Controls for LHCb experiment

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on behalf of the LHCb collaboration
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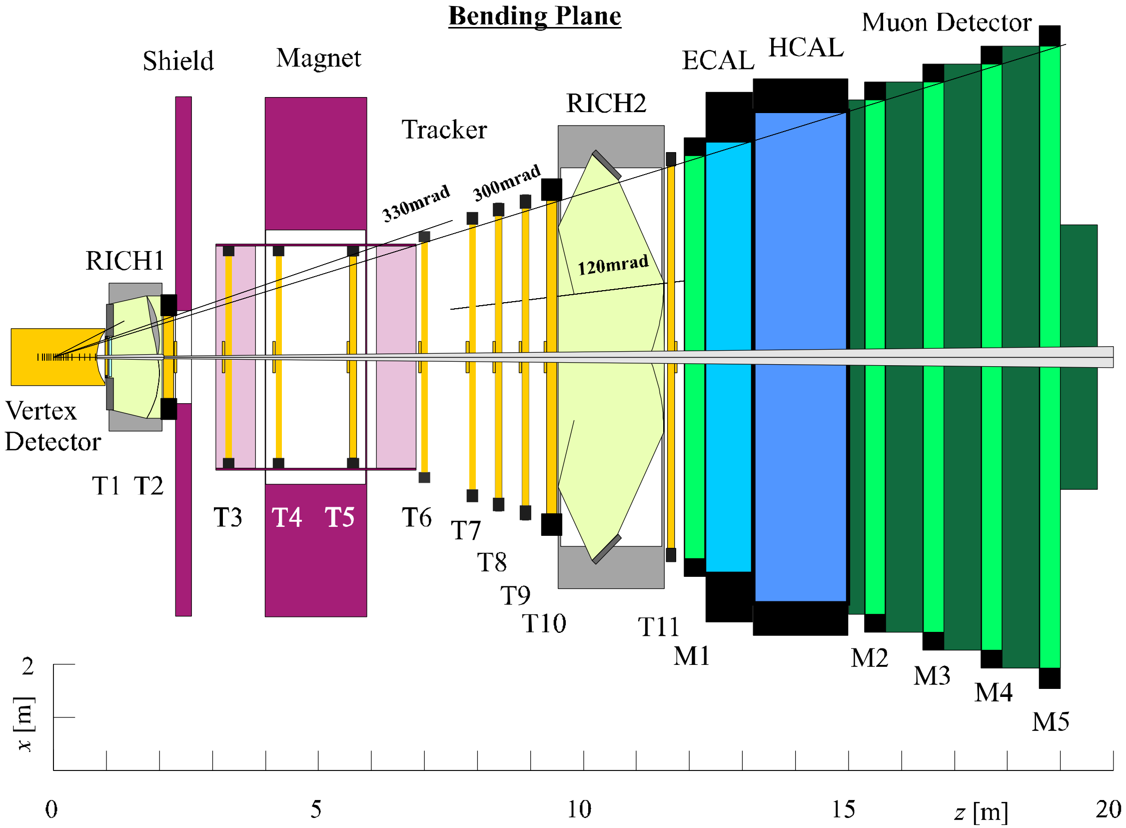
Outline

- LHCb Experiment
  - Goals, LHCb in numbers, Overall planning
- LHCb Computing Organization
  - Goals, Structure, Planning
- Update on requirements for controls
- Program of work and priorities
- Position of the experiment on what has been presented
- Conclusions

LHCb

- LHCb is a dedicated experiment at the LHC collider for precision measurements of CP-violation and rare decays
- Single-arm spectrometer with forward angular coverage from ~10 mrad to ~300(250) mrad
  - Vertex detector
  - Tracking system
  - RICH system
  - Calorimeter system
  - Muon system



LHCb in numbers

- Collaboration: ~45 Institutes, ~350 participants
- Cost of the experiment: 86 MCHF
- Electronics: ~10^6 readout channels
- Trigger System: 4 Levels. 40 MHz$\rightarrow$1 MHz $\rightarrow$40 kHz $\rightarrow$ 5 kHz $\rightarrow$200 Hz
- Data Acquisition: 100 kB/event. 2-4 GB/s $\rightarrow$20 MB/s. 1.5 10^6 MIPs
- Status of the Experiment:
  - Technical proposal submitted in February 1998
  - Approved in September 1998
  - R&D phase for ~2 years

