Cyber-physical view of the Internet of Everything

MEGATRIS COMP. LLC

IoT

IOT is a communication network connecting things which have naming, sensing and processing abilities.

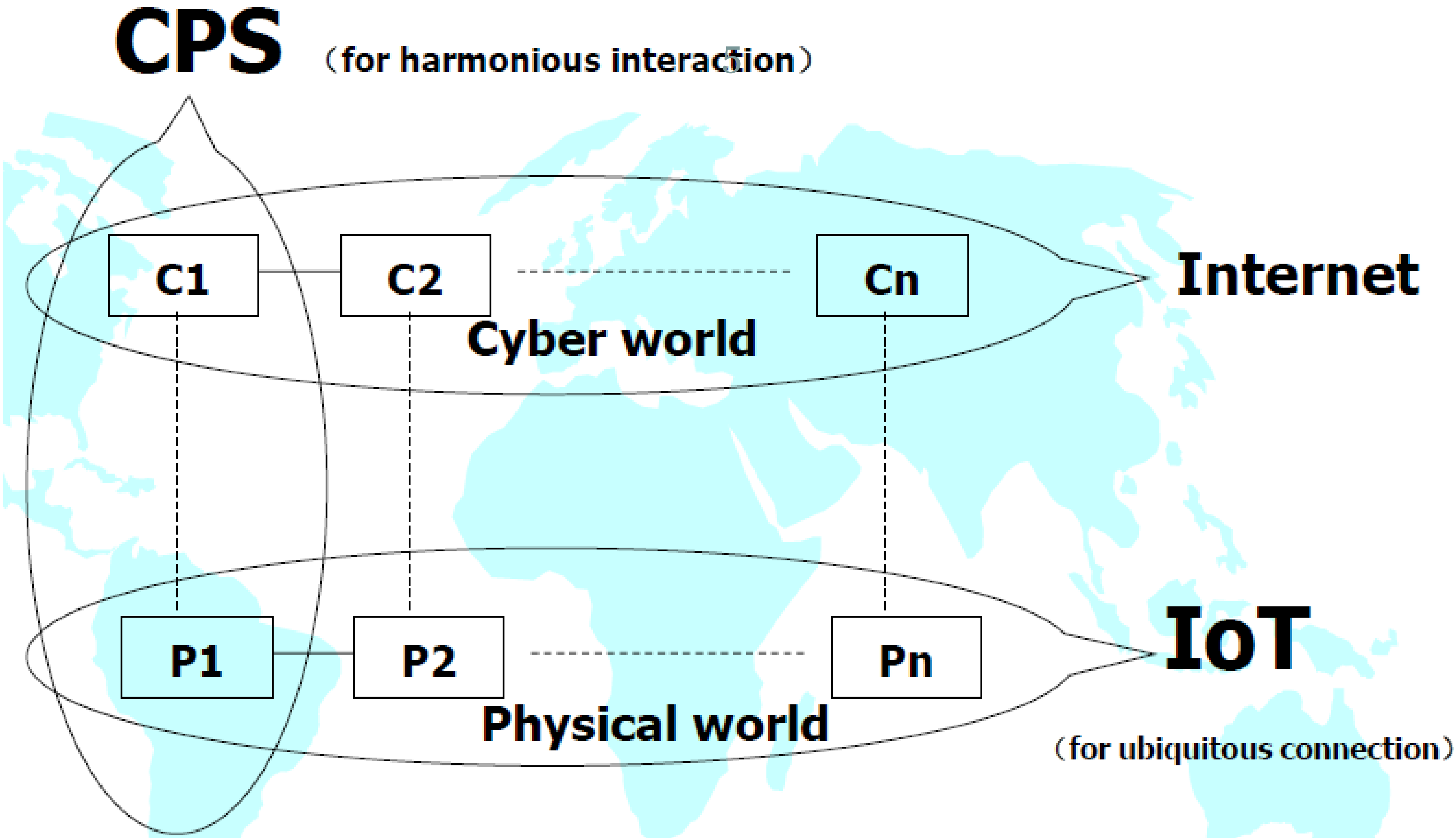
Cyber-Physical Systems

A cyber-physical system (CPS) is an integration of computation with physical processes. Embedded computers and networks monitor and control the physical processes, **usually with feedback loops where physical processes affect computations and vice versa.**

