Assessment of Industry Research Priorities for Intelligent Sensors and Control

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Outline

- Vision and Objectives
- Challenges and Perspectives
- NIST Sensor Network Testbed
- Research Opportunities
- Acknowledgements

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Initial Vision

Seamless integration and communication

- Sensors and control enjoy the same "plug and play" paradigm as consumer electronics
- Leverage "cloud computing"
  - Enable complex data analysis over distributed systems
  - Factory distributed systems support a fundamental set of services for infrastructure and application development
  - Manufacturing equipment provides high quality data, at right time, all the time
  - Future standards support development of a cloud computing platform to enable rapid data, software, and hardware integration
- Factory information and control systems respond and adapt to the real-time needs of Advanced Process Control (APC) and Predictive and Preventive Maintenance (PPM)

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Objectives
Sensors and control study

- Understand factory automation challenges
  - Factory/equipment cost, time, and technology constraints
  - Continuous improvement of cost, cycle time and yield
  - Next-Generation Factory (300mm Prime), Photovoltaic manufacturing (PV)
- Identify research needs and gaps
  - Innovation areas
  - Current and upcoming areas of research
  - How research can be used to address current challenges
- Call for Participation
  - Avoid re-inventing the wheel
  - Enable effective technology transfer
  - Focus on infrastructure, pre-competitive challenges

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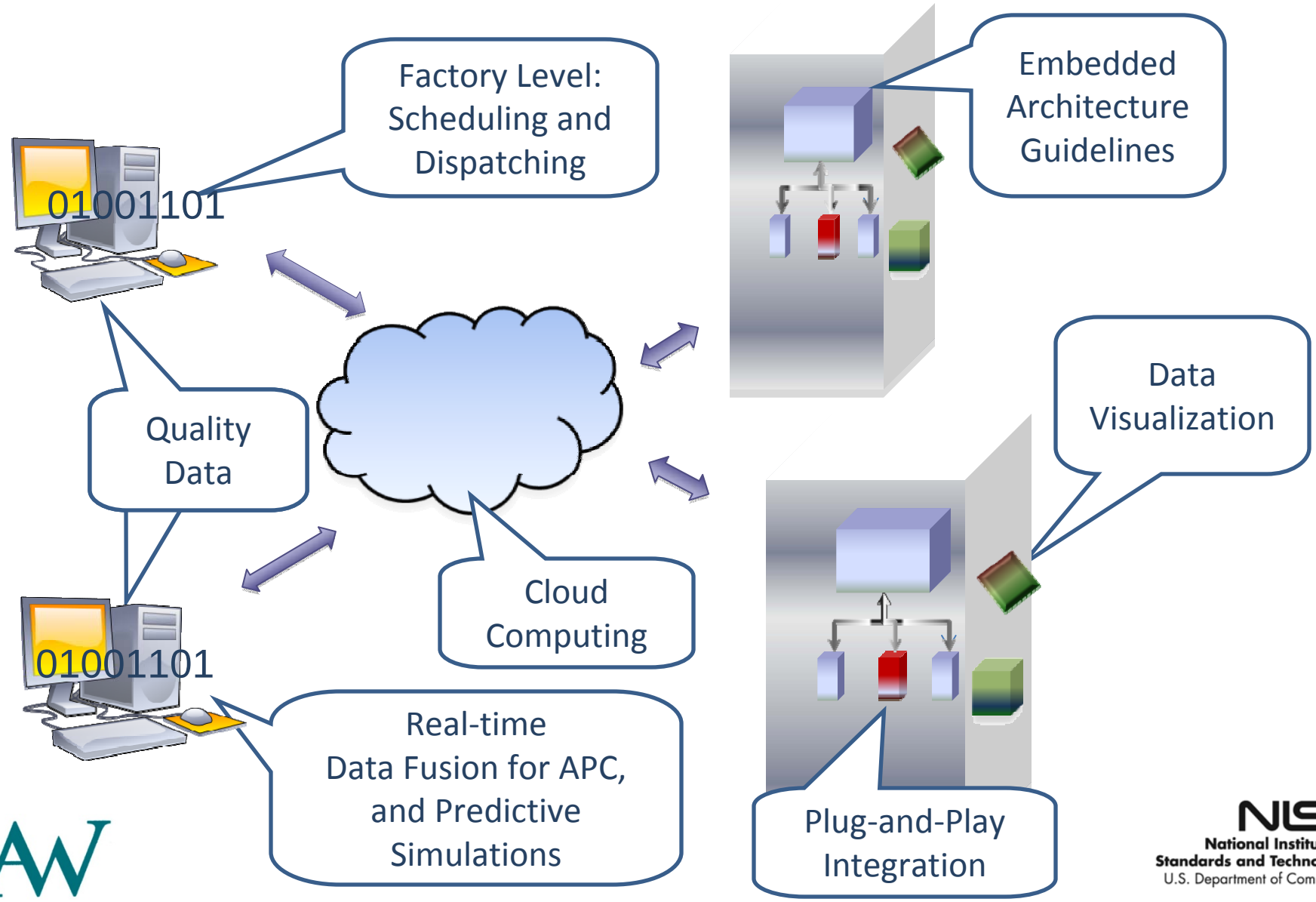
Potential Factory Improvements



