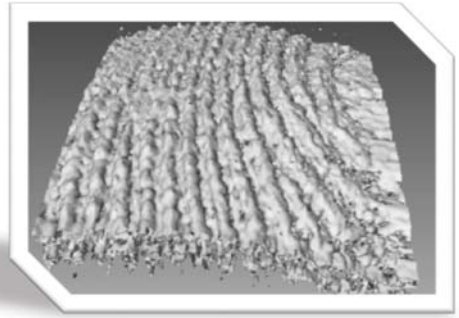

NATIONAL
INSTRUMENTS™

Industrial Needs of CPS Education

Jeff C. Jensen
Senior Product Manager, Real-Time Systems
National Instruments

The Impact of Great Engineering

Saving time,
effort, and money.



Improving quality
of life.

Averting catastrophic
damage.

Diversity of Applications

No Industry >15% of Revenue

Telecom

Academic

Automotive

Semiconductors

Electronics

Computers

ATE

Military/
Aerospace

Advanced
Research

Petrochemical

Food
Processing

Textiles

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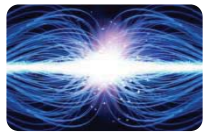
Engineering Grand Challenges

Advance health informatics

Engineer the tools of scientific discovery

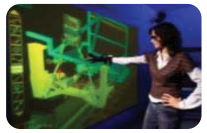