Internet of Everything

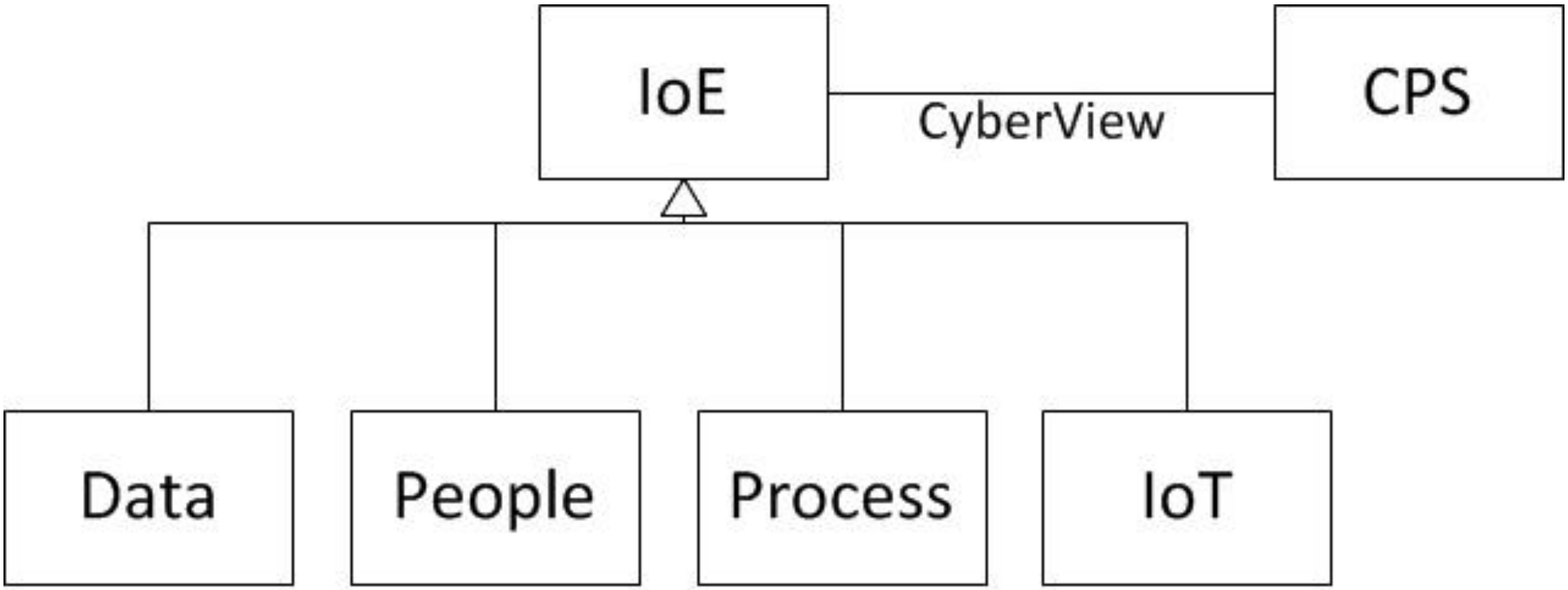
The Internet of Everything is a global entity organized at a high level of self-regulation of interrelationships between business units (enterprises, service centers, …) , individuals and intelligent objects able to cooperate with each other. They conduct various types of effective transactions preserving their independence in view of the shared results or common goals. In this sense, the Internet of Everything can be thought of in terms of organizational capacity potentials that favors rapid aggregation for the exploitation of opportunities.

IoT & CPS



- Cyber world: C=C1 ∨ C2 ∨ ----∨ Cn
- Physical world: P=P1 ∨ P2 ∨------∨ Pn

IoE Structure

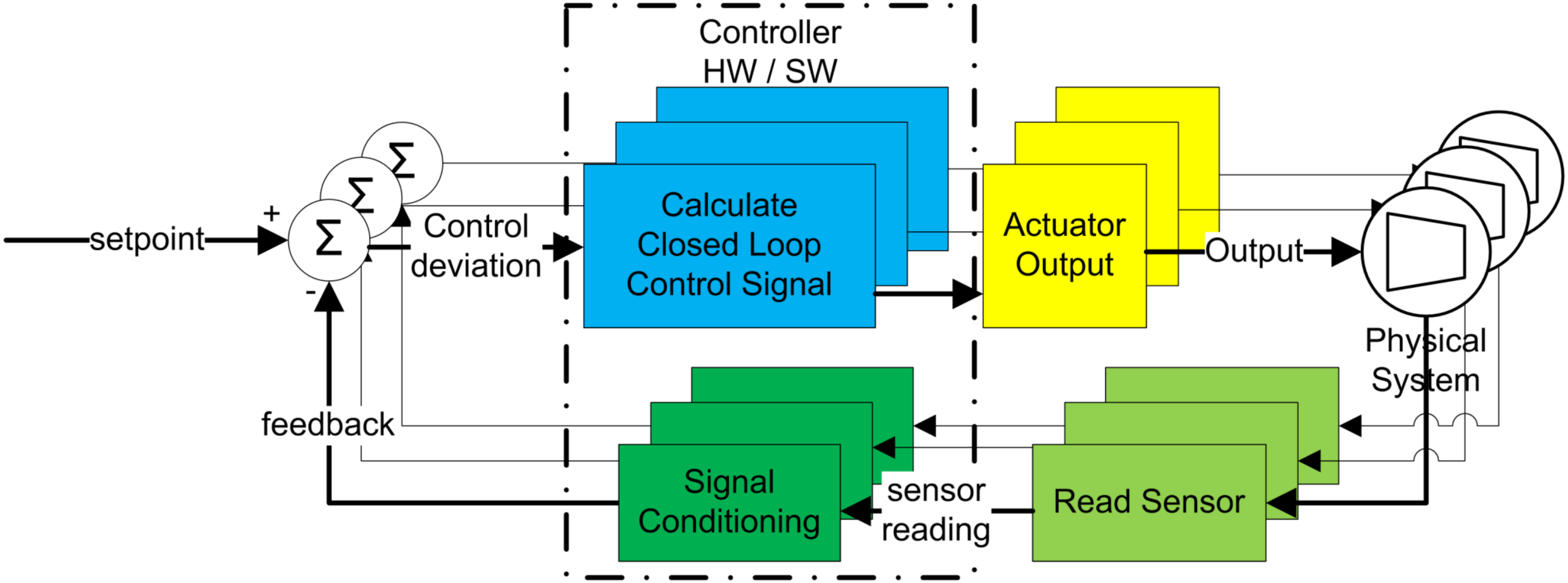


Feedback Systems

Feedback Systems

CPS application often includes algorithms that react to sensor data by issuing control signals via actuators to the physical components of the CPS.