LHCb Computing: Goals

- Need to focus on **quality** but at the same time be **efficient** in use of resources
- Quality
  - by designing quality architectures
  - by building or acquiring quality components
- Efficiency
  - by re-using components
  - by avoiding duplications

LHCb Computing:Project Organization

Steering Group

- Coordination, Planning, Resources

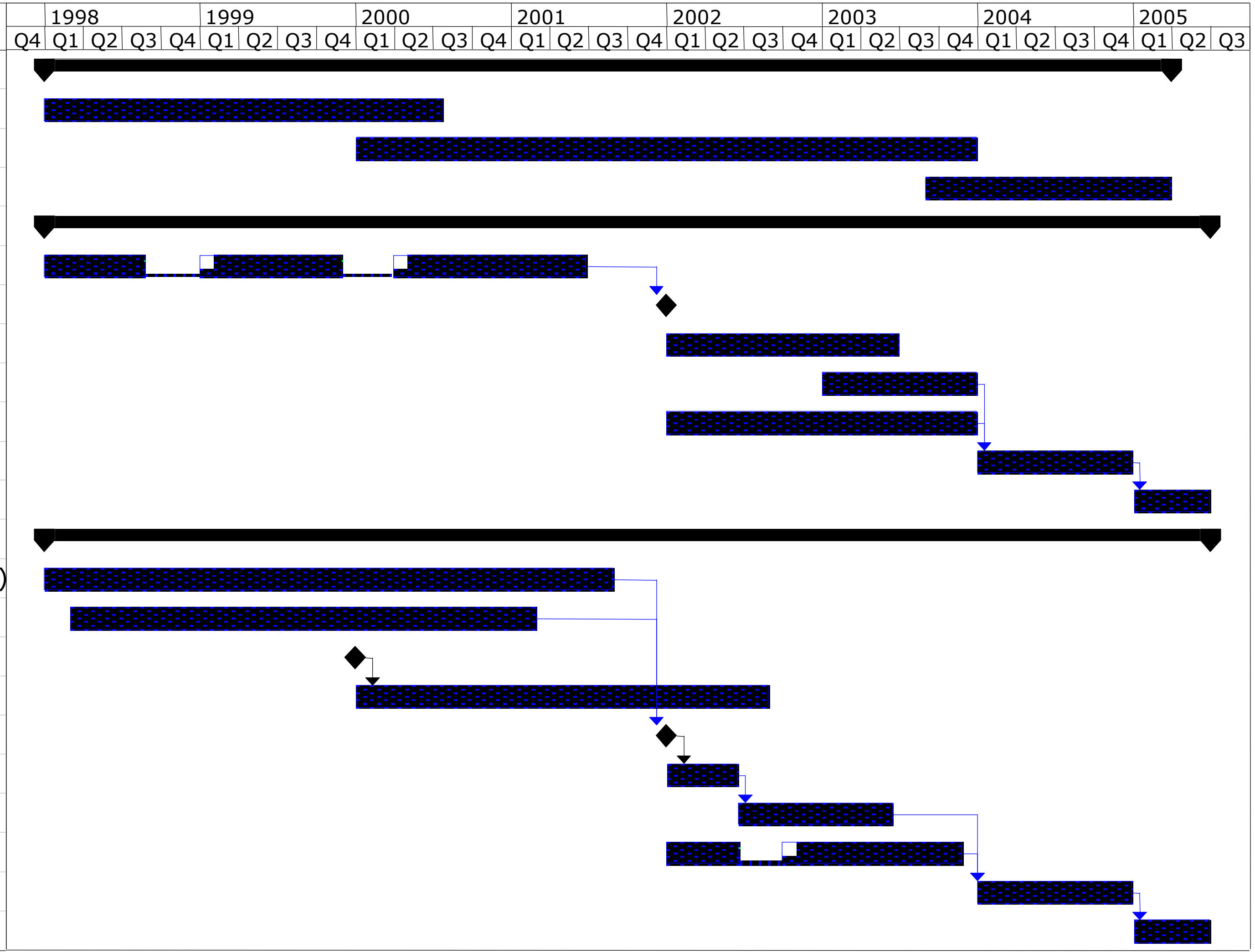
Computing Facilities	Recon-struction	Analysis	Simulation	DAQ	Controls	Control Room	Software Engineering Group
•Farms •Desktop •Storage •Network •Operating System	•Level 2 •Level 3 •Prompt Rec. •Full Rec. •Calibration	•Framewk •Tools	•GEANT4 Framewk •Tools •Production	•Event Builder •Readout Network •Interfaces •Links •Crates •DAQware	•DCS •LHC •Safety •Run Control	•Operations •Consoles •Shift Crew Enviroment	•Methods •Tools •Code Management •Quality •Document. •Training •Licenses •Collab. Tools