Reverse-engineer the brain



Provide energy from fusion

Engineer better medicines

Provide access to clean water



Enhance virtual reality

Improve urban infrastructure

Develop carbon sequestration methods

Advance personalized learning

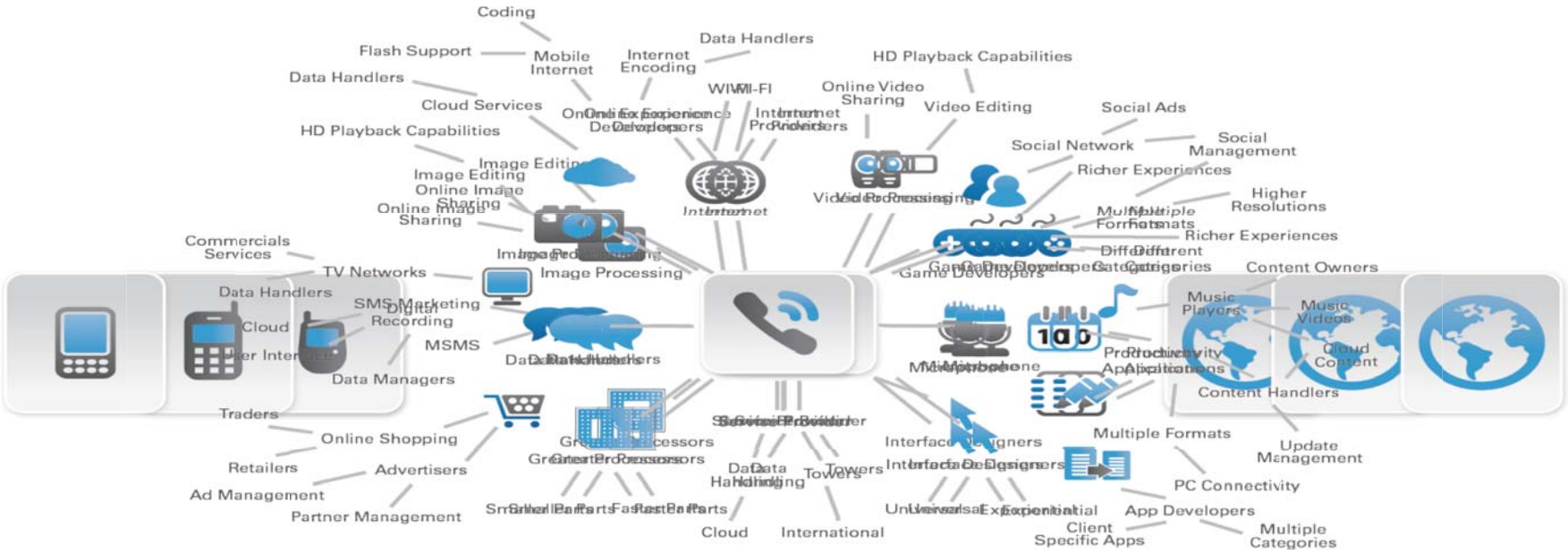
Make solar energy economical

Prevent nuclear terror

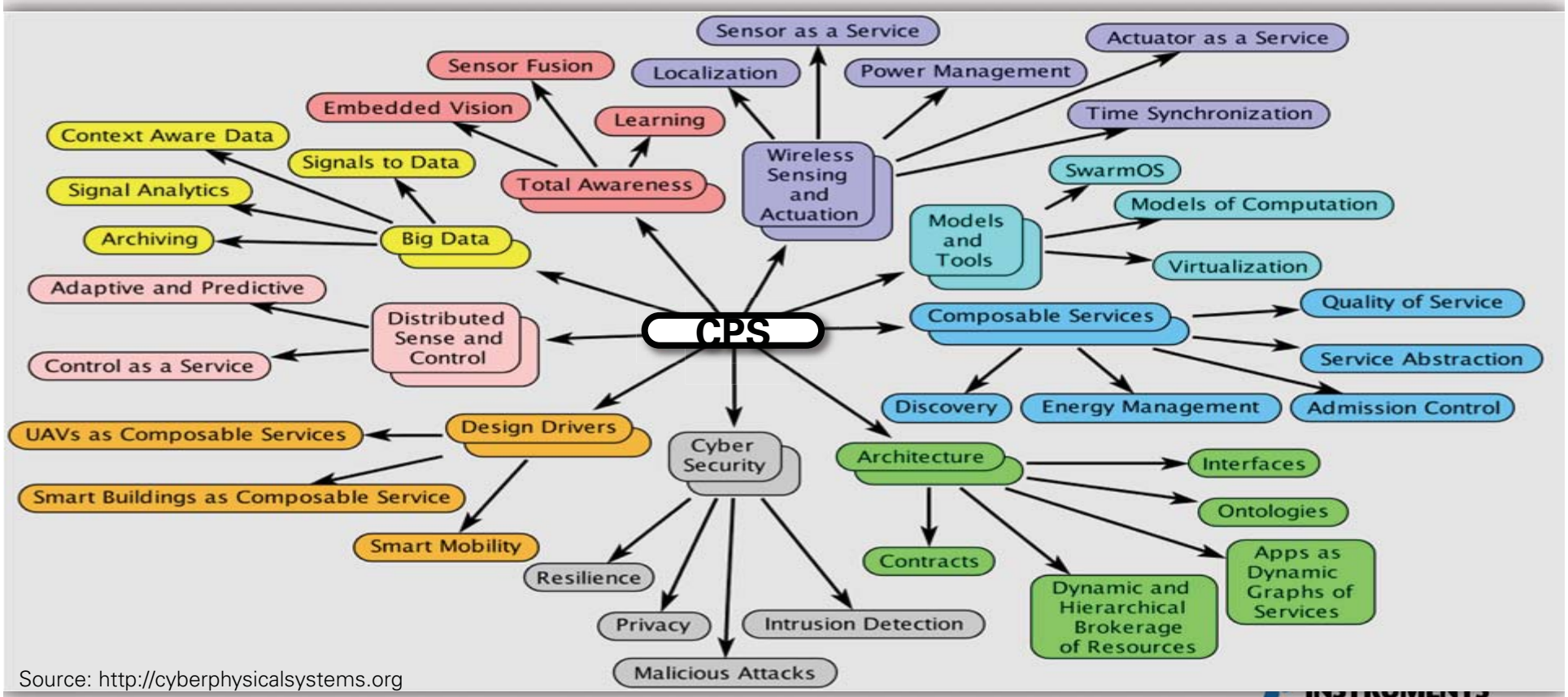
Secure cyberspace

Manage the nitrogen cycle

Escalating Complexity Over Time



Escalating Complexity of Concepts

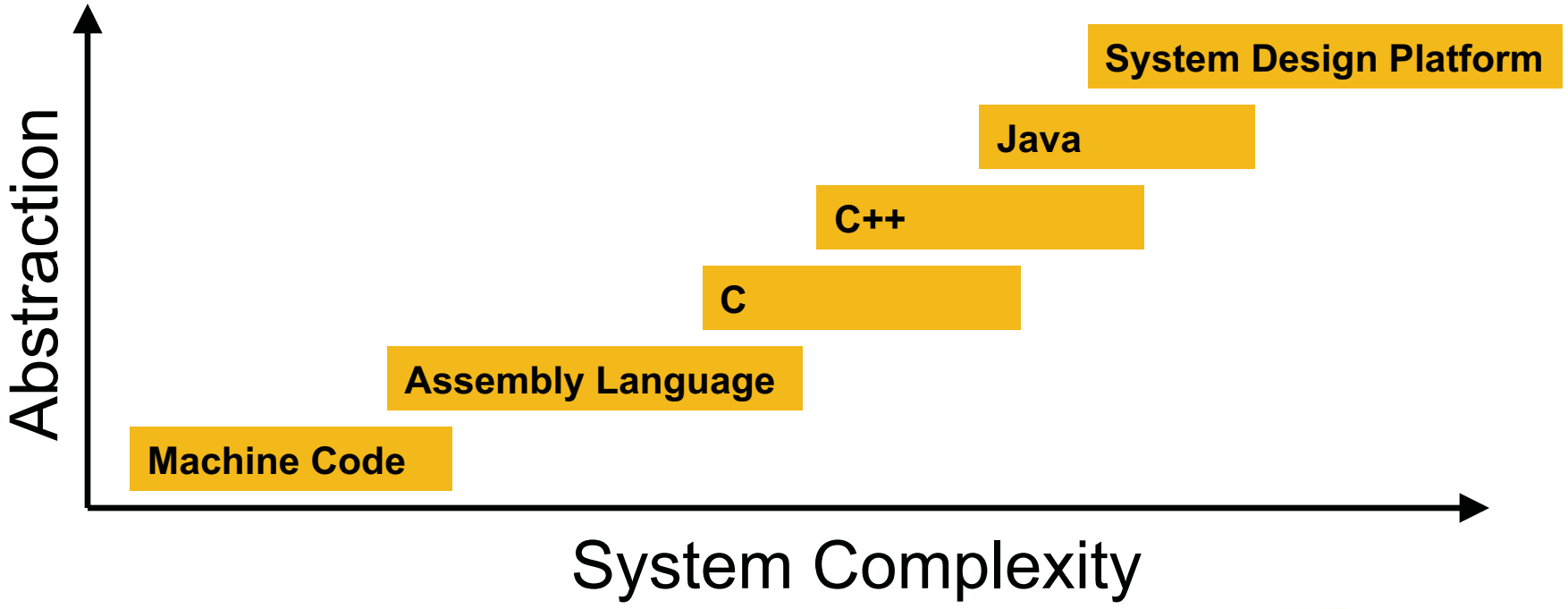


Source: http://cyberphysicalsystems.org

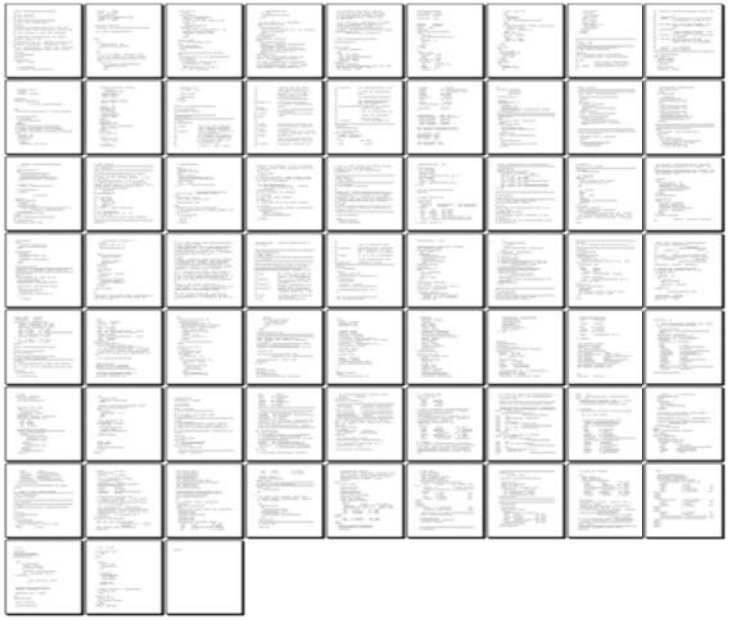
“Today’s students are familiar with abstraction, and virtual worlds, it’s physical intuition and real world constraints that are foreign”