CPS requires extending control theory to embrace the dynamics of software and networks, which can have profound effects on stability and dynamics of the physical subsystems.


Controller
HW / SW
setpoint
+
-
Σ
Control
deviation
Calculate
Closed Loop
Control Signal
Actuator
Output
Output
Physical
System
feedback
Signal
Conditioning
sensor
reading
Read Sensor

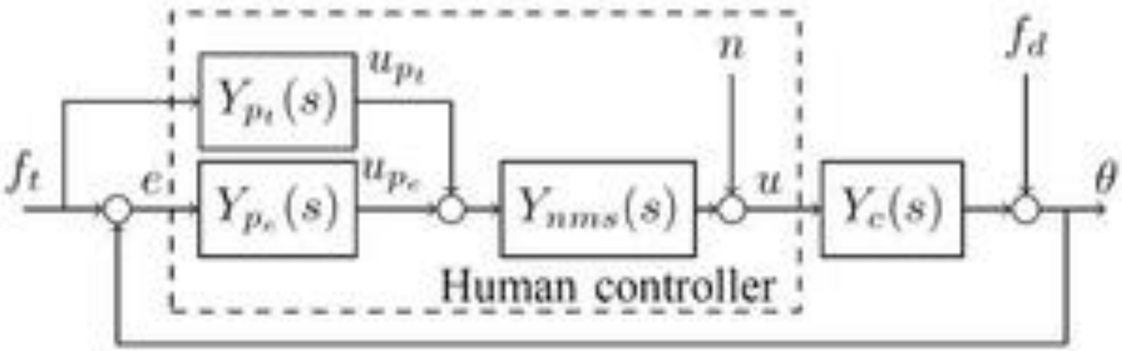
Distributed Homeostatis

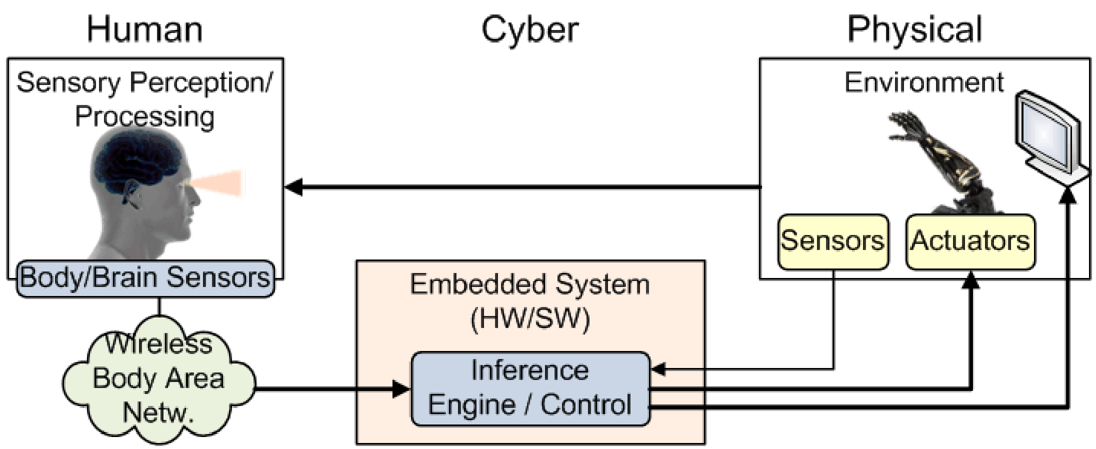
Homeostasis is the property of a system in which variables are regulated so that internal conditions remain stable and relatively constant.

