Don't make it *fast*, make it **real**


Real-Time
Jitter
Resolution
Cycle
Accuracy
Preemption
Latency
Determinism
Deadline
Priorities
Precision
Dead-time
Stability
Bandwidth
Update
Period
Speed
Synchronity

Some Basics Up Front

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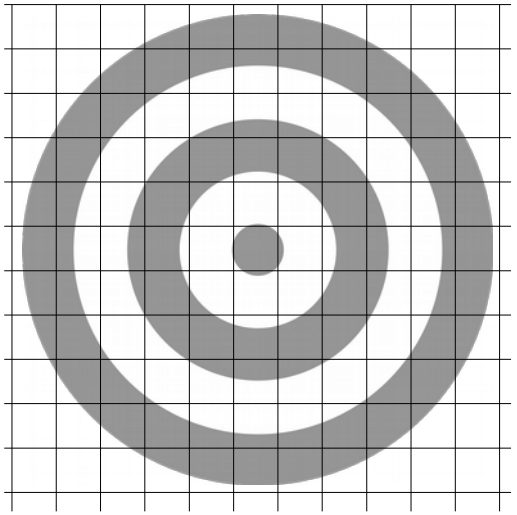
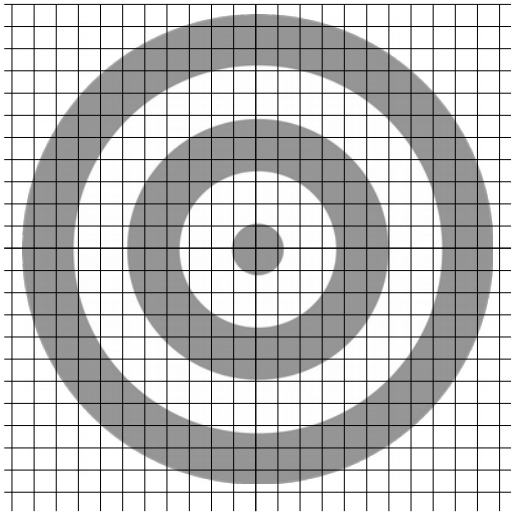
  - **Soft**: Online live $GAME scores
  - **Hard**: Nearly everything coupled to a moving physical thing, e.g. motor control, robotics.

Some Basics Up Front cont.

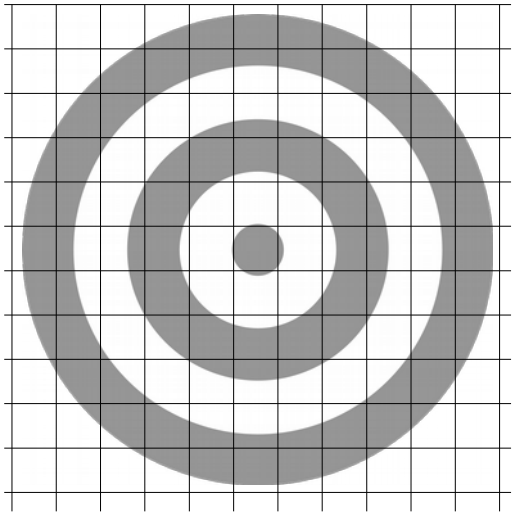


low resolution



high **resolution**

Some Basics Up Front cont.



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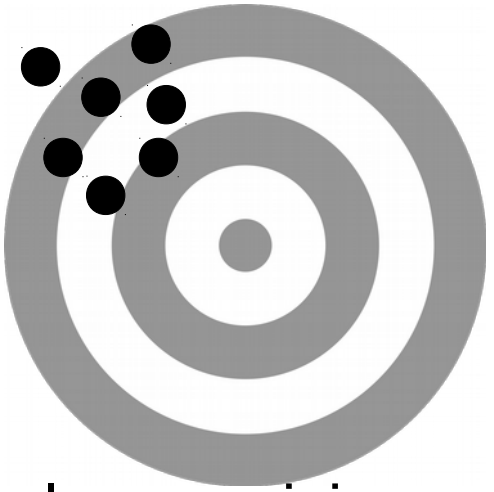
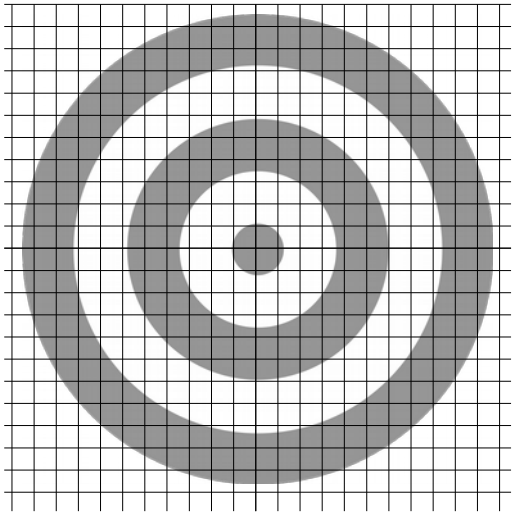


low precision,
low accuracy



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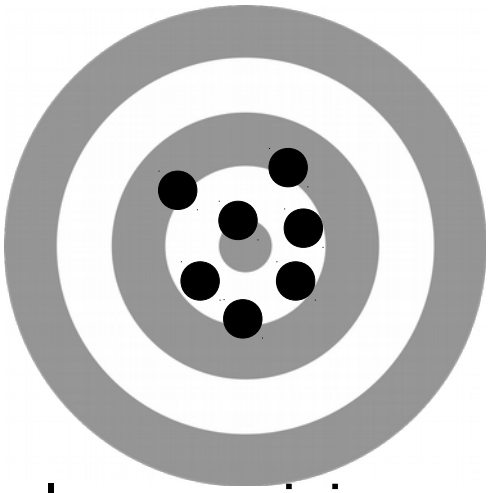

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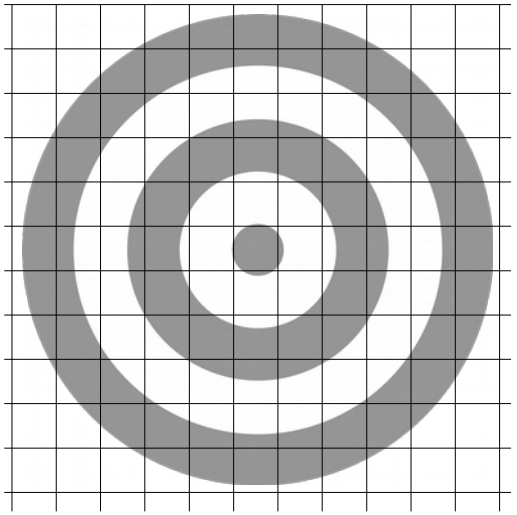

