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SRG 7 STUDY REPORT: CYBER-PHYSICAL SYSTEMS (CPS) FOR REAL-TIME IoT

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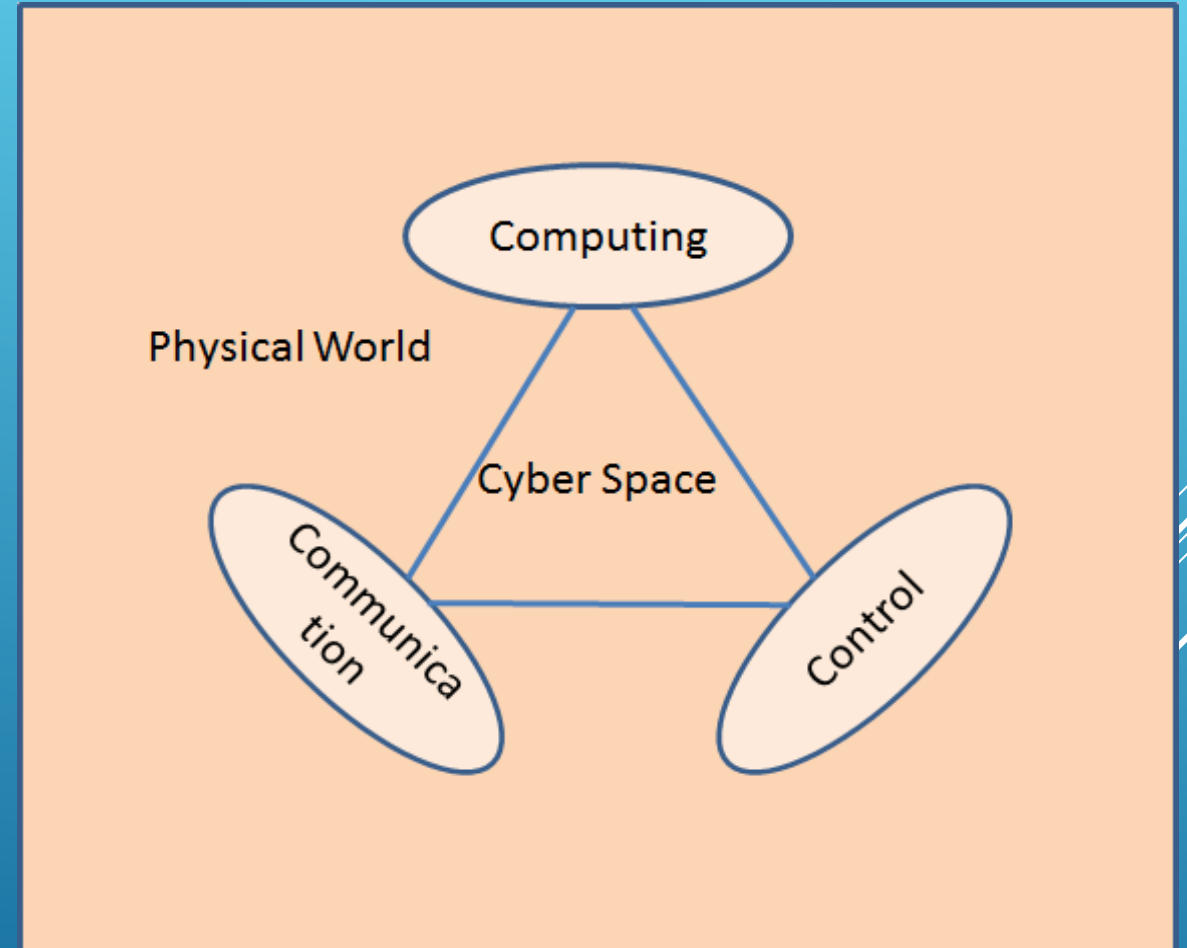
- ▶ Background
 - ▶ What is CPS
 - ▶ What is a real-time system
 - ▶ The framework of real-time IoT system
 - ▶ Why real-time IoT system
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Background