Consesus

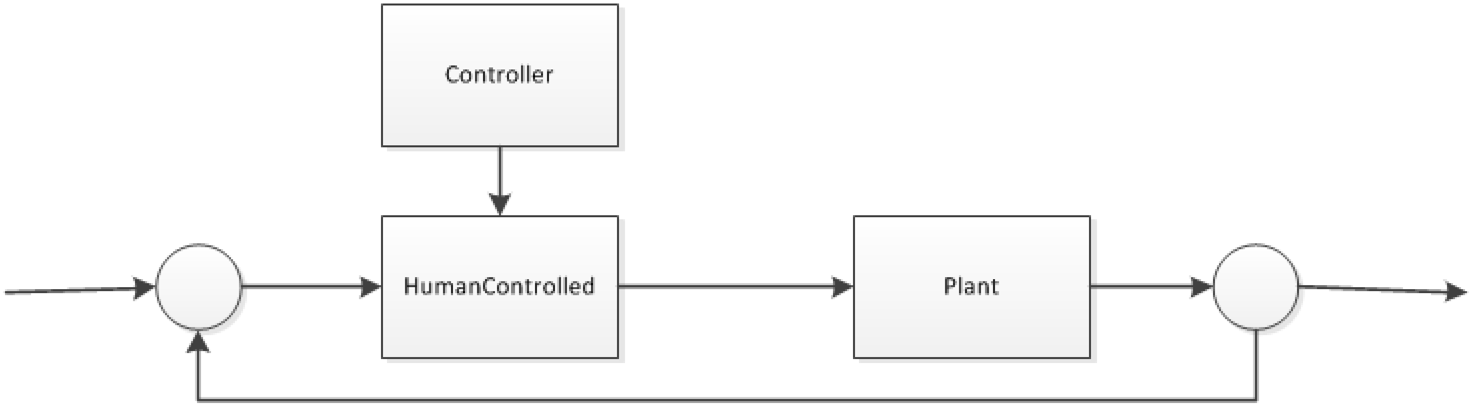
Human in the Loop

Many cyber-physical systems include humans as an integral components.