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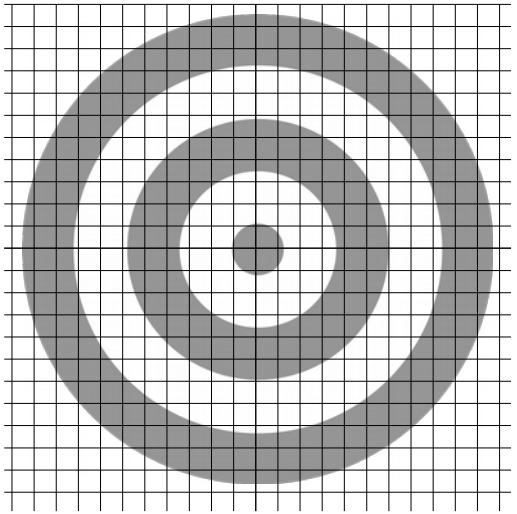

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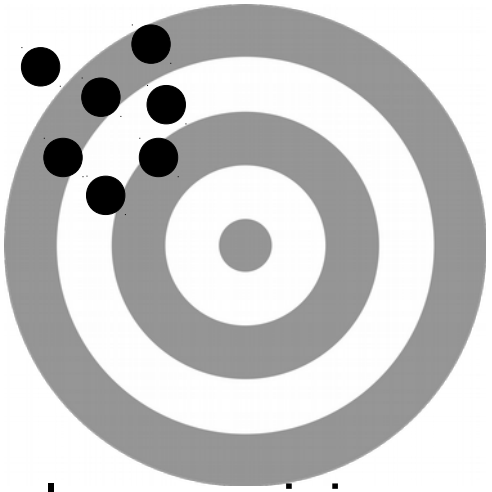

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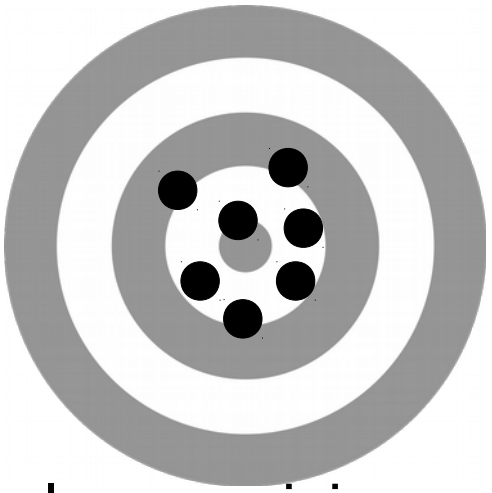

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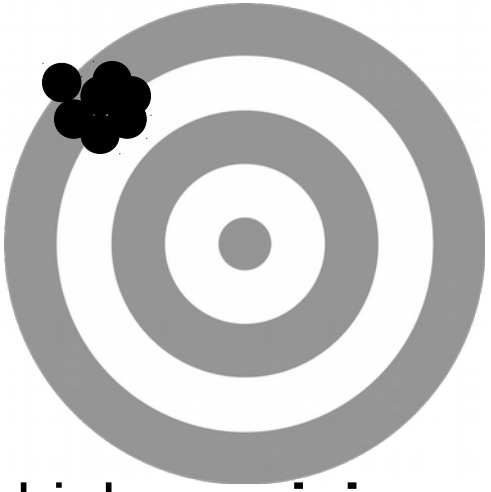

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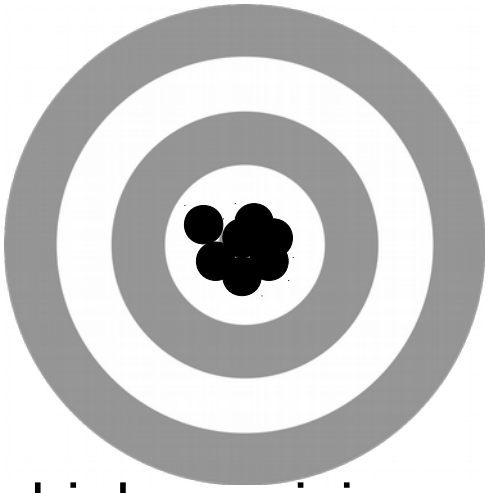

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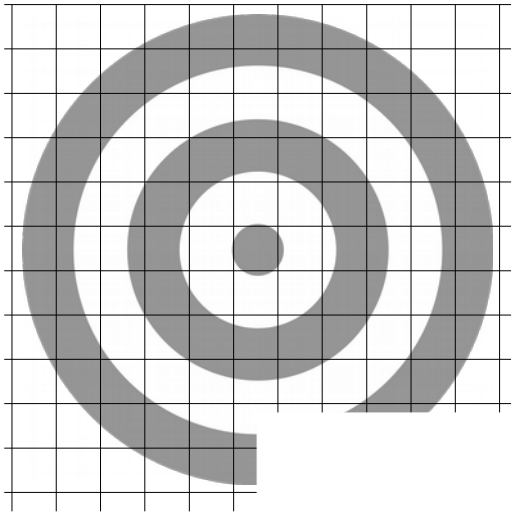
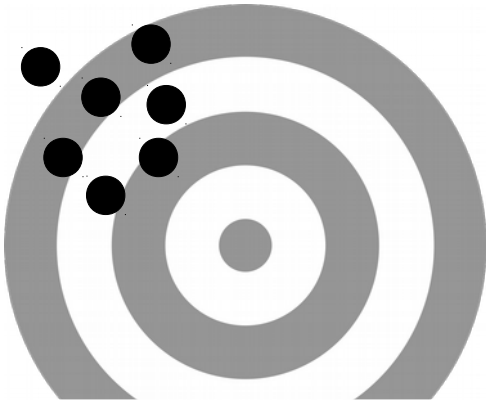
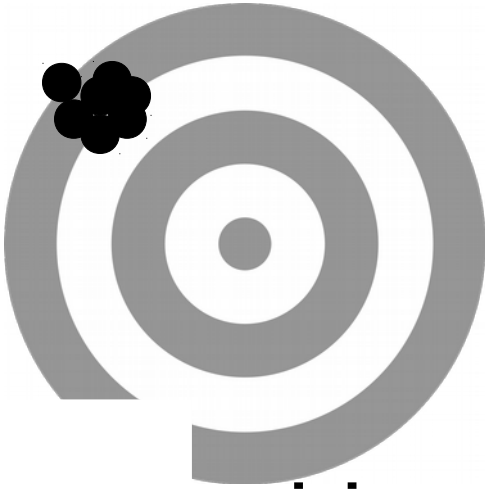