- ▶ At the 5th ISO/IEC JTC 1/WG 10 Meeting, 9-13 May 2016 in Berlin, Germany, ISO/IEC JTC 1/WG 10 approved the establishment of the SRG 7 on Cyber Physical Systems (CPS) for IoT.
 - ▶ The preliminary report was submitted on 20 July.
- ▶ At the 6th ISO/IEC JTC 1/WG 10 Meeting, 5-9 Sep 2016 in Busan, Korea, ISO/IEC JTC 1/WG 10 approved the re-establishment of the SRG 7 on Cyber Physical Systems (CPS) for IoT.
 - ▶ The report was on 17 Jan
- ▶ At the 7th ISO/IEC JTC 1/WG 10 Meeting, 15-17 February 2017 in Santa Clara, USA, ISO/IEC JTC 1/WG 10 approved the re-establishment of the Subgroup Rapporteur Group (SRG) 7 on Cyber Physical Systems (CPS) for Real-Time IoT

What is CPS

- ▶ An engineering system that deeply embeds
 - ▶ **computing,**
 - ▶ **communication, and**
 - ▶ **control**
- ▶ Into the physical system, perceives and controls the physical process through computing process, seamlessly combining **cyber space** and **physical world**.



The first CPS summit

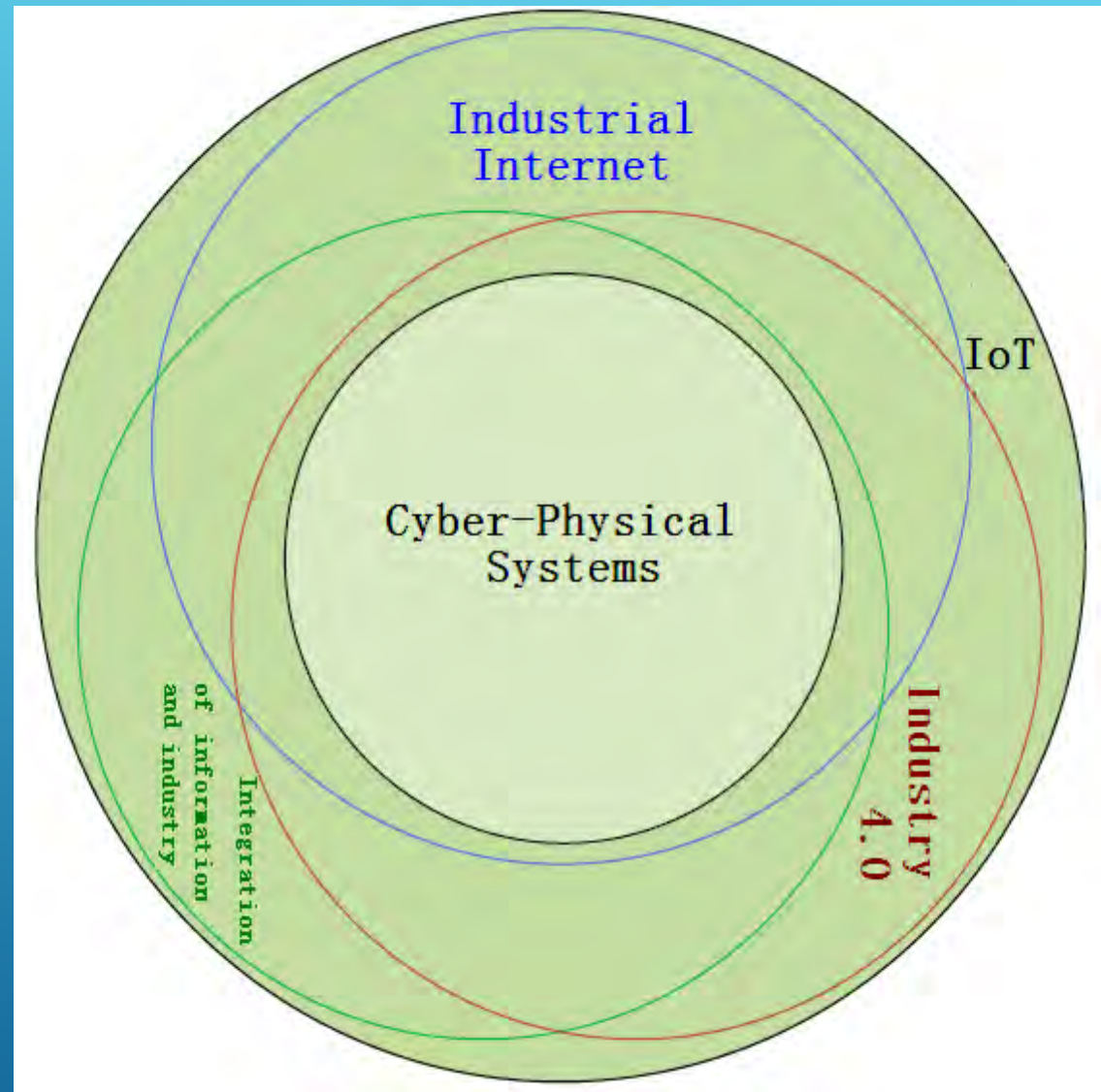
The screenshot shows a web browser window with the following elements:

- Address Bar:** file:///C:/Users/dchen.USAUST-DEJI5420/Desktop/Deji/Tongji/FundingApplication/IoTStanda
- Page Header:** National Science Foundation logo and text "WHERE DISCOVERIES BEGIN". Title: "Cyber-Physical Systems" with date "October 16-17, 2006".
- Navigation Menu (Left):** Home, Organizers, Position Papers, Schedule & Presentations, Working Groups, Registrants, Planning Meeting, Sister Workshops, Original Call for Papers, Hotel Info.
- Main Content:**
 - Quote:** "Cyber-physical systems will transform how we interact with the physical world just like the Internet transformed how we interact with one another."
 - Welcome:** Welcome to the home-page of the proposed NSF research initiative on Cyber-Physical Systems.
 - Initiative Description:** The research initiative on Cyber-Physical Systems seeks new scientific foundations and technologies to enable the rapid and reliable development and integration of computer- and information-centric physical and engineered systems. The goal of the initiative is to usher in a new generation of engineered systems that are highly dependable, efficiently produced, and capable of advanced performance in information, computation, communication, and control.
 - Applications:** Applications for cyber-physical systems can be found in health care (assisted living, bionics, wearable devices, ...), transportation and automotive networks, aerospace and avionics, automated manufacturing, blackout-free electricity generation and distribution, optimization of energy consumption in buildings and vehicles, critical infrastructure monitoring, disaster response, efficient agriculture, environmental science, and personal fitness. Sensing and manipulation of the physical world occurs locally, while control and observability are enabled safely, securely, reliably and in real-time across a virtual network. This capability is referred to as "Globally Virtual, Locally Physical".
 - Workshop Info:** An NSF Workshop on Cyber-Physical Systems was held on October 16 and 17 in Austin, Texas. Position papers have been received (see Call for Position Papers). The workshop slides can be seen at Presentations.
 - NSF Sponsors:** Dr. Wei Zhao, Dr. Usha Varshney

The browser's taskbar at the bottom shows the Windows Start button, several application icons (Internet Explorer, Chrome, File Explorer, Word, PowerPoint, etc.), and the system tray with the date and time: 2:12 AM, 9/27/2015.

CPS is Real-Time IoT

- ▶ **Industrial Internet (II) is IoT**
 - ▶ II renamed as IIoT in 2016.
 - ▶ CPS is the core of II.
 - ▶ CPS is IoT.
- ▶ **Industry 4.0 (I4.0) is IoT**
 - ▶ CPSS is the core of I4.0.
 - ▶ CPS is IoT.