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Challenges
Technical

- Physical integration (mounting, signal access) of a sensor is often more difficult than the logical (commands, data) integration
- Knowing whether or not a sensor is providing an accurate measurement (may be the sensor, NOT the process, that's drifting)
- New processes require better data accessibility to understand correlations among parameters and process yield
- Time synchronization of raw data, especially between the separate subsystems within a single tool
- Drawing the lines in a hierarchical control scheme, given the technology to support broadly distributed control
- Building factory-level integrated control systems that can seamlessly incorporate sensor-level information

Challenges
Commercial

- Semiconductor manufacturers and equipment suppliers both feel that detailed equipment/process data is their IP
- Overcoming the "do-it-yourself" mentality with respect to equipment control system design requires more thorough life-cycle analysis
- Add-on sensor projects are heavily ROI driven
  - It's often difficult to get the needed data
  - Equipment suppliers to an established fab have little motivation to change embedded control systems for one-off sensor projects
- Equipment suppliers require more understanding of what data would be necessary and what justifies the need for higher data collection frequency to benefit the process in order to justify ROI

Challenges
Structural

- The independence of semiconductor equipment suppliers works against the objective of having standards-based embedded control systems across the industry
- Developing a new sensor and related control scheme is often [at least] a three-party problem
  - Access to a production fab and its data often the biggest issue
- Standards development process
  - Needs to maintain the pace of technology evolution
  - Should include full validation and adoption support
- There is still a lot to be learned from other industries
  - Even in a "moving target" rapid technology evolution environment

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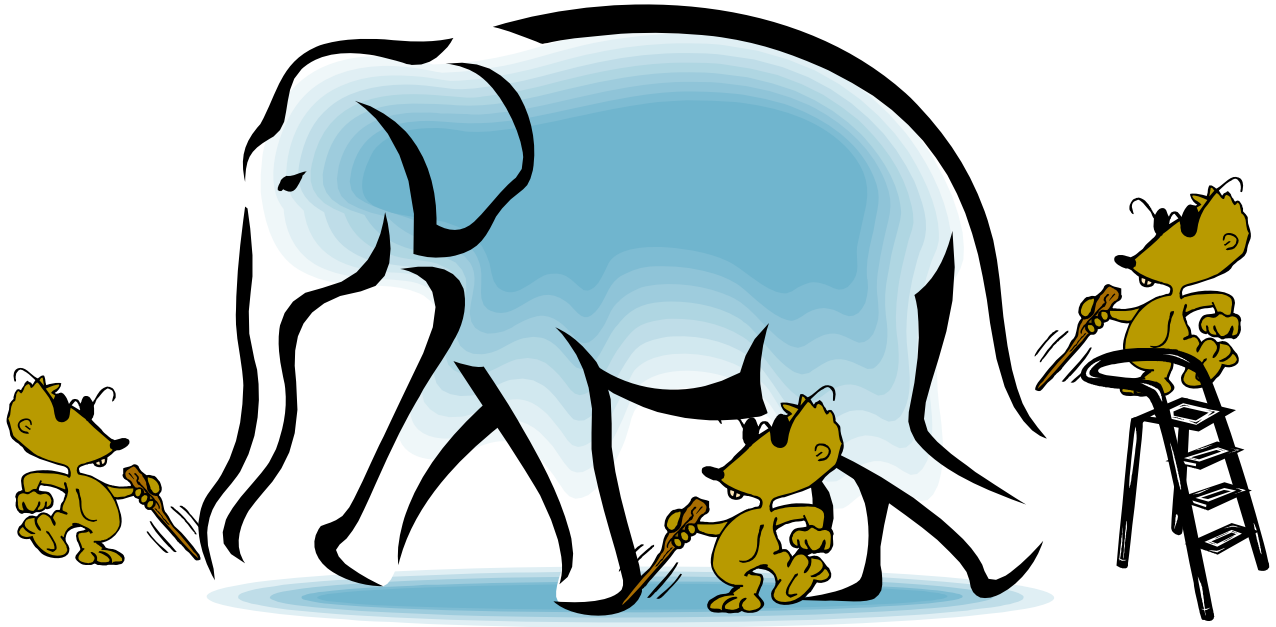
Perspectives