Re-usable Components

- Data Management : Event Store, Geometry, Database Utilities, ODBMS
- Architecture : Frameworks, Component model, Distributed system
- Toolkits : GUI, Histograms, Communications
- Utilities : data quality monitoring, event display, bookkeeping

LHCb DAQ/Controls Project: Planning

ID	Task Name
1	**Detectors**
2	R&D and prototypes
3	Construction
4	Installation
5	**DAQ system**
6	Architecture/Protocols/R&D
7	Technology choices
8	Hardware Development
9	Production/Purchase
10	Software Development
11	Installation/Integration/test
12	LHCb startup
13	**Control system (DCS)**
14	UR (sub-detectors,infrastructure)
15	Architecture/Evaluations/R&D
16	Interface recommendations
17	Interim develop/test beam
18	Final Technology/Product choice
19	Purchase
20	Common infrastructure develop.
21	Subdetector development
22	System Installation/Integration
23	LHCb startup



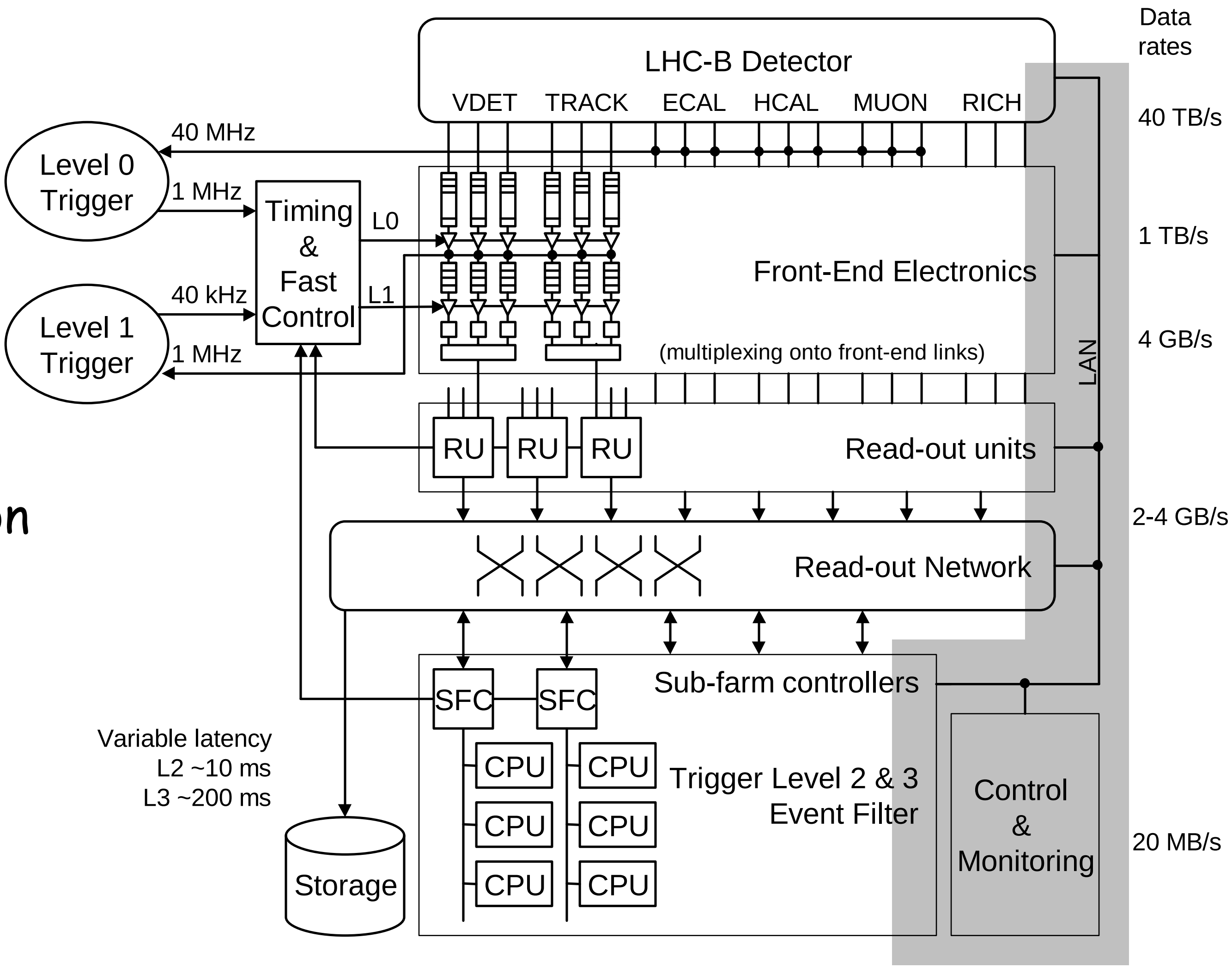
Update in Requirements

Experiment Control System