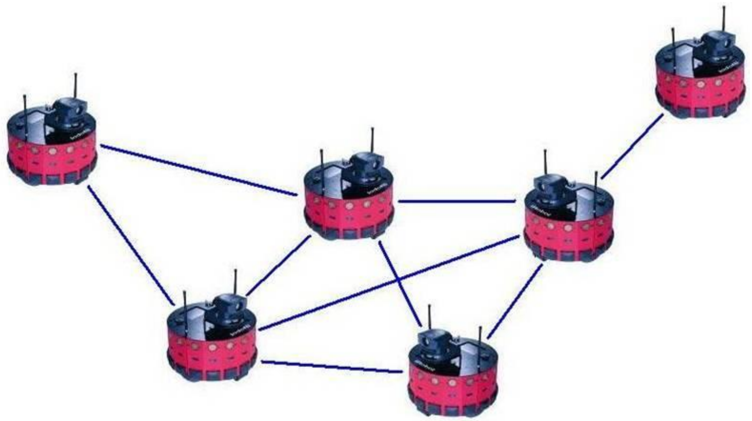


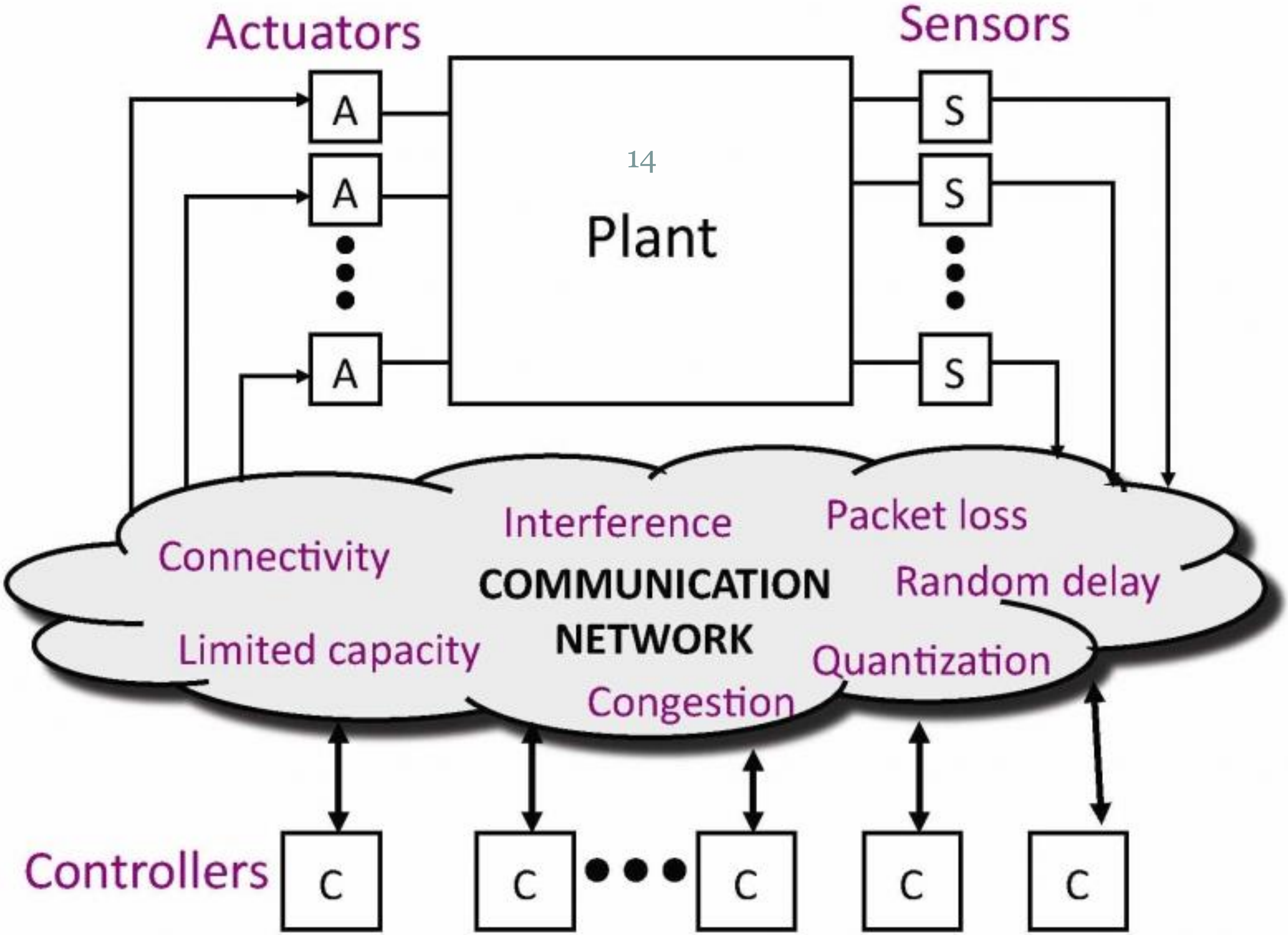
Human in the Loop



Networked Control

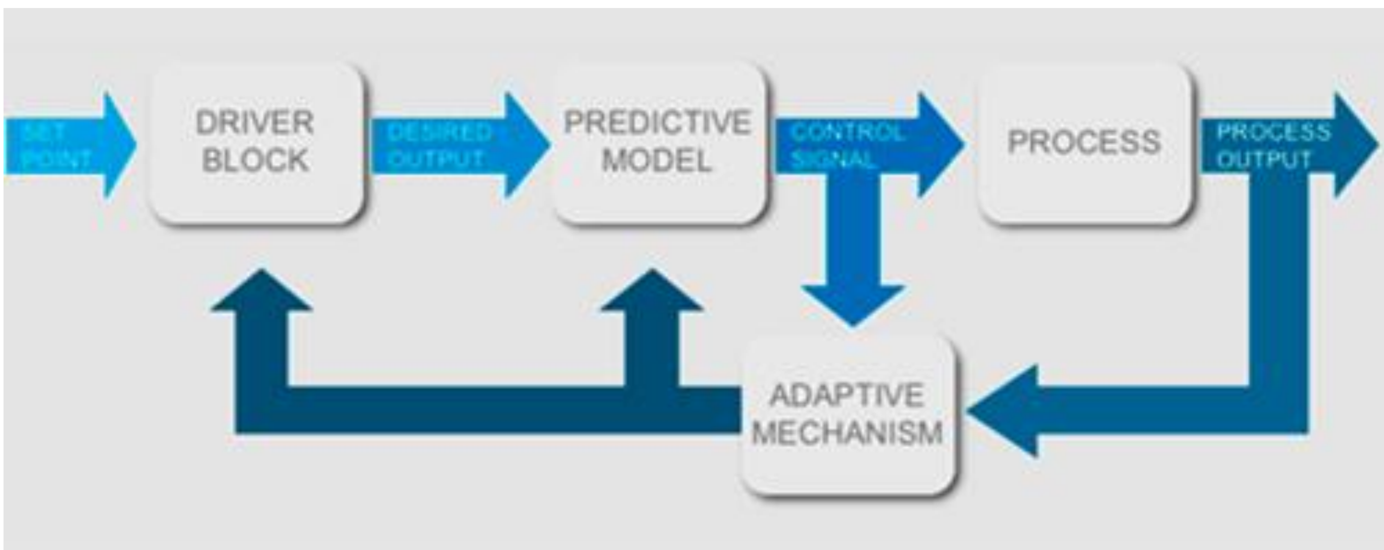
In a typical CPS architecture, the signaling is mediated by software and networks that do not have such continuous or periodic behavior. NCSs differ from more traditional control systems because of their interdisciplinary which requires the convergence of control theory, communications, computer science and software engineering.