- The problems and opportunities are very different depending on a company's perspective
  - Semiconductor manufacturers
  - Equipment suppliers
  - Sensor, subsystem, and software suppliers



NIST Sensor Network Testbed Goals

- Characterize sensor network data issues
  - Data sources
  - Data communication
  - Data processing (filtering, linearization, compression)
  - Data analysis (dynamic summary statistics in real-time)
- Explore high-risk concepts and technologies
  - Time synchronization of embedded systems (reference implementation)
  - Sensor mote technologies
  - Adaptive learning, self-aware systems
- Prototypes and recommended practices
  - Example "best practice" for embedded control system architecture
  - Configurable reference RF chamber and/or process simulation tools for new sensor validation
  - Pre-standards development and demonstration
  - Standards adoption support (e.g. guidelines for equipment emulators)

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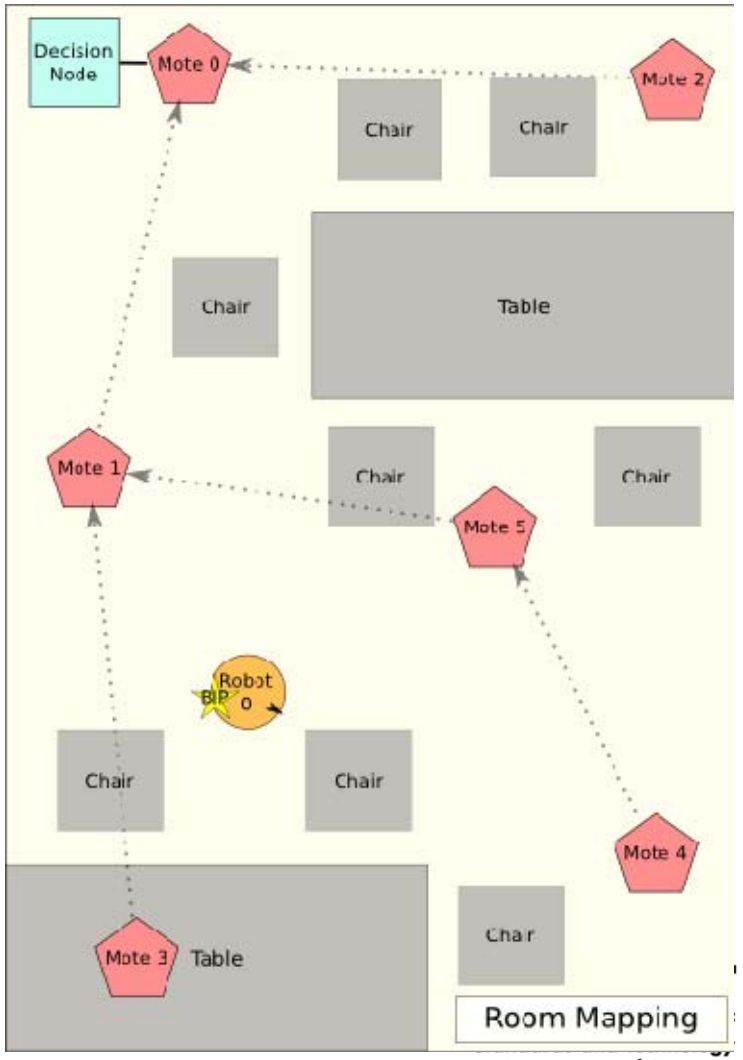
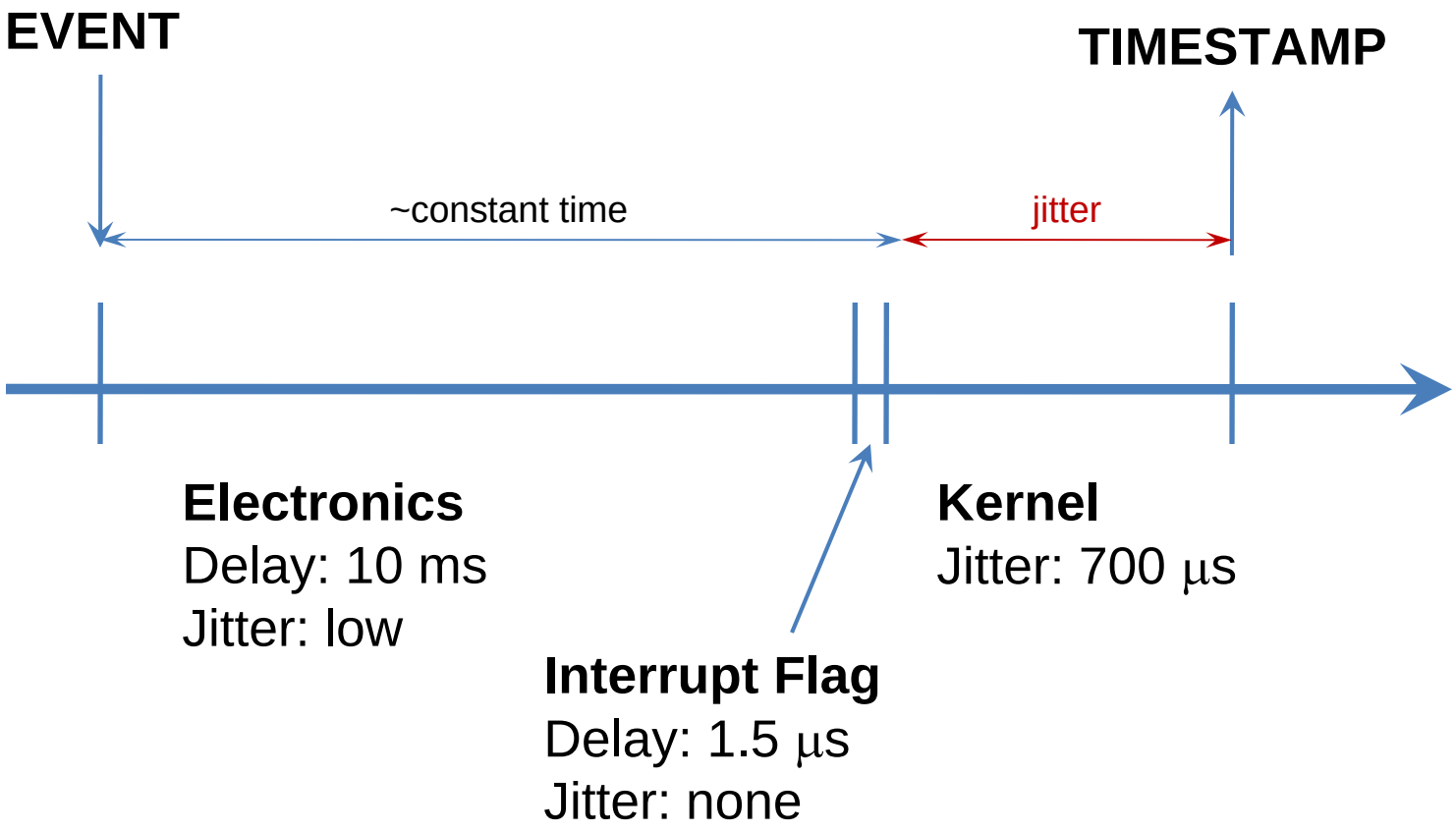
Sensor Network Testbed Setup

- Initial abstraction of issues
  - Time synchronization
  - Sensor time-stamping
  - Data filtering
  - Data fusion
- Components
  - Decision node (data fusion and analysis)
  - Sensor motes (data source)
  - Mobile robots (control)



Characterization of data time-stamping



Research Opportunities

- Sensor Integration
  - Self-description and discovery
  - Interface development
  - Dynamic behavior and required interactions
- Data Acquisition Systems
  - Real-time acquisition
  - Software data filtering techniques
  - Novel user interfaces and visualization
  - Data mining and correlation
  - Data fusion techniques (time-stamping)

Research Opportunities

- Communications
  - Network characterization and performance
  - Wired and wireless
- Equipment Control Systems
  - Finer granularities of control
  - Distributed processing
  - Real-time decision making and adaptive control
  - Improving current programming models (concurrency)
- Standards Adoption
  - Rapid prototyping before and during standards development
  - Guidelines, reference implementation, and compliance testing

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