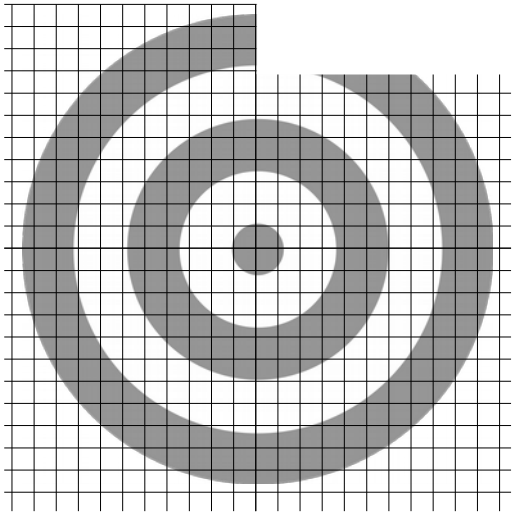
low res



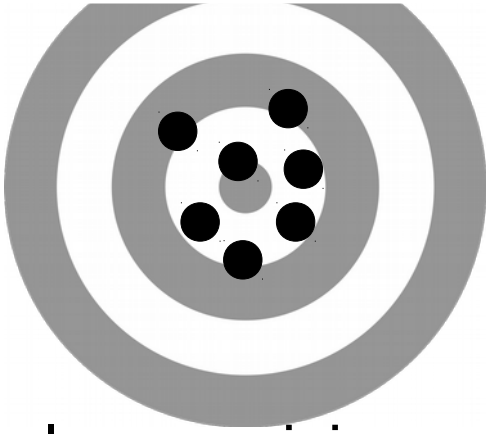


recision,
ccuracy

See spatial, but think **temporal**



high **resolution**



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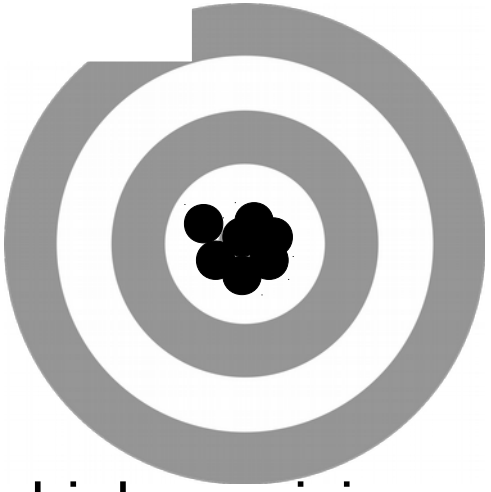

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  - Average Execution Time

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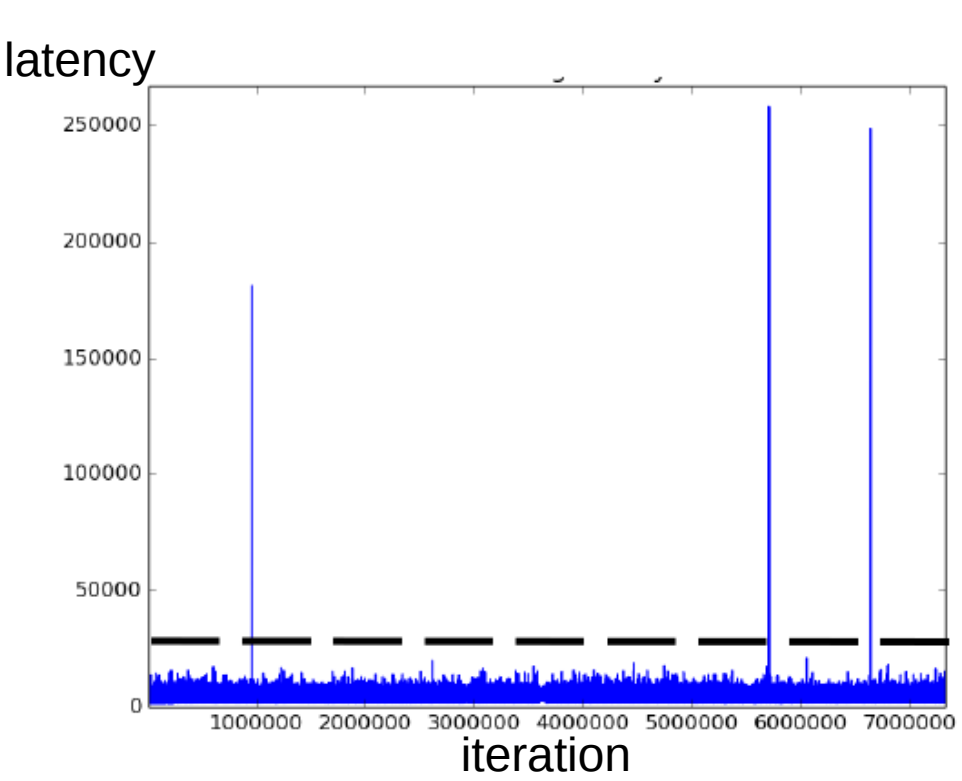