Dr. Mark A. Horowitz
EE Chair, Stanford

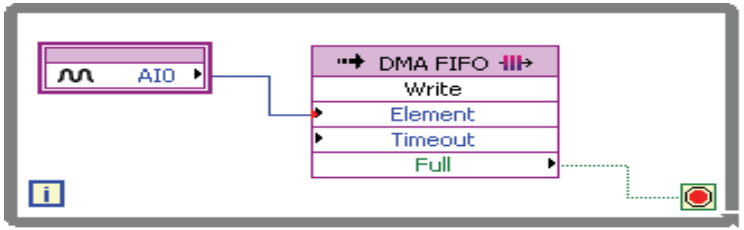
Scalable Software Abstraction



Abstraction to the Pin



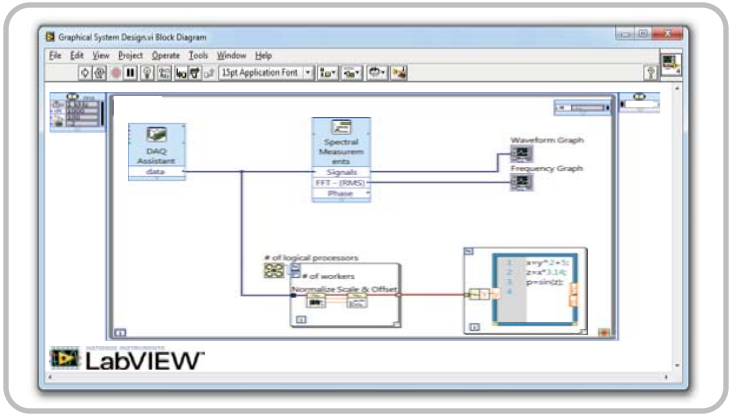
VHDL



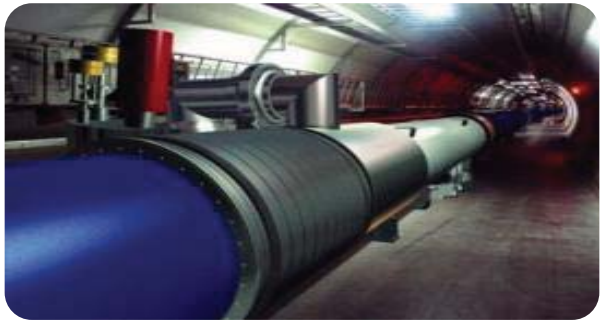
Graphical System Design

The Power of Abstraction

Lego Mindstorms



Graphical System Design



CERN Large Hadron Collider

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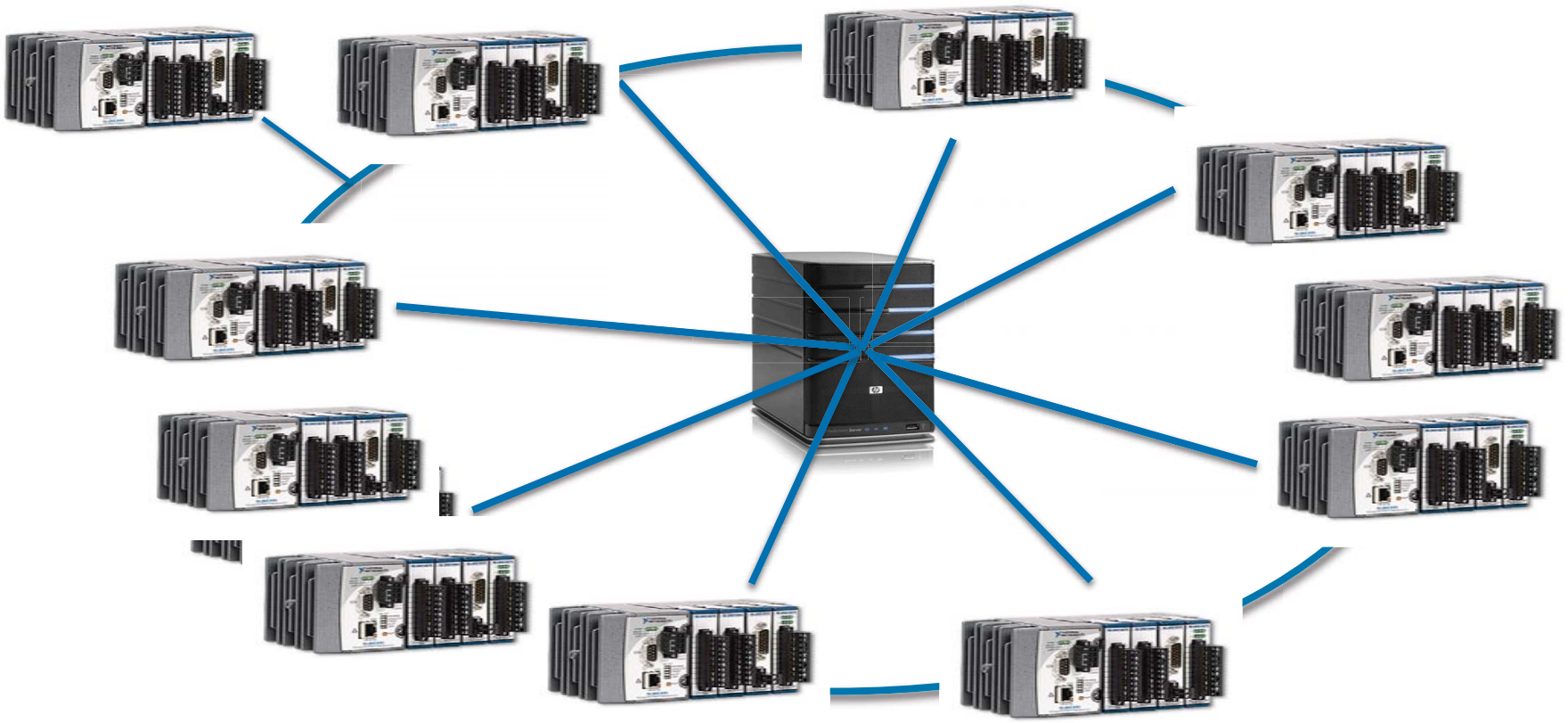
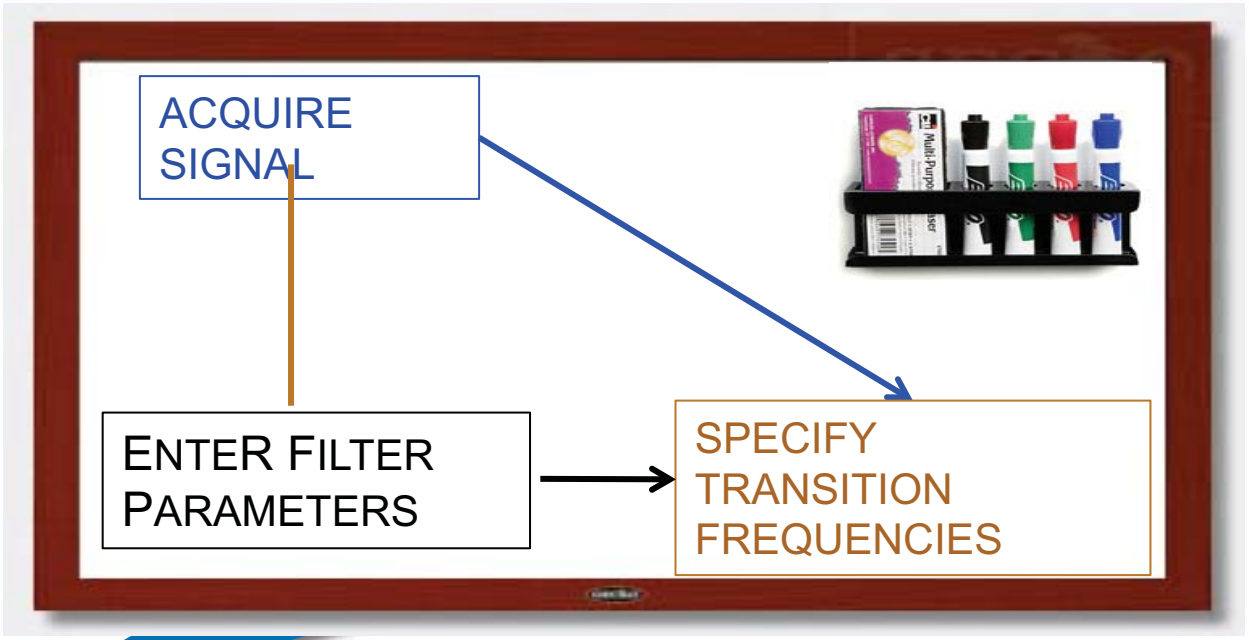
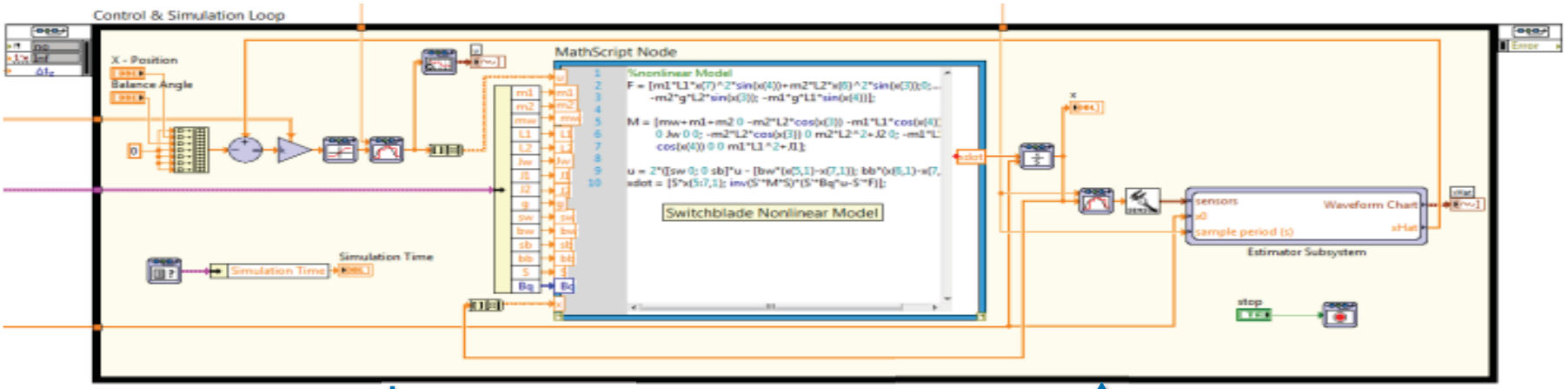