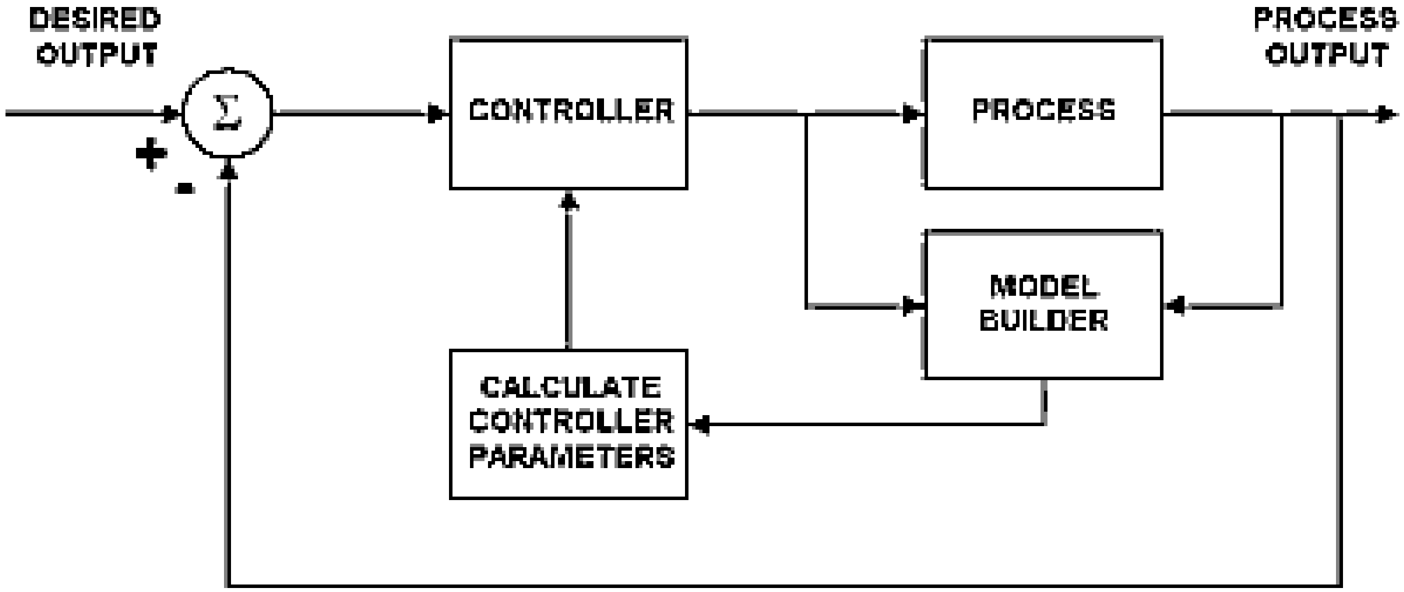

Actuators
Sensors
A
A
A
Plant
S
S
S
Connectivity
Interference
Packet loss
COMMUNICATION
NETWORK
Random delay
Limited capacity
Quantization
Congestion
Controllers
C
C
C
C
C

Adaptive and Predictive

CPS systems are typically closed-loop systems, where sensors make measurements of physical processes, the measurements are processed in the cyber subsystems, which then drive actuators that affect the physical processes. The control strategies implemented in the cyber subsystems need to be adaptive (responding to changing conditions) and predictive (anticipating changes in the physical processes).