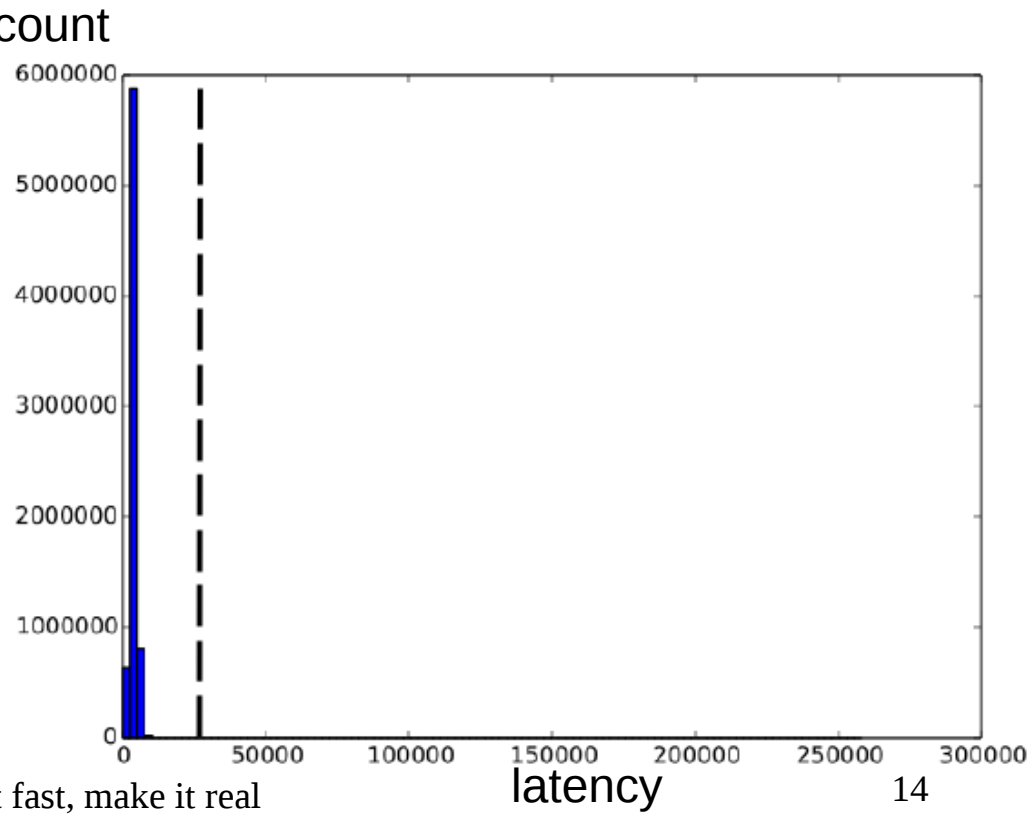

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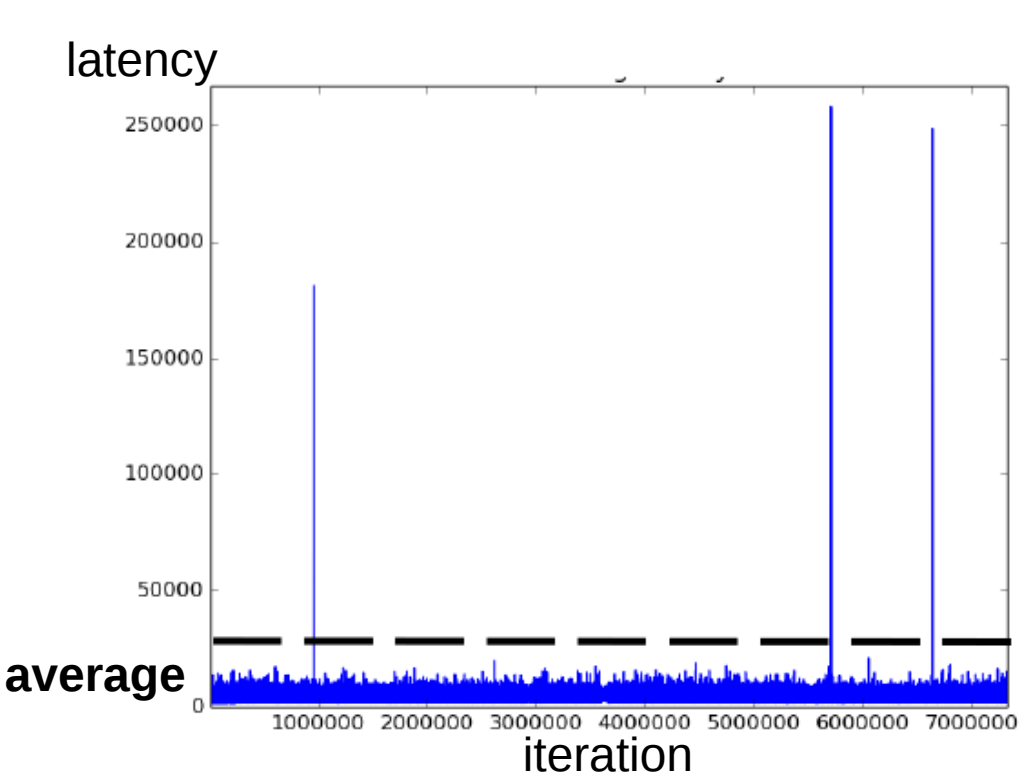