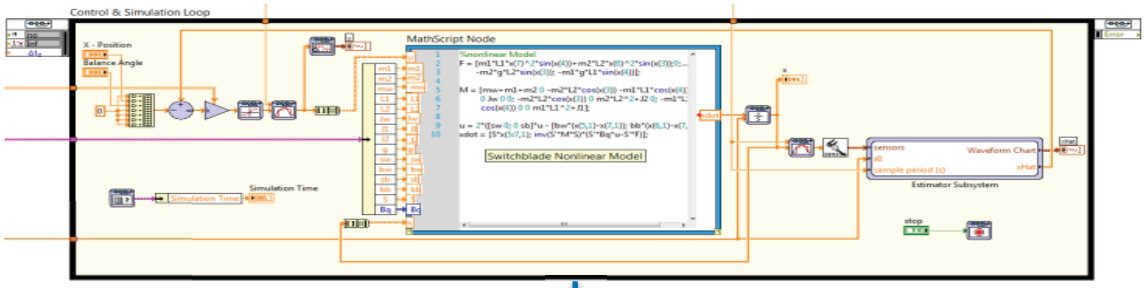

ACQUIRE SIGNAL
ENTER FILTER PARAMETERS
SPECIFY TRANSITION FREQUENCIES



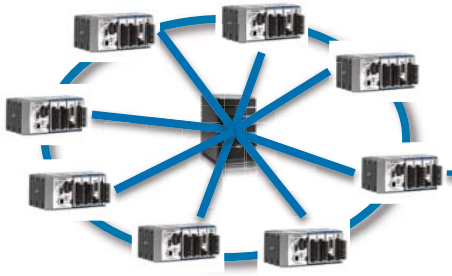
Plant Model

Controller

Controller Model



Plant Model



Network Model

$$\hat{\theta} \in \mathcal{S}(\beta, \theta) \Leftrightarrow \left[t < t_0 \Rightarrow \hat{\theta}(t) = \theta(t) \right]$$
$$\wedge \left| b\frac{d\hat{\theta}(t)}{dt} + J\frac{d^2\hat{\theta}(t)}{dt^2} \right| < K_G \tau_{\text{stall}}$$
$$\wedge \left| \frac{d\hat{\theta}(t)}{dt} \right| < K_G \omega_{\text{stall}}$$
$$\wedge \ \textbf{Success}(\beta, \hat{\theta})$$