What is a real-time system

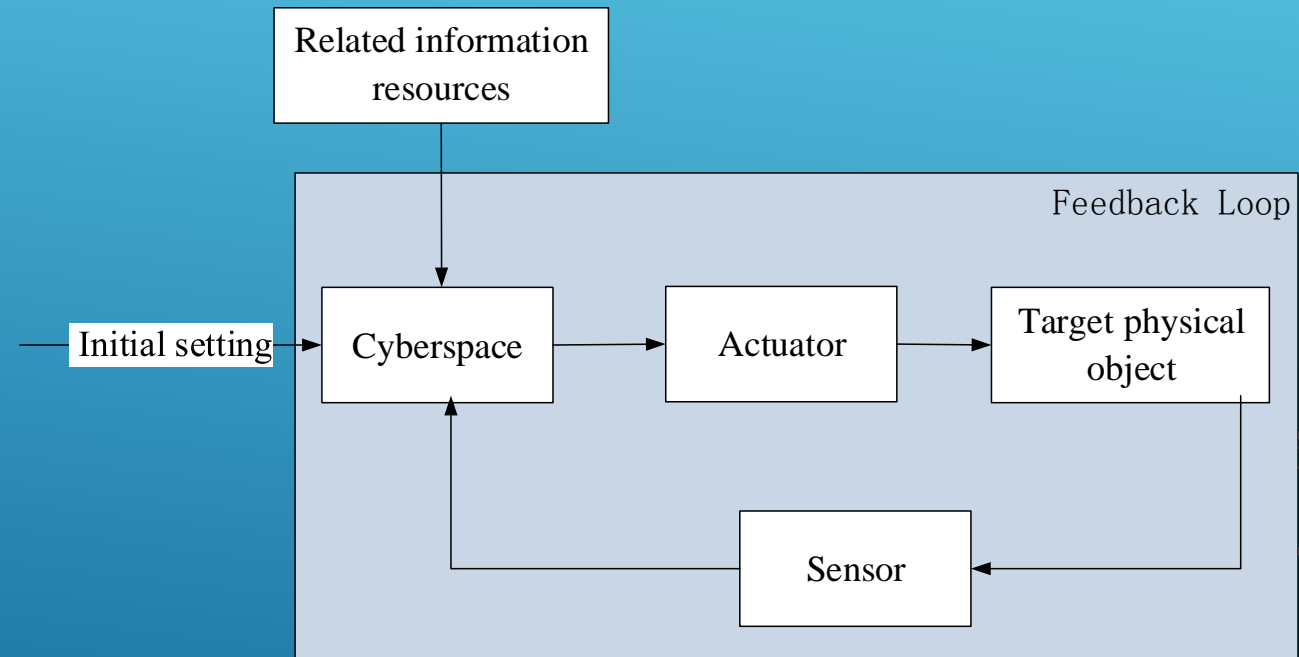
- ▶ A real-time system is a system whose correctness depends on being able to meet timing constraints.
 - ▶ Its correctness depends not only on the logical correctness, but also on the timeliness of its actions.
- ▶ Hard real-time systems
 - ▶ If timing requirements would be violated, the results could be catastrophic.

What is a real-time system

- ▶ Real-time is about deterministic, not about speed
 - ▶ Confusing terms:
 - ▶ deterministic vs predictability
 - ▶ timeliness vs real-time
 - ▶ reliability
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NWIP: The real-Time IoT framework (1/4) - feedback control

- ▶ Control is covered in the IoT architecture, while it is the key component in a real-time IoT system.