- The ECS will be used to monitor and control the operational state of the LHCb detector, of the data acquisition and of the associated experimental infrastructures.
- Typical sub-systems are:
  - Environmental parameters (temperature, pressure, etc.)
  - Equipment Safety
  - High and Low voltages
  - Read-out electronics (front-end and read-out network)
  - Gas systems
  - Cooling and ventilation

Controls: Scope

Trigger &
Data Acquisition
system



DAQ Configuration Parameters

Element	#Units	#Parameters	
		Configuration	Monitoring
Front-End Chips	10'000	5	0
TTCrx Chips	2'000	5	0
ODE Boards/DSPs	2'000	1'000	10
Front-End Multiplexers	300	10	10
Readout Units	100	200	10
Sub-Farm Controllers	100	200	10
Level 0 Trigger	100	1'000	100
Level 1 Trigger	200	1'000	100
Level 2/3 Farm Processors*	2'000	n00000	100
Totals	16'800	2'403'000	255'000

Read/Write frequency of Configuration Parameters: every run, fill, error recovery

Monitoring frequency of Alarm/Monitoring Items: every 1 minute

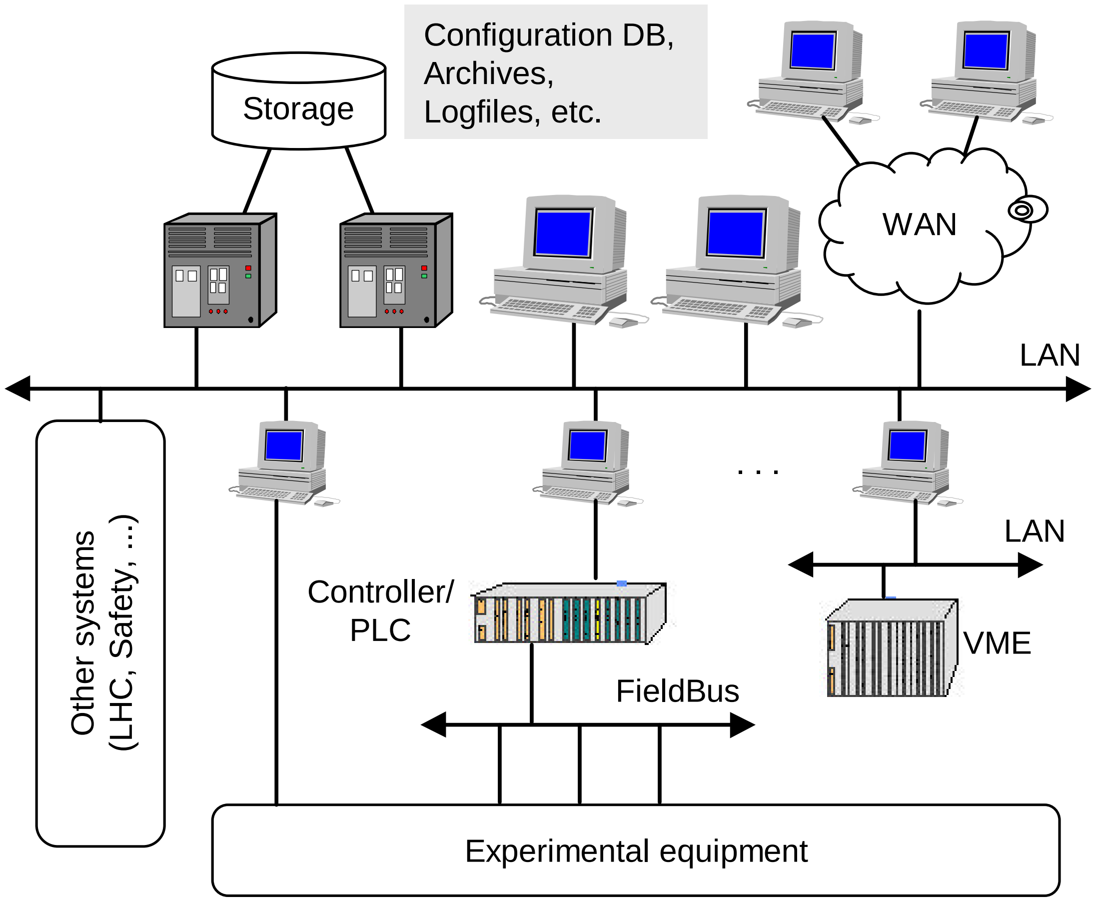
(*) same parameter set will be loaded into ~2000 processors