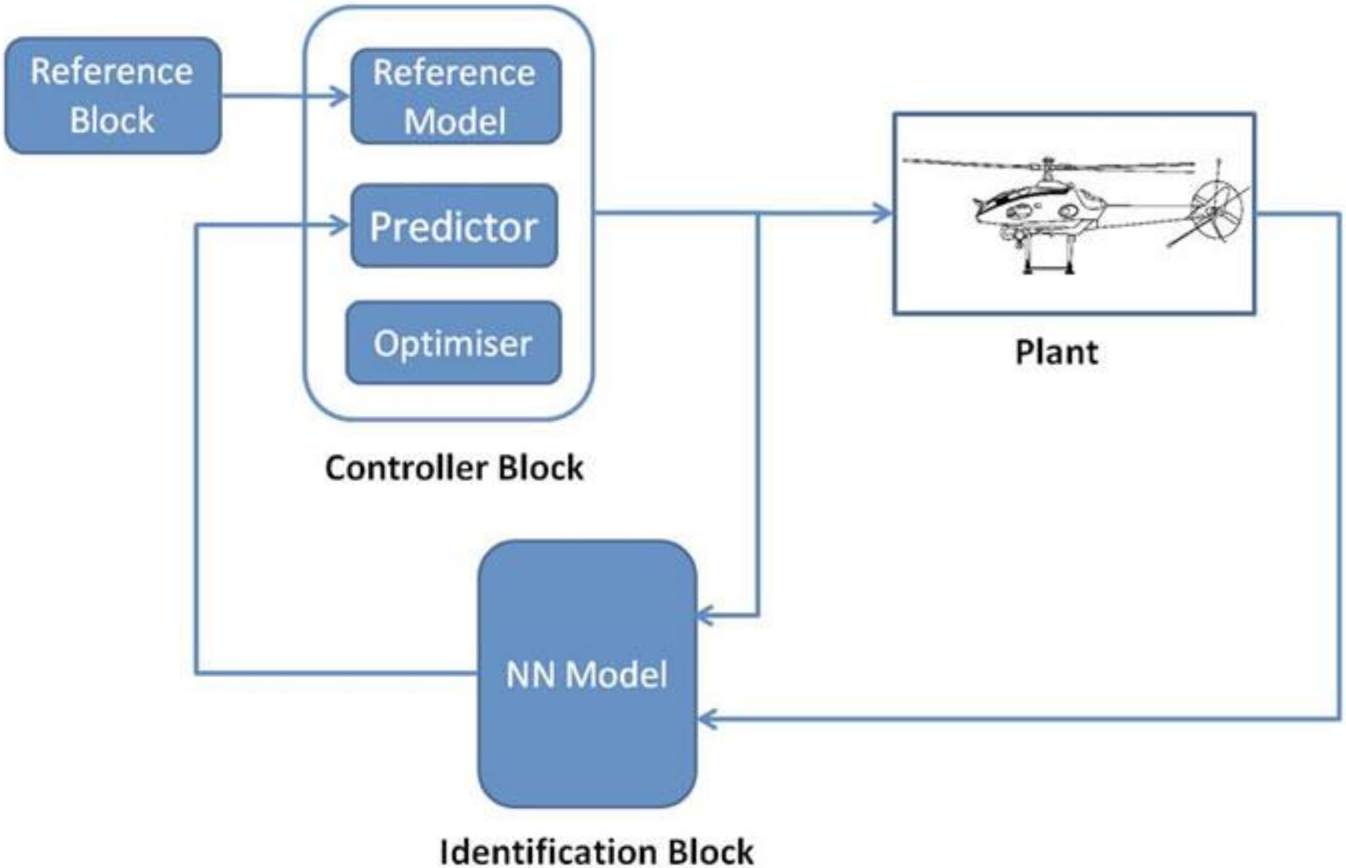


Structure of Adaptive Controllers



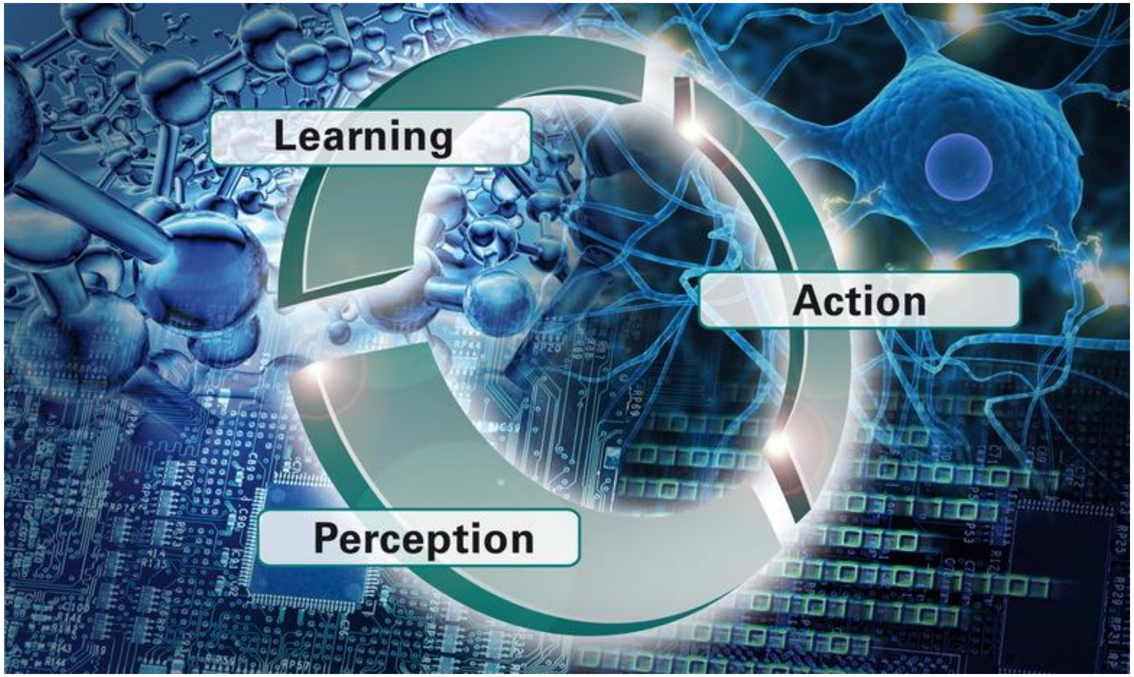
Simplified Schematic of the Structure of Adaptive Controllers

Structure of Predictor Controllers



Intelligent Systems

An intelligent system is a machine with an embedded, Internet-connected computer that has the capacity to gather and analyze data and communicate with other systems.



Real-Time Systems

Cyber-physical systems typically include software that has timing constraints, including tasks that must be executed periodically, deadline constraints, or latency constraints. A key opportunity is to develop programming models for timed systems, and most interestingly for distributed timed systems.

Design Methodology

Specification, Modeling, and Analysis

Cyber-physical systems are intrinsically concurrent. Models of concurrency in the physical world (coexisting physical dynamics in a time continuum) are very different from models of concurrency in software (arbitrary interleaving of sequences of atomic actions), and very different from models of concurrency in networks (asynchronous, partially-ordered discrete actions or clock-driven time slots). Reconciling these divergent models of concurrency, and ensuring interoperability and communication between components that have divergent models of concurrency, is a central problem in CPS.

Hybrid and Heterogeneous Models

A CPS integrates deep-physics models with the digital world. Technologies for co-designing and analyzing hybrid networked systems with integrated cyber, engineered, and human elements center around the divergent abstractions that are used for physical engineered systems, biological systems, human systems, and computation and networking.

Heterogeneity

Cyber-physical systems are intrinsically heterogeneous. There are two distinct approaches to modeling heterogeneous systems:

(1) a **grand unified theory** (GUT) and

(2) an **abstract semantics**.

Grand Unified Theory

GUT is about developing a modeling language and conceptual framework into which heterogeneous modeling languages and frameworks can be translated. The latter is about developing interfaces between heterogeneous modeling languages that are sufficient for interoperation, but not so rich that the interface language itself becomes a modeling language. A GUT has the advantage of enabling model exchange between tools, but the disadvantage that the semantic richness that is required to be able to encompass all interesting heterogeneous modeling languages makes analysis of models difficult.