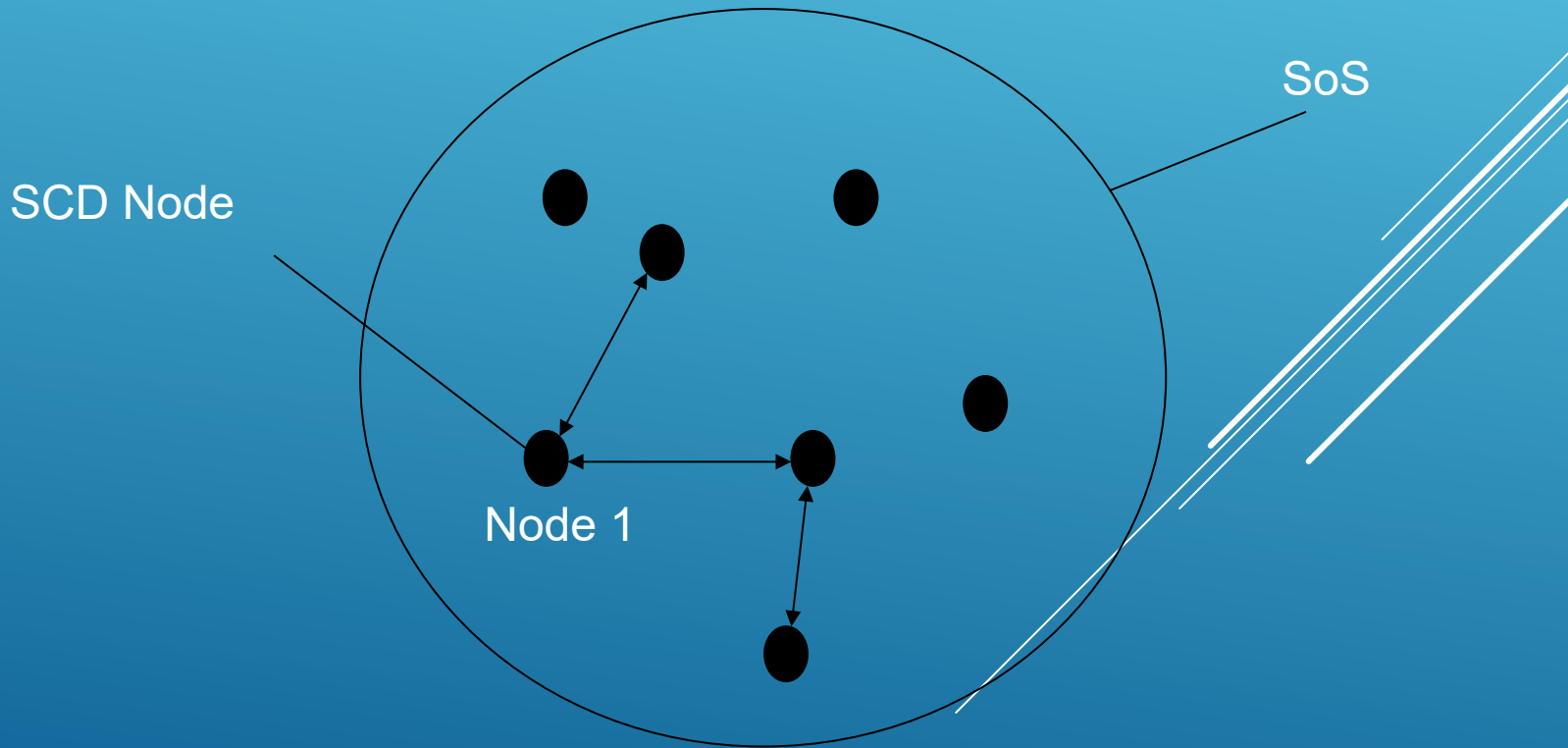
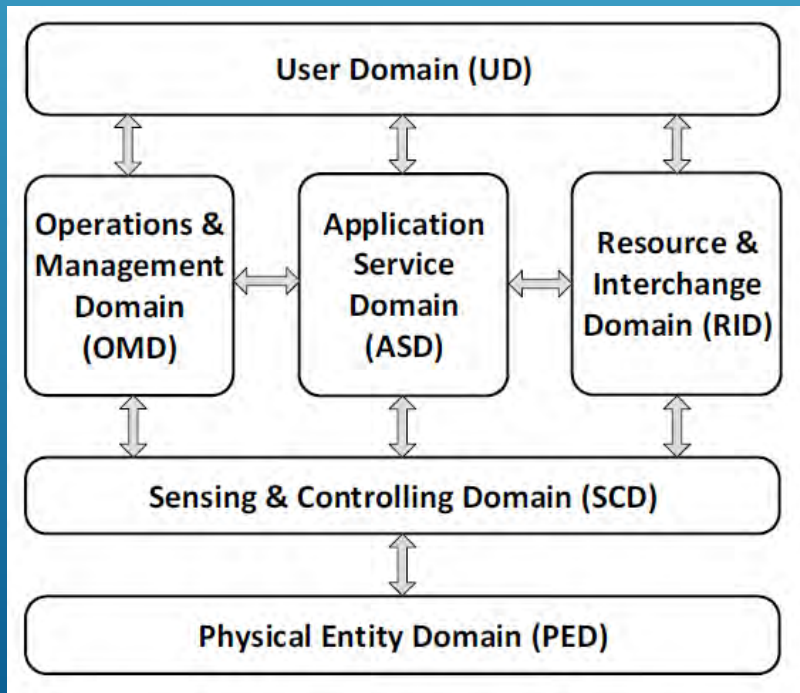


Operating mechanism of the real-time IoT system

NWIP: The real-Time IoT framework (2/4)

- System of systems

- ▶ Multiple SCD modules work alone, yet collaborate with other shared domains to achieve a common goal.



NWIP: The real-Time IoT framework (3/4)

- Real-time

- ▶ Real-time Computing
 - ▶ Real-time Communication
 - ▶ Real-time Control
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NWIP: The real-Time IoT framework (4/4)

– Safety and Security

- ▶ The failure of a real-time system could be catastrophic.