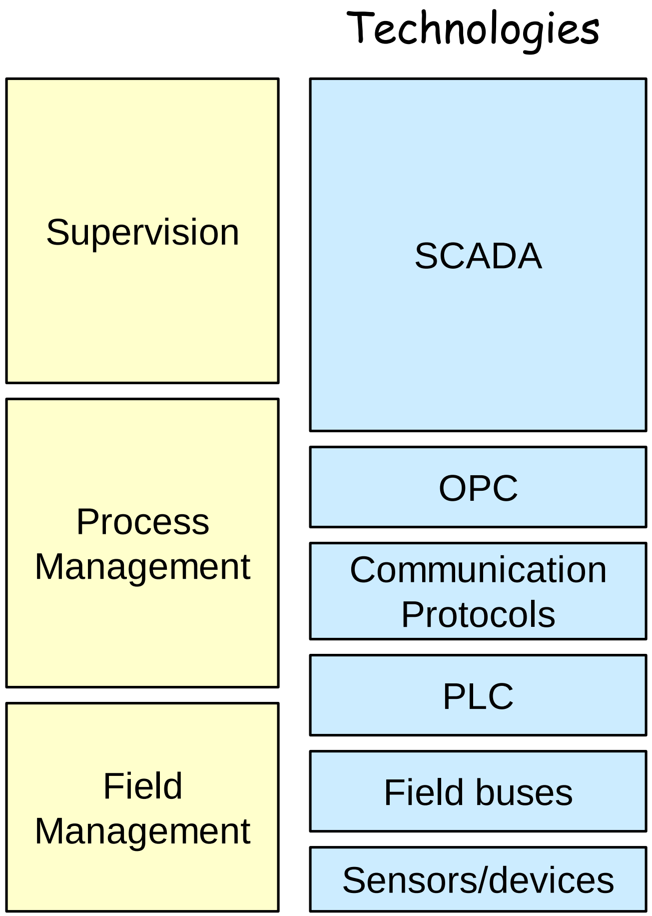
DAQ configuration

- Observations
  - The number of different **device types** is of the order of a dozen
  - The number of **devices** is of the order of 17’000
  - The number of **parameters** is of the order of $n \cdot 10^6$
  - The number of monitored quantities is of the order of $n \cdot 10^5$
- Implications
  - A tag-oriented system is unrealistic if each parameter is an entry.
  - We need a namespace hierarchy (Device->Parameters).
  - For highly repetitive items (e.g. individual detector channels in an electronics board) arrays are needed (don’t want to name each of them).