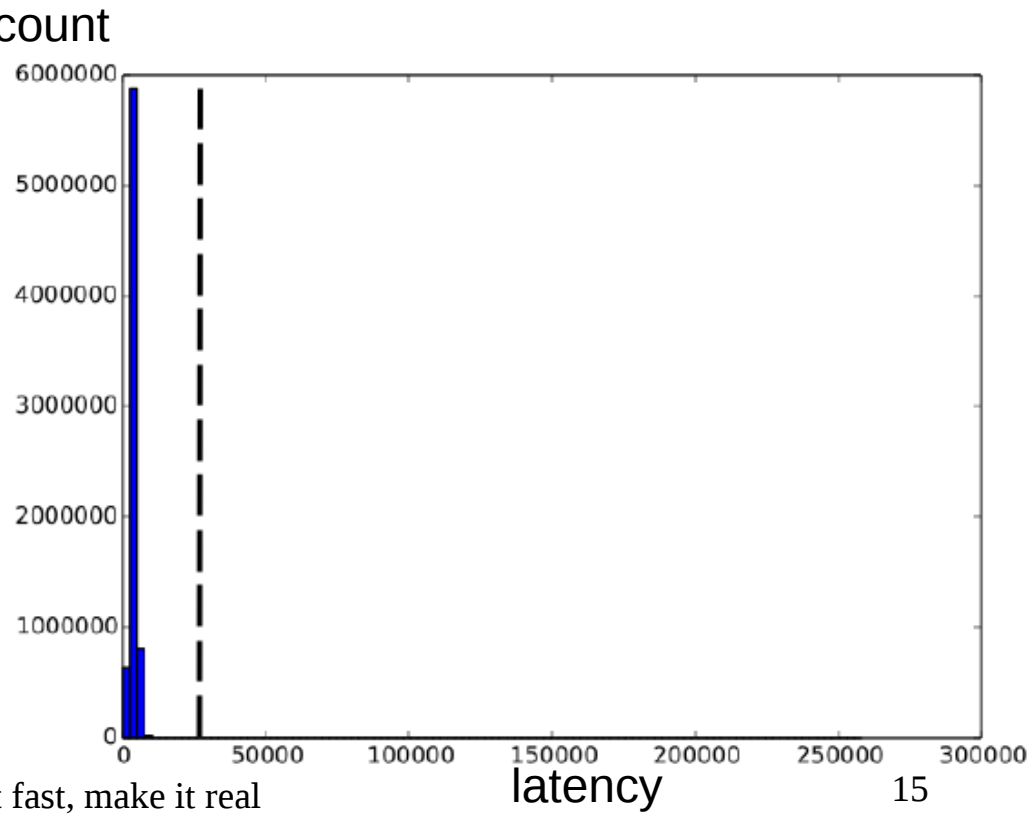

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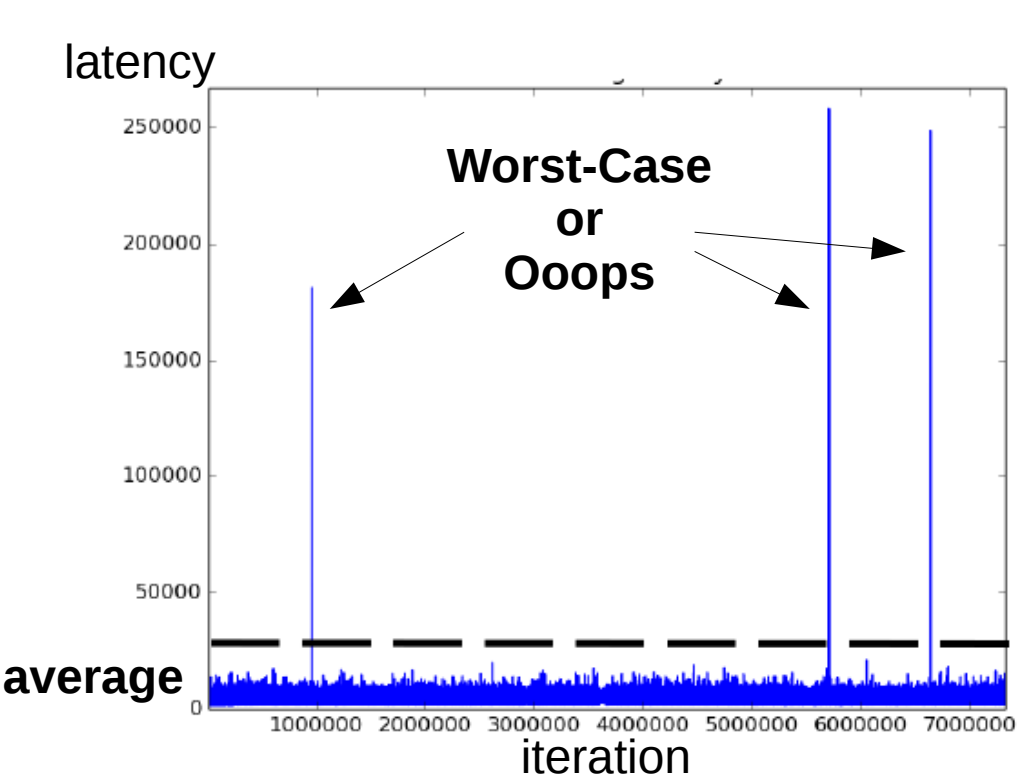