Formal Verification

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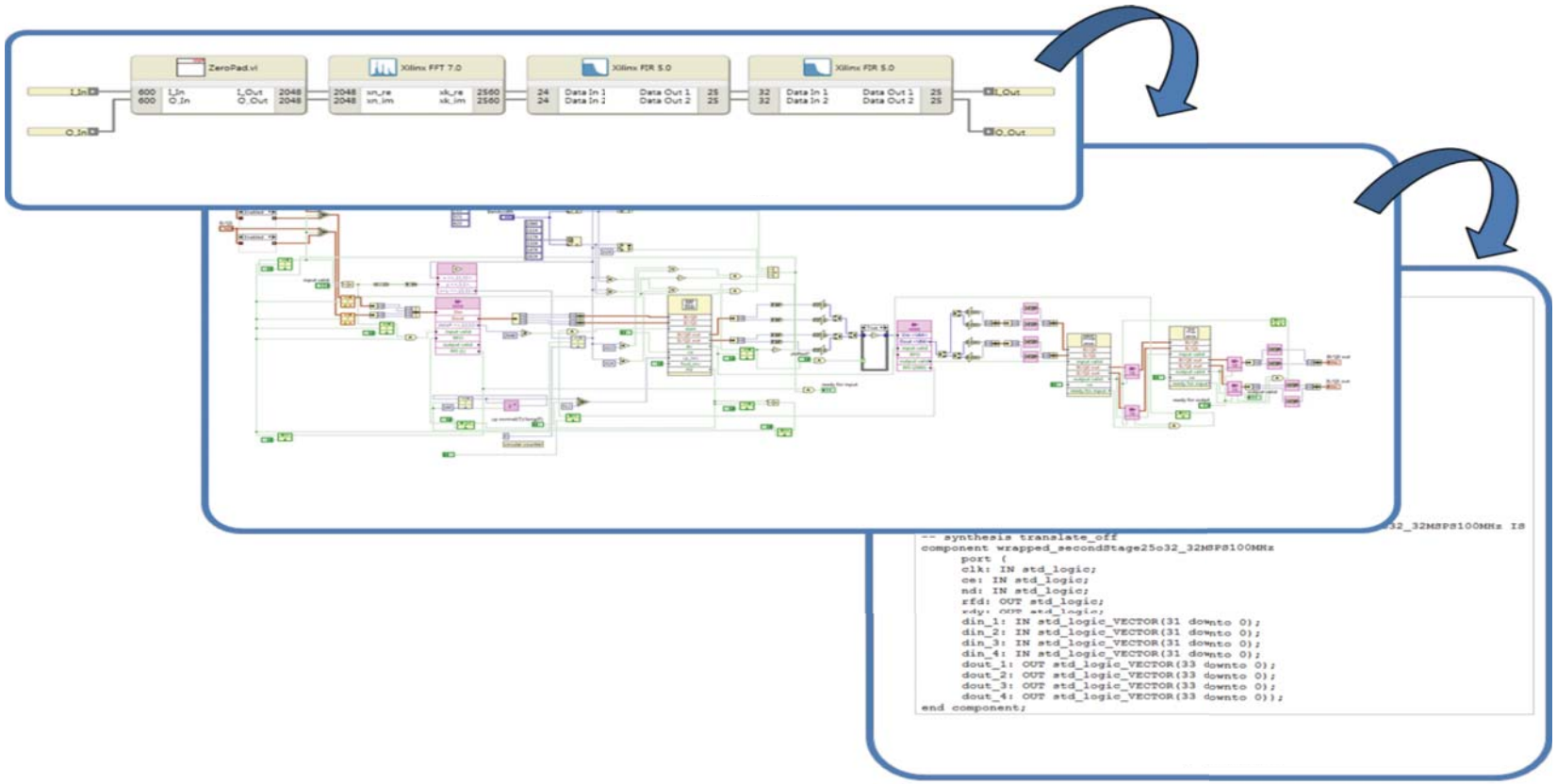
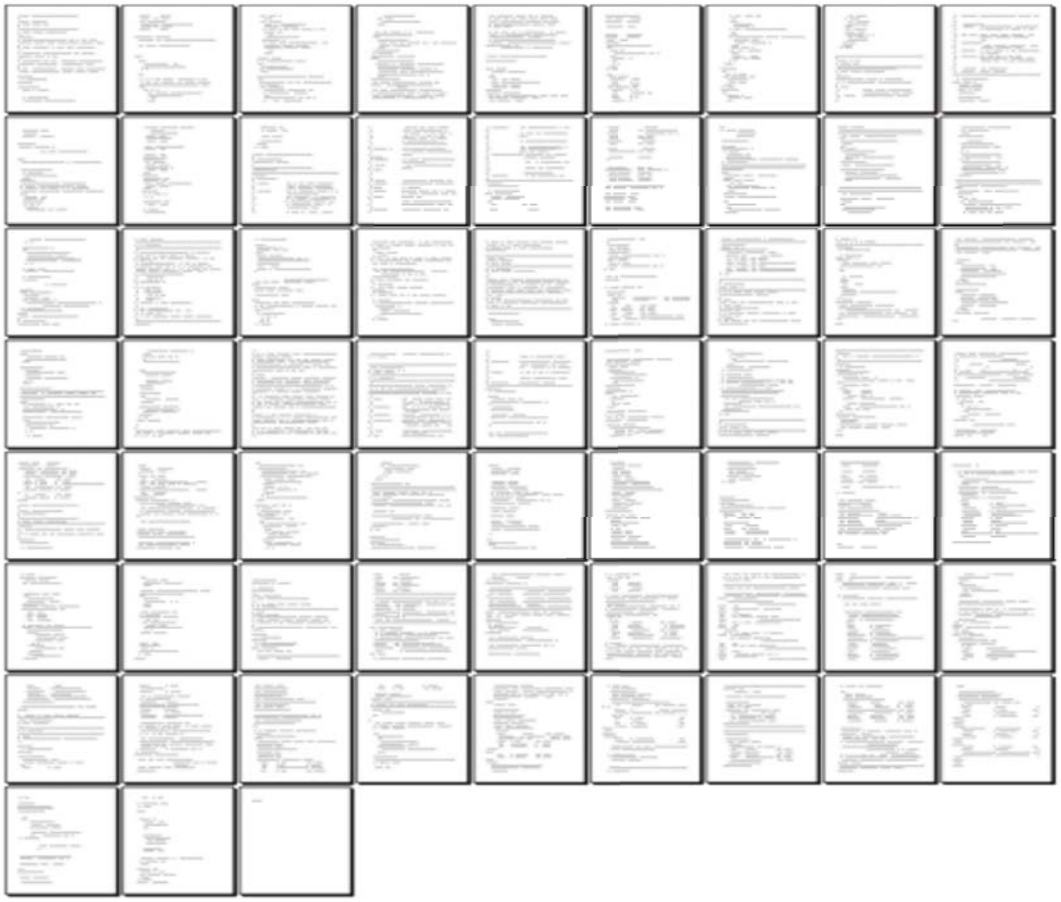
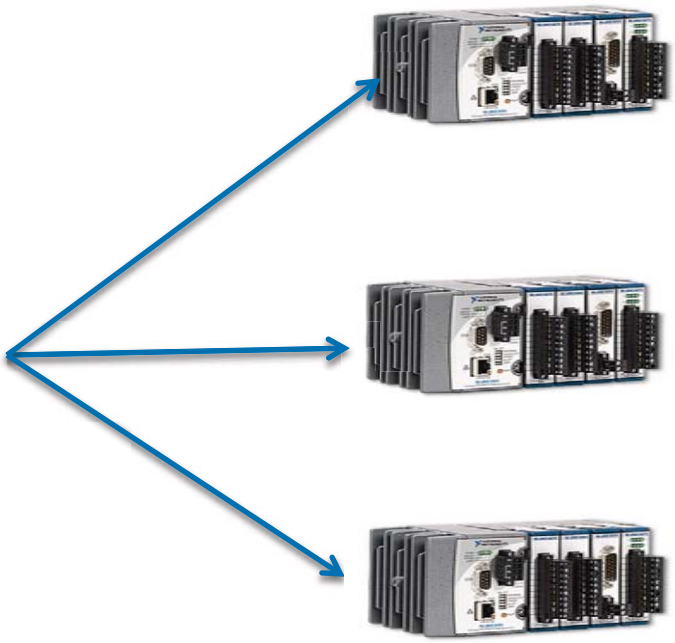

ZeroPad.vi
Xilinx FFT 7.0
Xilinx FDR 5.0
Xilinx FDR 5.0
I_In
O_In
I_Out
O_Out
-- synthesis translate_off
component wrapped_secondStage25o32_32MSPS100MHz
port (
clk: IN std_logic;
ce: IN std_logic;
nd: IN std_logic;
rfd: OUT std_logic;
din_1: IN std_logic_VECTOR(31 downto 0);
din_2: IN std_logic_VECTOR(31 downto 0);
din_3: IN std_logic_VECTOR(31 downto 0);
din_4: IN std_logic_VECTOR(31 downto 0);
dout_1: OUT std_logic_VECTOR(33 downto 0);
dout_2: OUT std_logic_VECTOR(33 downto 0);
dout_3: OUT std_logic_VECTOR(33 downto 0);
dout_4: OUT std_logic_VECTOR(33 downto 0));
end component;