Program of work and Priorities

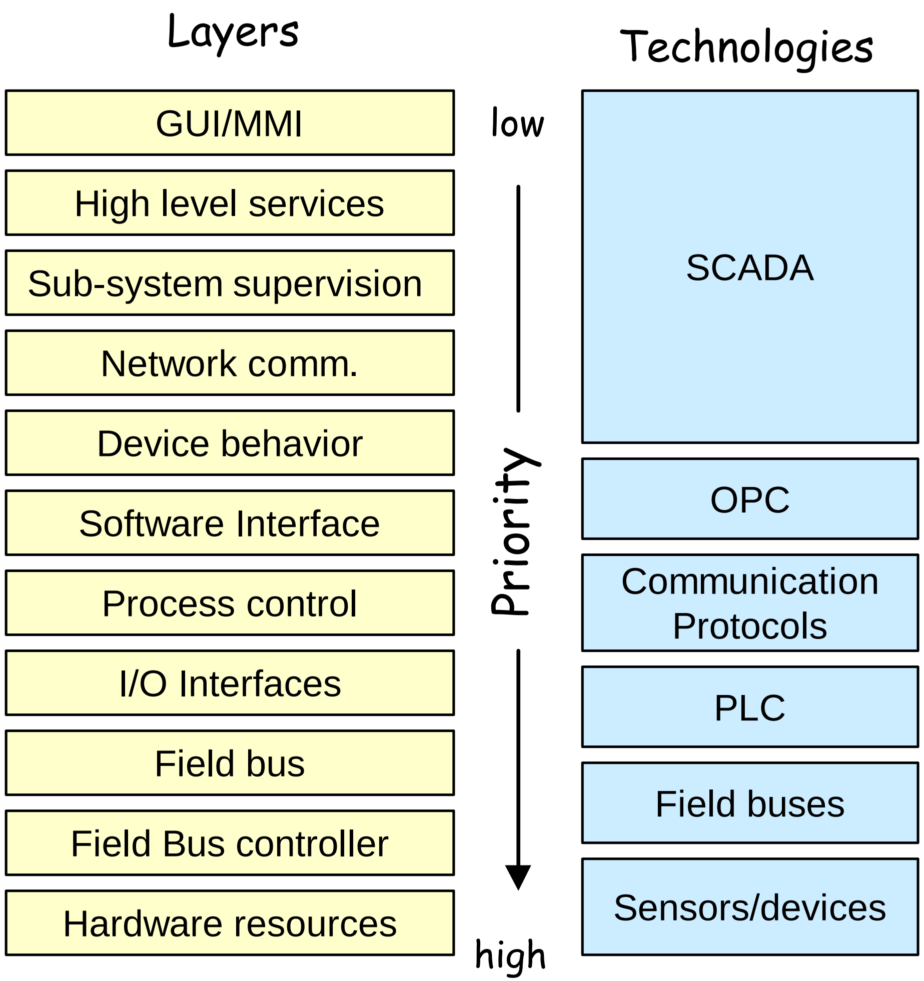
Control/Monitoring structure





SCADA = supervisory control and data acquisition
OPC = OLE for process control
PLC = Programmable logic controller
Field buses = CAN, ProfiBus, WorldFip, ...

LHCb Priorities



- Decisions for the lower layers need to be taken sooner.
- Studies need to be completed before making informed choices.
- Logically, our priority is in the lower layers.
  - Viewpoint not shared by JCOP
- Milestone for recommended hardware interfaces: end of the year.
- SCADA low priority.

Need for an Architecture

- We continue to be convinced of the importance of defining an architecture.
  - We need to decompose the system into components/layers with well defined interfaces.
  - Specific functionality should be assigned to each component or layer.
  - Needs to be documented and adopted
- Aspects like "partitioning" need to be studied
  - Use cases
- This has very high priority for LHCb.