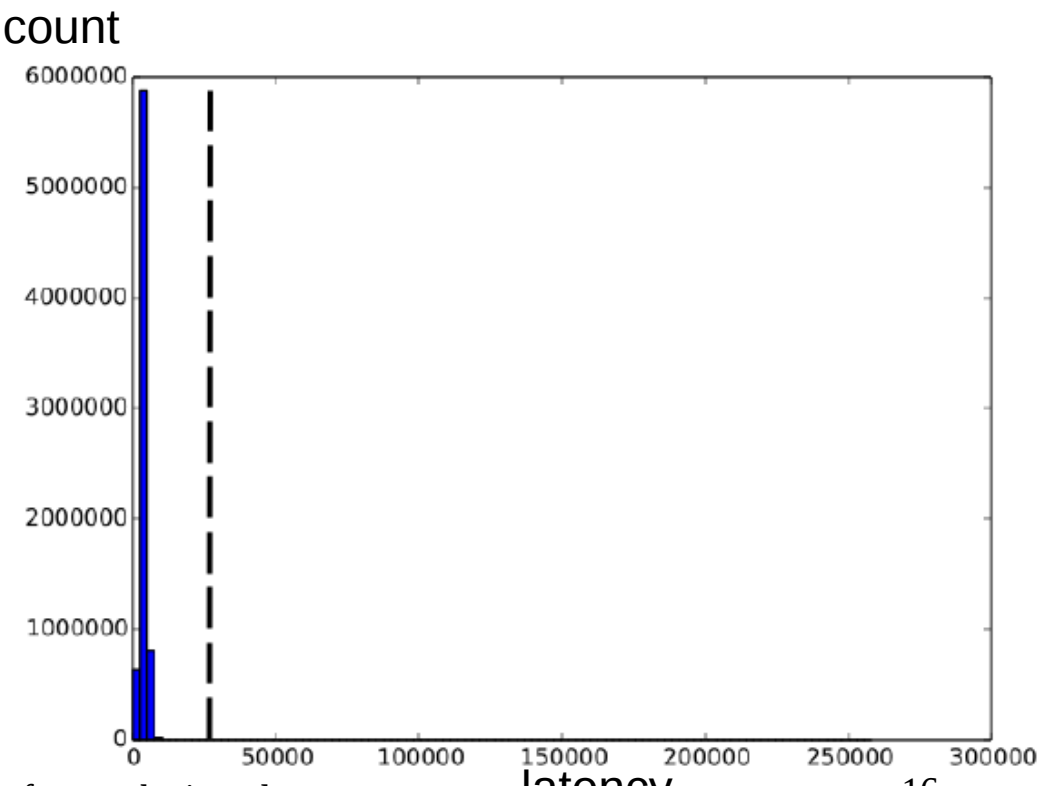

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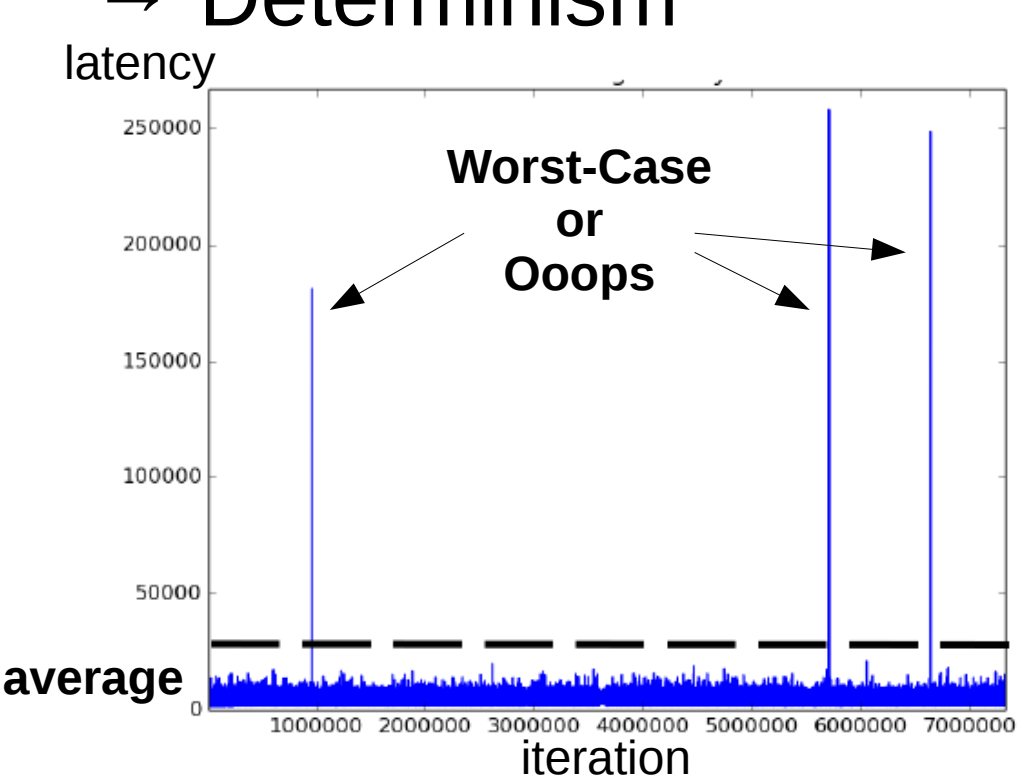

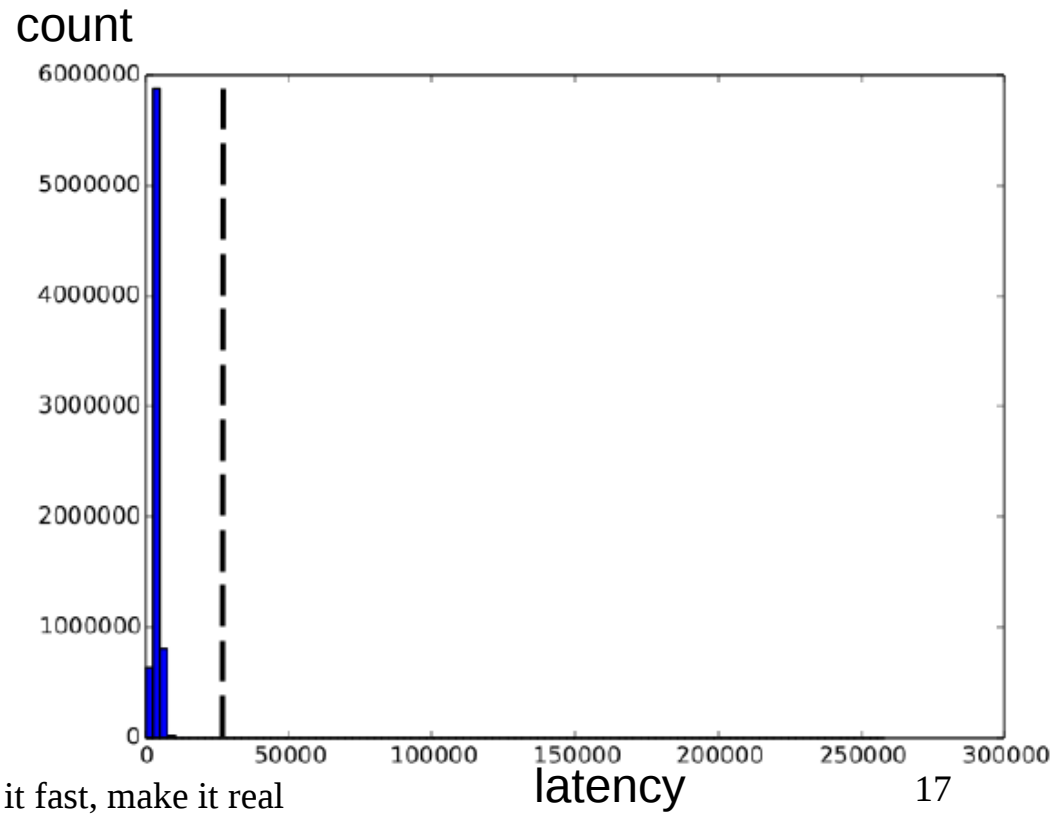

Networks

- Bandwidth

  Amount of data transferred per time unit

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“Never underestimate the bandwidth of a station wagon full of tapes hurtling down the highway.”