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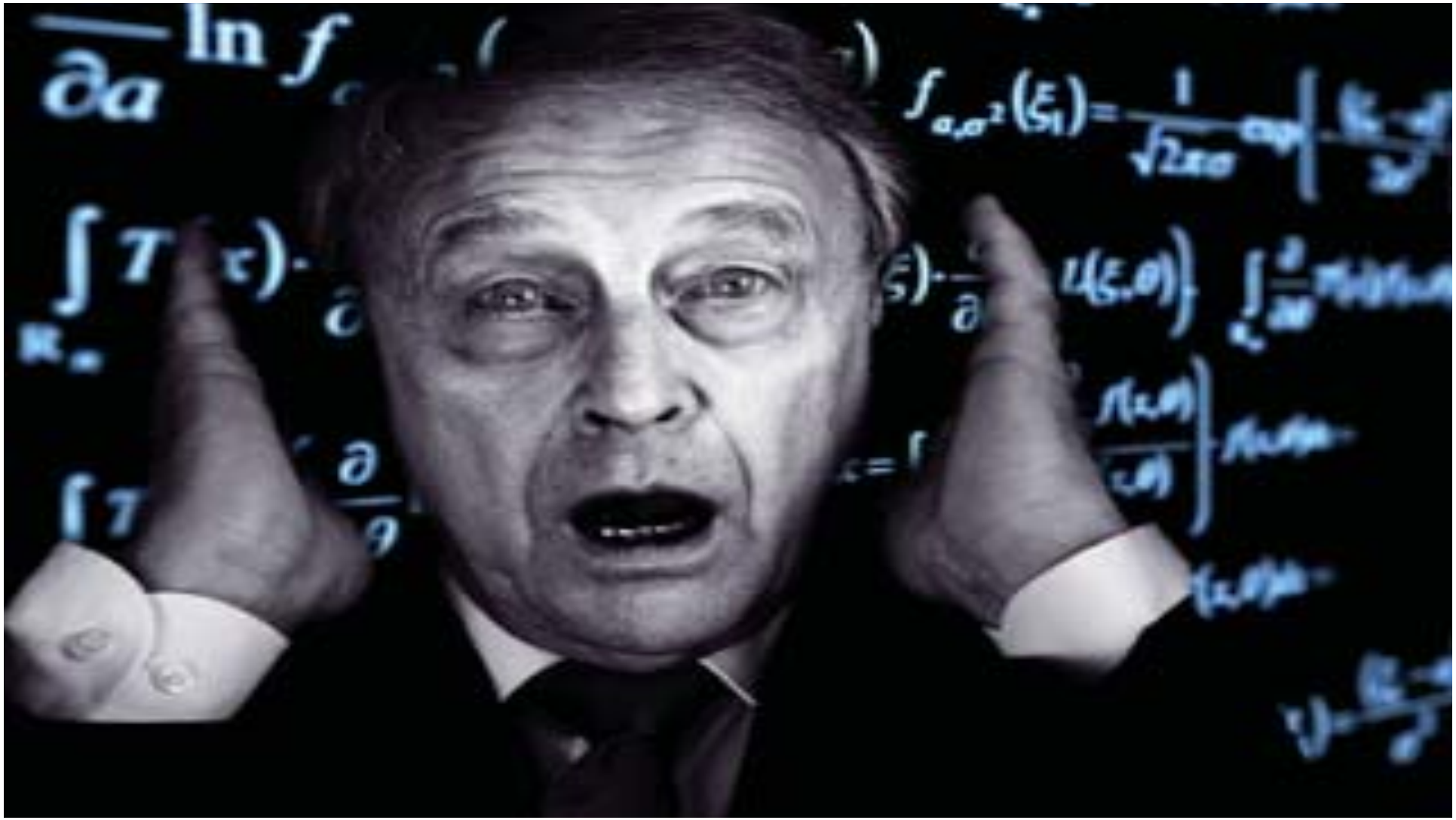
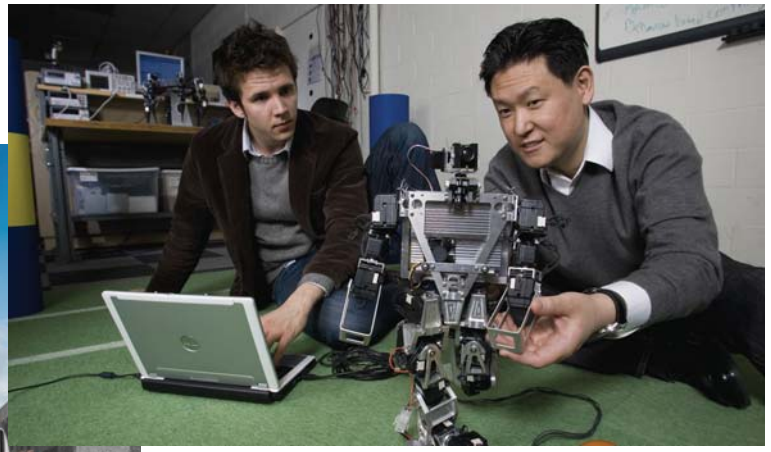
Proposed New Tool

2 engineers
1 year

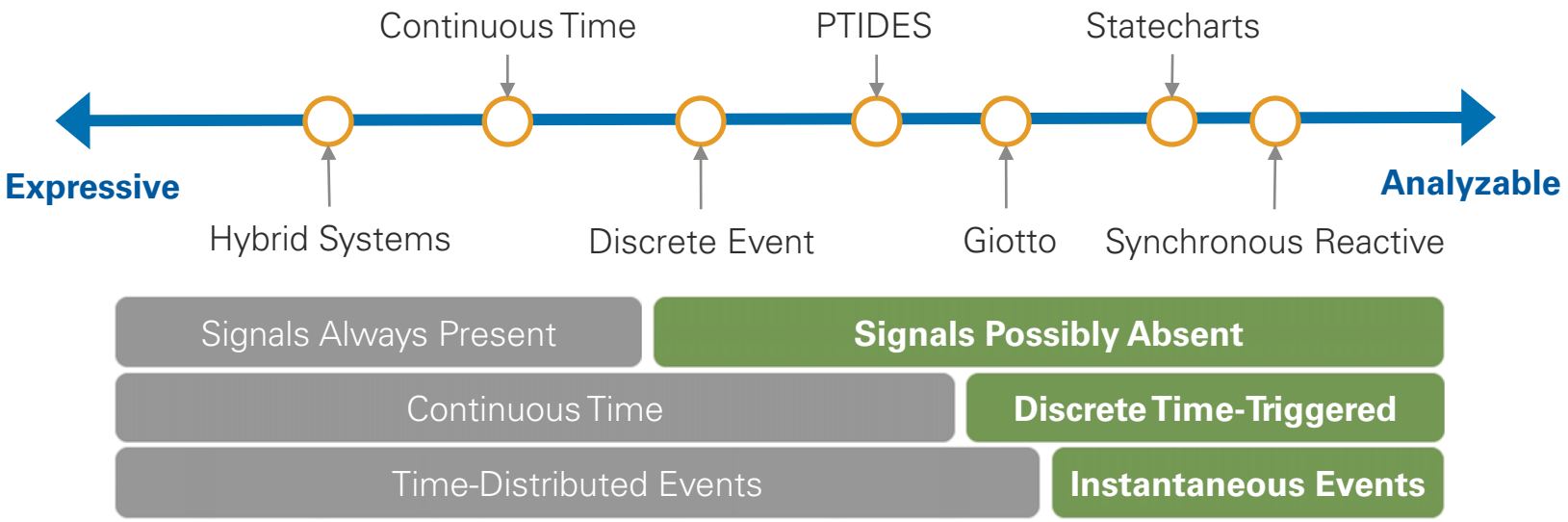


Physical Intuition **Is** Emphasized



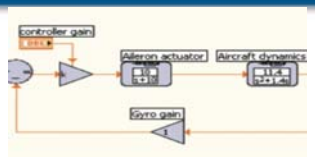
Make:

Design Tradeoffs

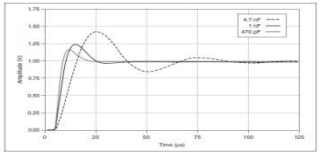


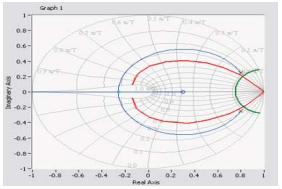
Timestamps and synchronization
for computing with time

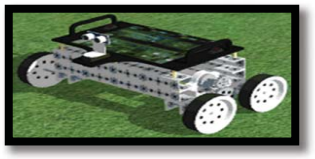
Untimed (clock-triggered) execution
for predictability and analyzability




```
1 c = 0.285 + 0.013i;
2 [X Y] = meshgrid(x, y);
3 z = X + i*Y;
4 for k=1:30
5     z = z.^2 + c;
6 end
```