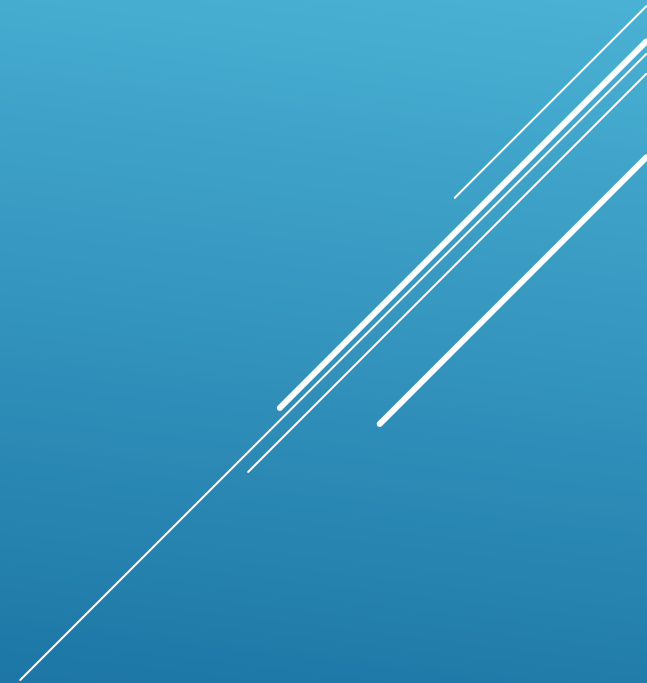
Other standardization opportunities

- ▶ NWIP: Real-time OS.
 - ▶ NWIP: Deterministic network.
 - ▶ NWIP: Real-time wireless sensor network.
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Real-time IoT system metrics

- ▶ Dependability
 - ▶ Connectivity
 - ▶ Dataflow
 - ▶ Device Interaction Patterns
 - ▶ Field Storage
 - ▶ Interface Complexity
 - ▶ Physical Requirements
 - ▶ Development
 - ▶ Services
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WHY REAL-TIME IOT SYSTEM?

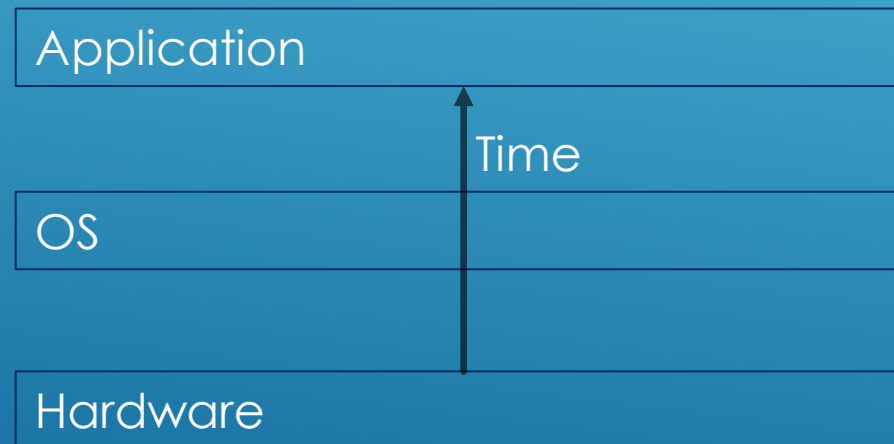


Computer System vs Real-Time system

A real-time system is a computer system that satisfies real-time requirements.

- A task must finish within a specified time, i.e., the deadline.

Yet Real-Time system is treated as a distinct discipline.



IoT System vs Real-Time IoT system

A real-time IoT system is an IoT system that satisfies real-time requirements.

Real-time IoT will expand on IoT's aspects that concern with "time":

- Control


- System of systems

- Real-time

- Safety & Security



Why not just the term CPS?

- ▶ CPS is perceived differently by different people: academia, industry, literature
 - ▶ CPS is called CPPS in I4.0
 - ▶ Real-time IoT covers a broader range than CPS does
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The consequence of no Real-Time Internet

- ▶ Anxiety of IoT using the Internet
 - ▶ No real-time support by the Internet: Net-Neutrality
 - ▶ Hard to add Real-time support as an afterthought: QoS, GENI
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Quote from the 2006 first CPS meeting

- ▶ What would a suitable real-time technology infrastructure look like for the long-term future?
 - Helen Gill
 - ▶ Our answer: Real-time IoT
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