A. Tanenbaum

bandwidth↑ latency↑ jitter↑

(RT)OS / Scheduling

- **Preemption**

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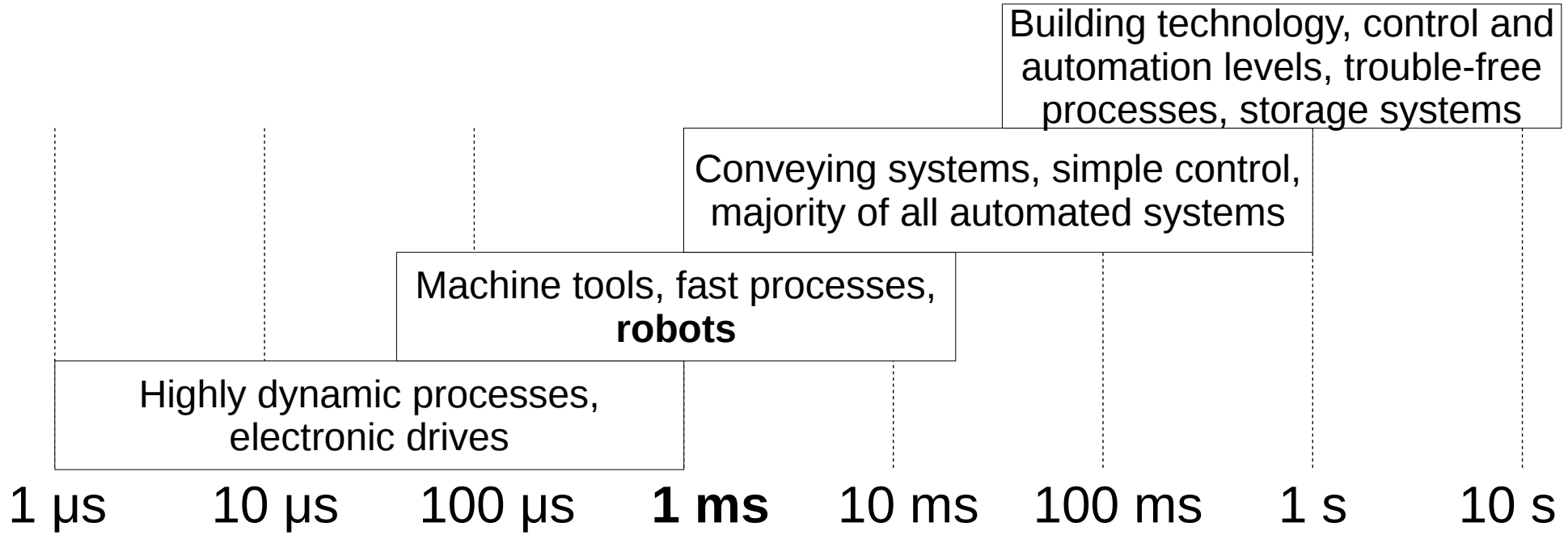

adapted from Industrial Ethernet Facts - 3rd Edition

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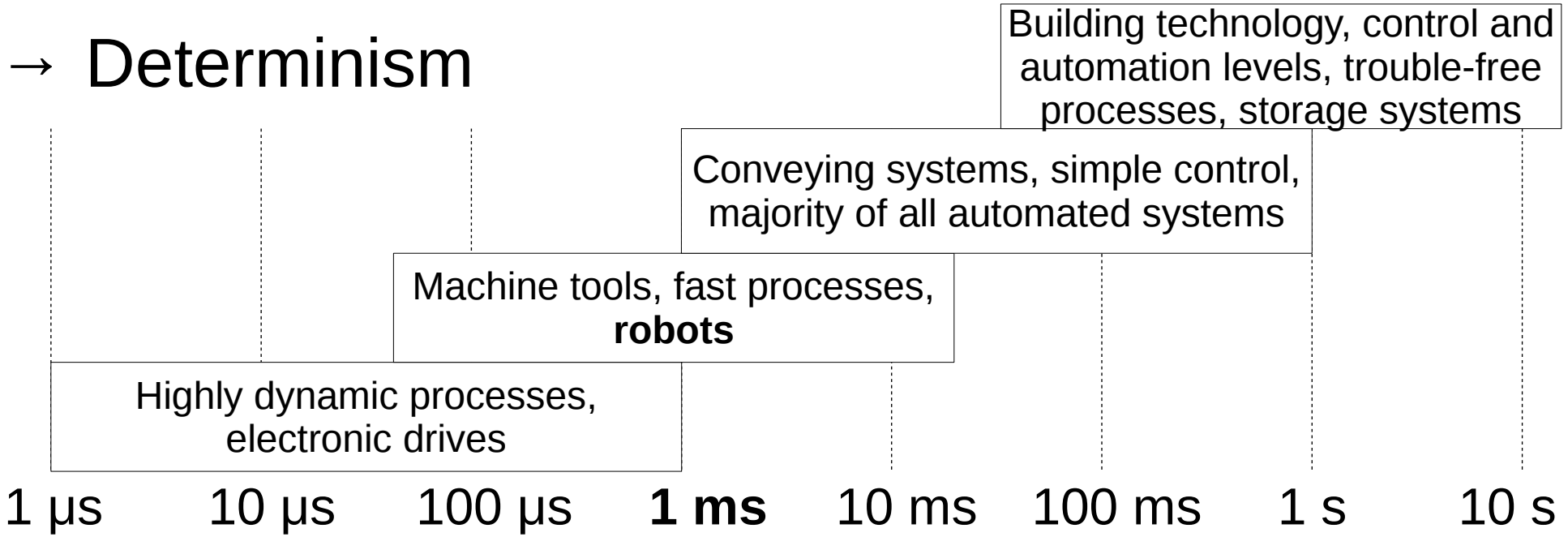

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Control

- **Dead-time**

Control

- **Dead-time**
- **Phase**

Control

- **Dead-time**
- **Phase**
- **Stability**

Distributed Physical Systems

(aka: CPS, IoT, IIOT, Industrie 4.0, ...)

- **Synchronity**

→ *physical* speed and acceleration limited by real-time capabilities!

"I'm using a µC bare metal, I don't care"