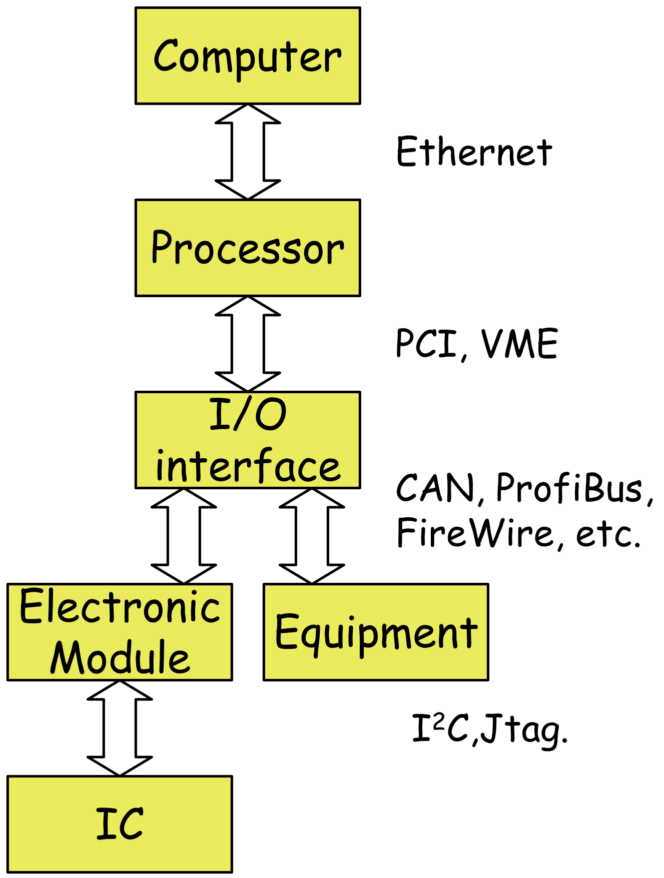
Areas where LHCb is active

- Field buses (with IT-CO)
  - Need to provide guidelines to designers of read-out electronics.
  - Study the goodies of each solution. Survey market. Provide practical advice. Chip-sets, evaluation boards,…
- OPC (within JCOP)
  - Evaluation of OPC standard
  - Practical experience developing OPC servers
  - Answer the question: Can we standardize on it?
- SCADA Evaluation (within JCOP)
  - Follow the SCADA evaluation in order to have an opinion.

Position of the experiment on what has been presented

Field buses

- We need to consider other candidate buses (bandwidth, addressability,…)
  - Maybe the 3 CERN standard field buses are not sufficient
  - Specially for the needs of DAQ control
- Standard solutions for:
  - Adapter to I^2C, JTAG,…
  - Bus controllers (chipsets, daughter boards, programming)
  - PCI/VME interfaces



PLCs

- Our vision:
  - We will use a mixture of “traditional” processors (probably PC based) and PLCs in our control system.
  - PLCs will be used in specialized domains:
    - » Well defined process control (gas systems, magnet,…)
    - » If safety is required
  - Traditional processors will be used for the rest:
    - » Cheaper solution
    - » Program flexibility. Programmed eventually by end users.
    - » SoftPLC?
- We think there is sufficient expertise on PLCs at CERN and JCOP.

OPC

- OPC is a good standard
  - Well designed
  - Adopted by many vendors. Strong industry support
  - Performance seems adequate
- Known problems
  - Security
  - Basically NT based. Difficulty to communicate to UNIX world.
- JCOP should recommend OPC.

SCADA Evaluation

- The SCADA evaluation has been extremely useful as information gathering
  - We know what commercial systems can provide
  - We know better the goodies and badies of industrial systems
  - We know better the companies. Links and contacts.
- Very rapidly changing domain
  - New products and new versions appearing continuously
  - For how long the information obtained will still be valid?

Is one of the SCADA systems likely to be acceptable?

- Mandatory Features:
  - **Support for devices**. To handle the complexity and scale of our problem.
  - **Support for arrays**. To handle highly repetitive items.
  - **Openness**. To extern its functionality and interface with existing systems
- The only exiting candidate is XXXXX
  - With the next two announced versions, all the mandatory features will be available.
  - Problems encountered have prevented the completion of the evaluation.

Time scale for an eventual decision

- LHCb do not need to take a decision on the SCADA product before end 2001.
- Taking a final decision too early on this kind of products is very risky. Rapid evolution.
- We think it is not needed to tender now. LHCb will not know what to do with the licenses!
- If the majority of JCOP collaborators decides with an earlier date, then LHCb will go along with it. Provided it can be used!

What can we do for the next 2 years?

- Architecture
  - Collect use cases.
- Focus on the low level stuff (field buses, …)
- Study experiment configuration database issues
- Use the most promising (XXXXX) SCADA product to build realistic prototype systems
  - Run control type of application, test beam, etc.
  - Only few licenses needed
  - Start the engineering activity
- Continue technology watch. Investigate alternatives.

Summary

- The LHCb approach to controls have not changed since last year: Integrated ECS.
- LHCb priority is currently in the lower level stuff and architecture.
- Position of LHCb on what has been presented:
  - Field buses: Open the scope of applicability and investigate standard solutions.
  - PLCs: Well covered in general.
  - OPC: Should be recommended by JCOP.
  - SCADA evaluation: Very successful. At least one usable product.
- LHCb needs a decision on the supervisory software by end 2001.No need for tendering now.