Abstract Semantics

An abstract semantics has the advantage of enabling composition of domain-specific modeling languages that are themselves sufficiently constrained that analysis is still possible, but the disadvantage that engineers must learn a multiciplicity of modeling languages and must understand how they interact within an abstract semantics.

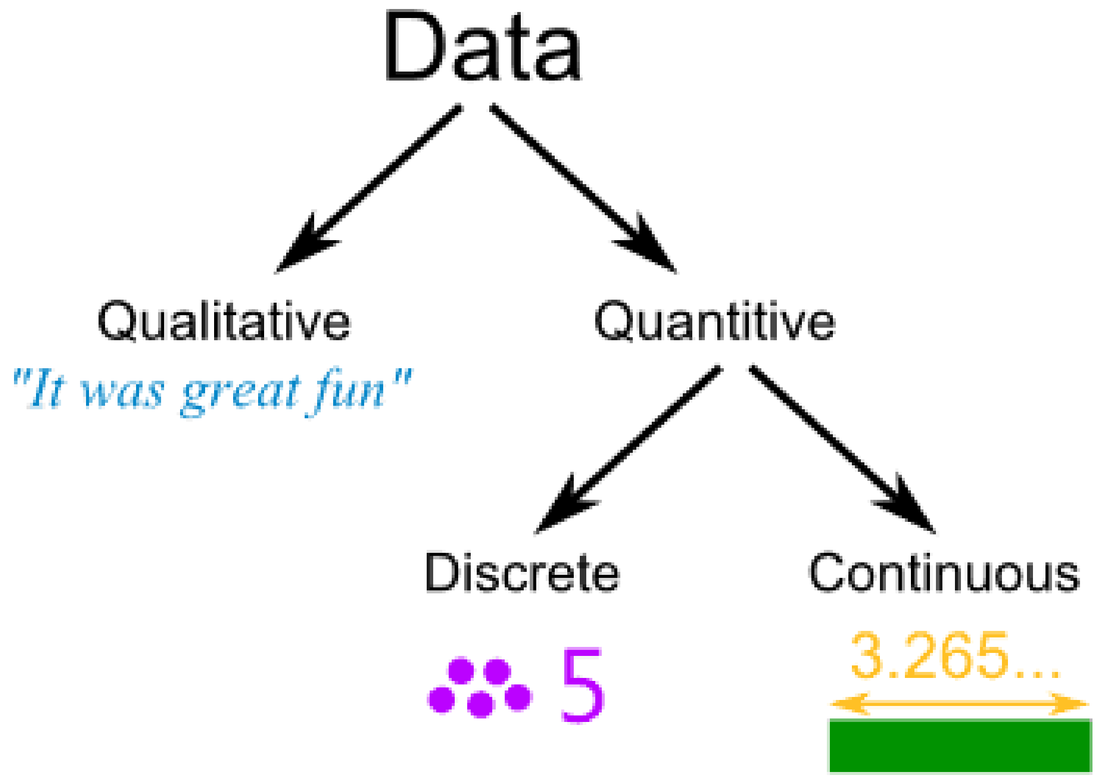
Multiform Time

Central to cyber-physical systems is the interaction between cyber and physical components. These interactions occur in time. A naive model of time, which assumes all players in a system have access to a common, smoothly advancing measurement of time, is usually not adequate. In the context of CPS, models of time must be able to deal with non-homogeneous measurements of time, where different parts of a system may disagree on the current time of day. Models of time must also be capable of making a semantic distinction between continuously evolving processes and discrete state changes.

Models of Computation

Extending classical theories to embrace metric time, to handle multiform time, and to provide concurrency models that match better the concurrency of the physical world is a central CPS problem. For example, when considering software components, the classical software-engineering notion of objects, which interact with one another through procedure calls, might be replaced or supplemented with an "actor-oriented" component model. Actors interact with one another through input-output stimuli rather than procedure calls. An actor reacts to input stimulus by changing state and providing output stimulus that other actors can react to. Many distinct models of computation can be built around this basic notion of actors.

Continuous and Discrete



CeBit 2015: Industrie 4.0, IoT and other enterprise technology trends

HTTP://WWW.THEINQUIRER.NET/INQUIRER/ANALYSIS/2400807/CEBIT-2015-INDUSTRIE-40-IOT-AND-OTHER-ENTERPRISE-TECHNOLOGY-TRENDS

4.0 Industries, IoT

4.0 Industries is about 5G and IoT technologies coming together to take manufacturing, industry and other businesses to the next level.
5G sensors will be everywhere, monitoring the supply chain, manufacturing and quality control, for example.
By crunching all the data that these sensors produce, firms will be able to, say, maintain optimum staff levels at all times and even predict production problems before they occur.

The Internet of Services

A high level of market intelligence, coupled with the analysis provided by big data analytics, multiplied by a global scale, makes that service worth paying for.

Data is fast becoming the new currency, and we're talking about the value of information to feed the ever-growing supercomputers. That's the Internet of Services. Food for the number-crunchers.

The Connected Car

Connected cars were a big theme. For every technology company touting their dashboard solution, there was a car manufacturer (Mercedes and BMW, naturally) demonstrating their own solution.

There are of course many advantages to having a wired car o better fuel consumption, a good computerised interface can open up a whole world of opportunities for the driver.

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