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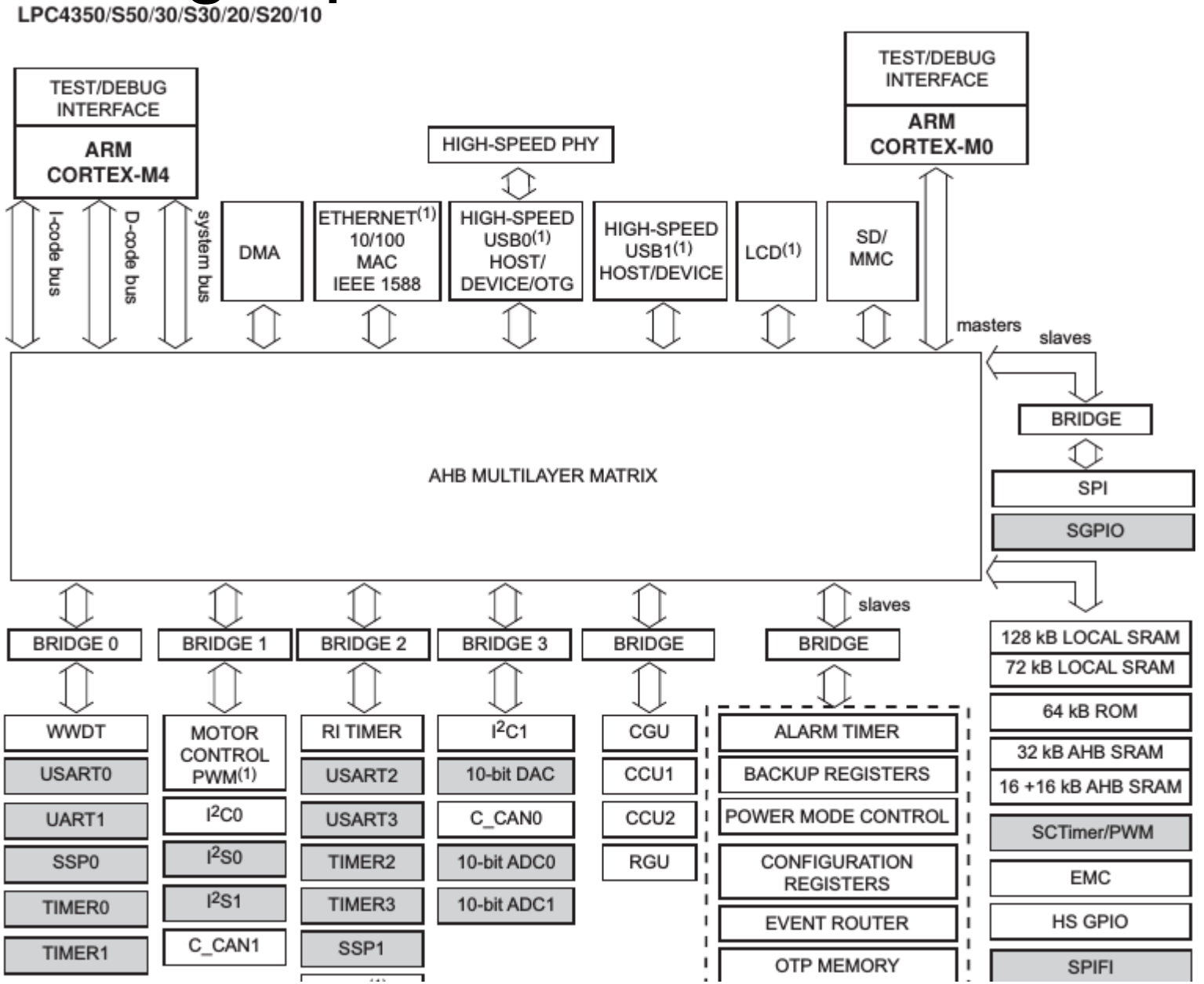

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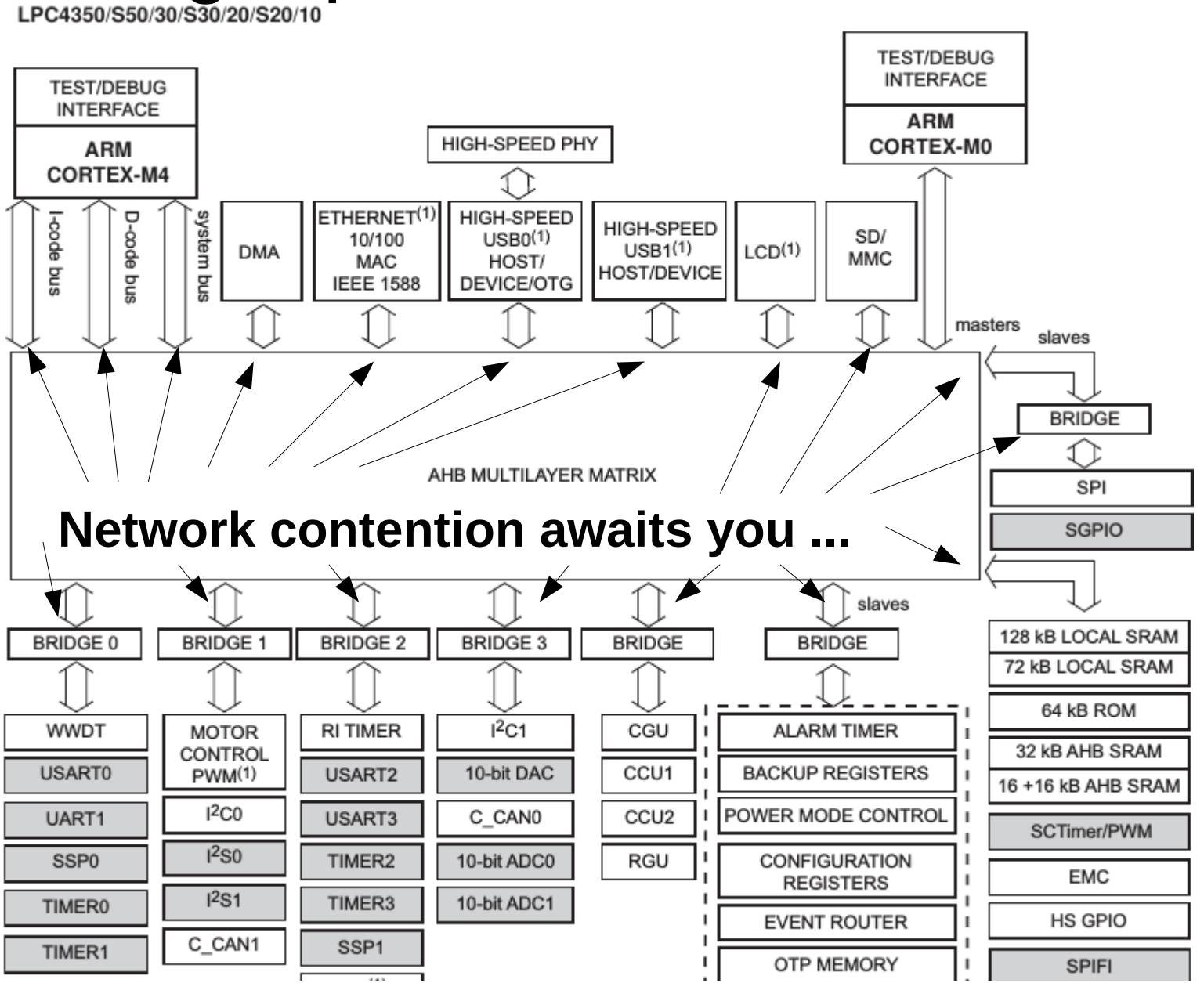

every. where.

IF you want to

- know more
- talk about *open-source real-time software*
  - Linux PREEMPT_RT
  - LinuxCNC / machinekit
  - Orocos
  - µC RTOS: FreeRTOS, ChibiOS, mbed, nuttx
  - ROS control
  - bare metal on Cortex-M
  - ...
- curse about “the lack of temporal semantics and adequate concurrency models in computing” (Lee 08)
- just correct me

then talk to me here or contact me

bihlmaier@robodev.eu