Model Physical Processes

Derive & Refine Control Algorithm

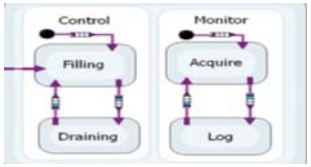
Choose Models of Computation

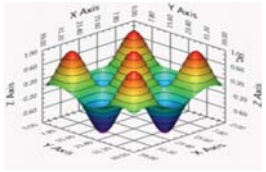
Specify Hardware

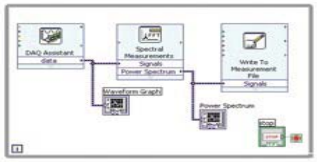
Simulate

Test, Verify, Validate

Cyber Physical Design







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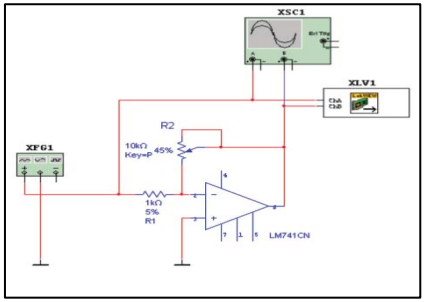
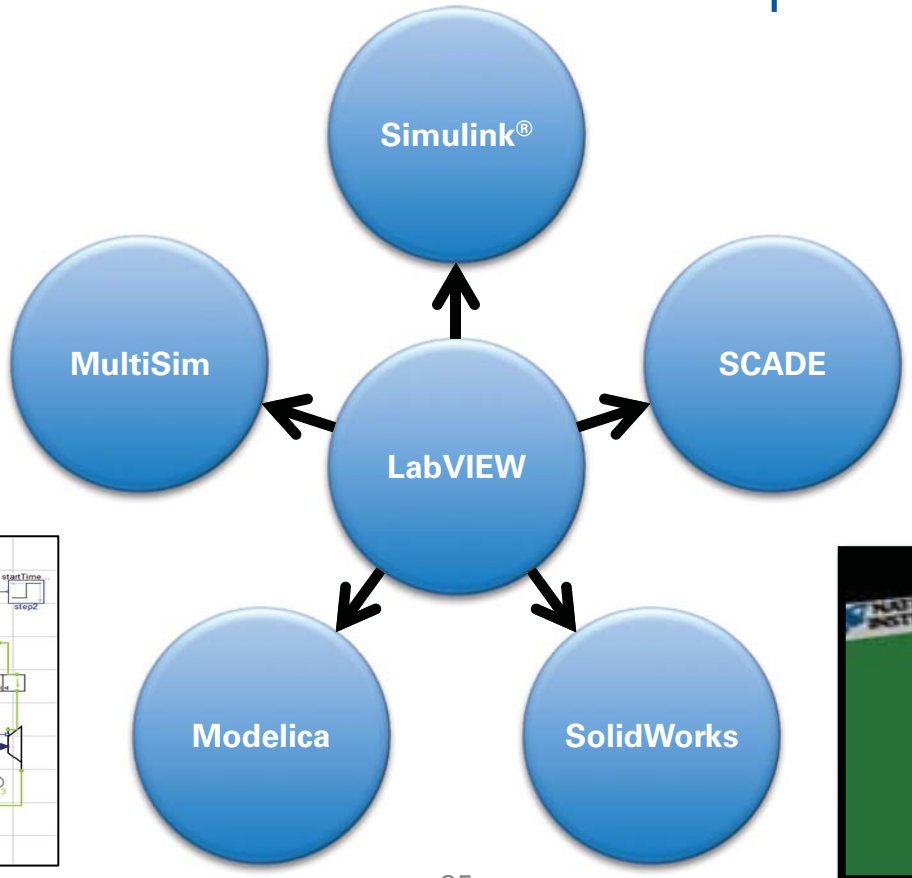
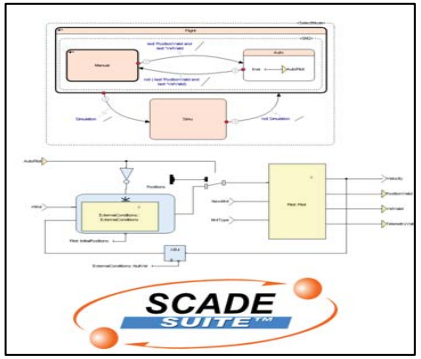
Source: Jeff C. Jensen, Danica H. Chang, and Edward A. Lee; "A Model-Based Design Methodology for Cyber-Physical Systems"

