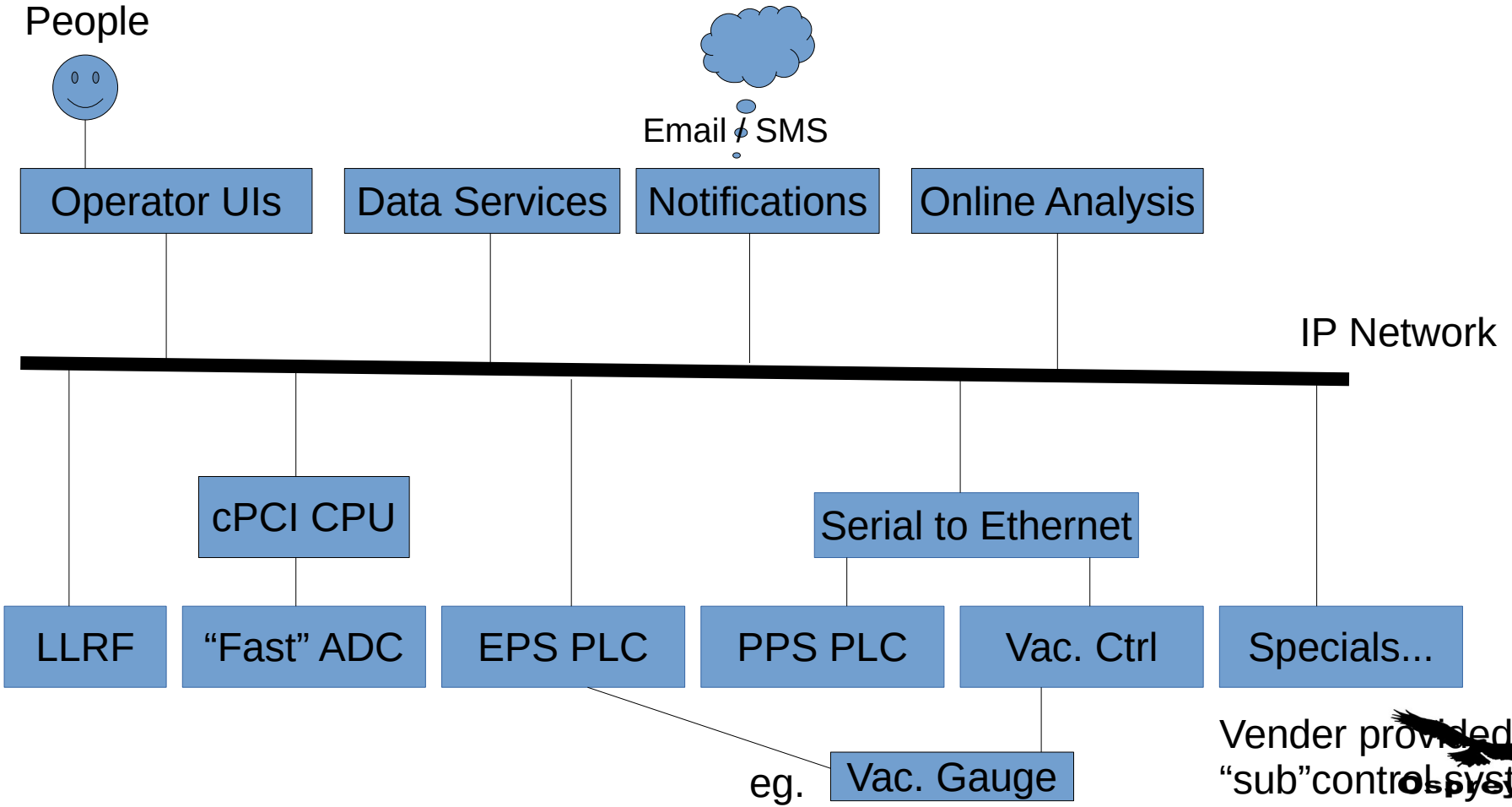
EPICS - Architecture



Controls Interfaces *Example*



When to use EPICS

- Integrating hardware from many vendors
  - Leverage existing driver SW
- Large scale (loosely coupled)
- Flexible

When not to use EPICS

- Not a PLC
  - Not a safety system!
- Not an FPGA

Demo