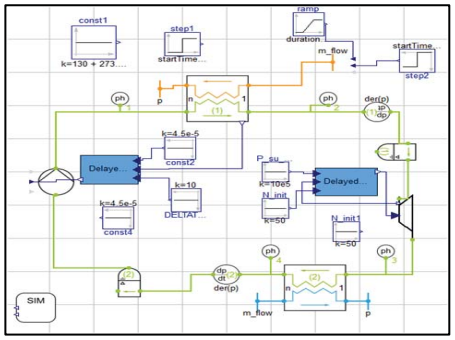
ni.com

Domain-Specific Software Interoperability

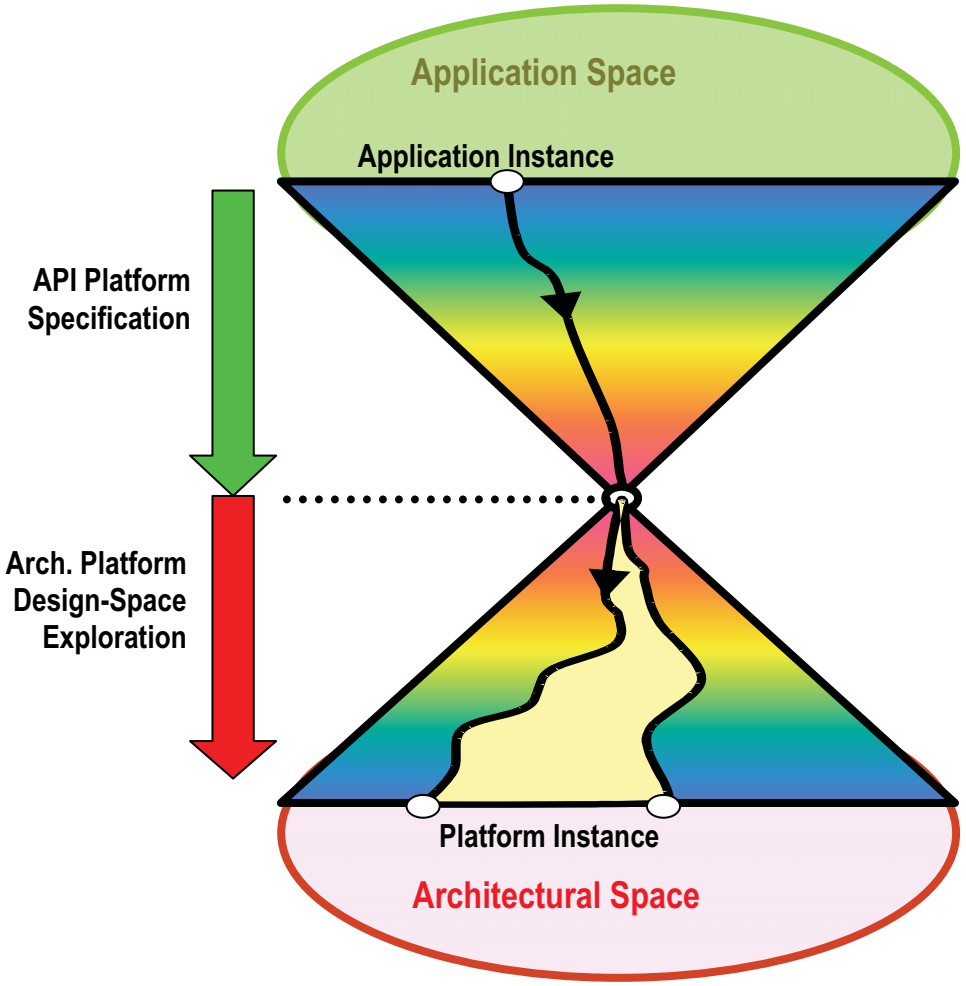


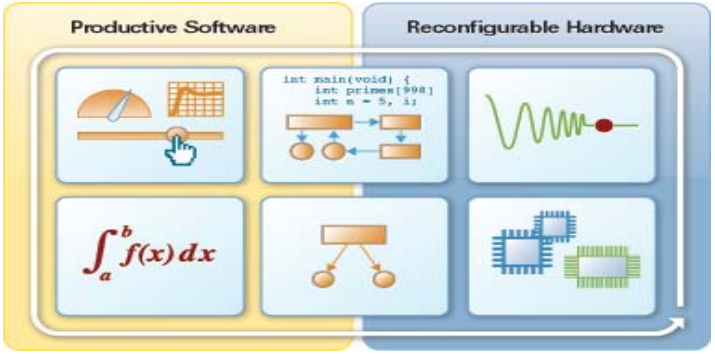






Simulink is a registered trademark of The MathWorks, Inc.

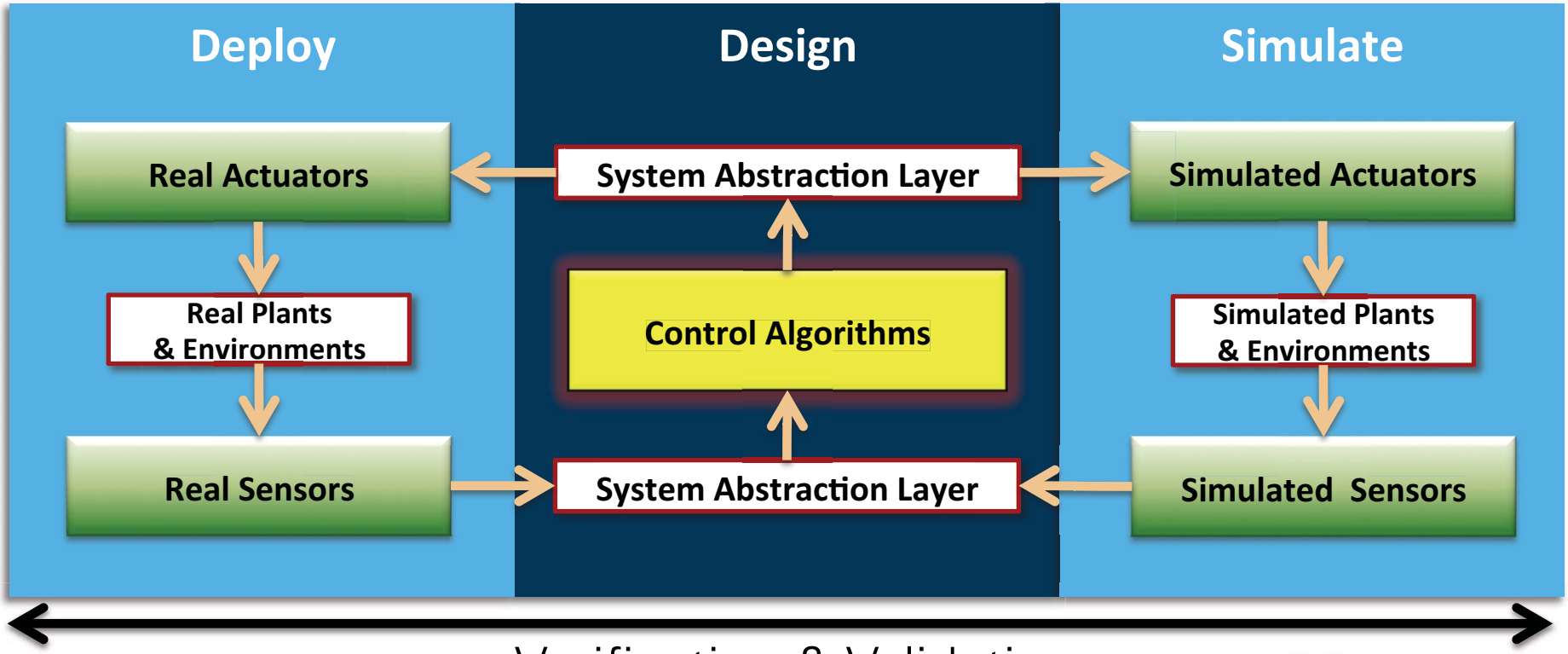

Application Space
Application Instance
API Platform
Specification
Arch. Platform
Design-Space
Exploration
Platform Instance
Architectural Space



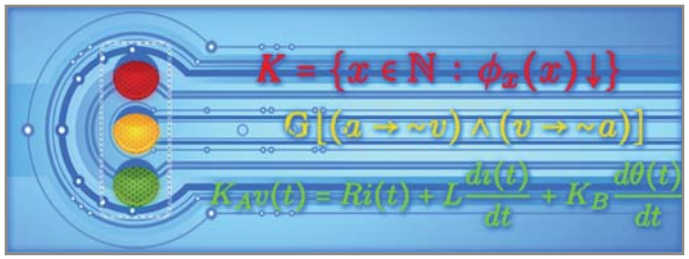
Think Platform.

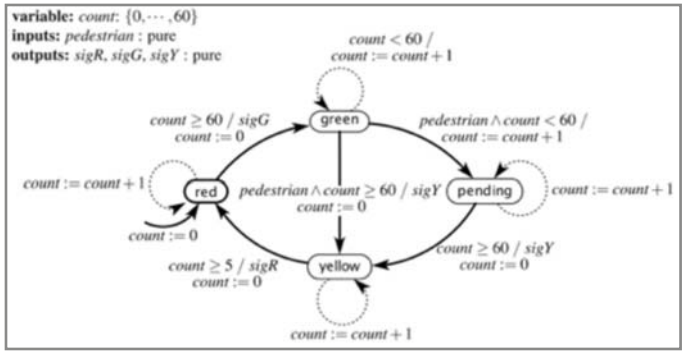
Invest in a platform-based approach to help you more easily adapt to changing requirements and technology over time.

Model-Based Design for Cyber-Physical Systems

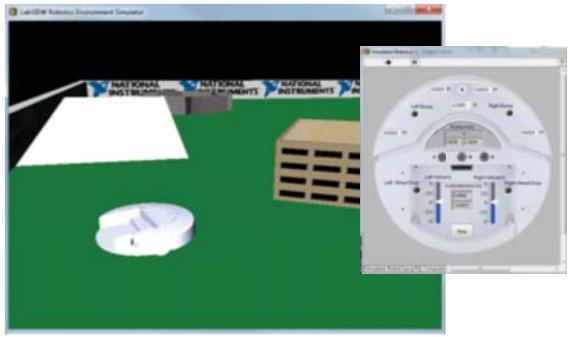


UC Berkeley MOOC





UC BerkeleyX EECS149.1x
Introduction to Cyber-Physical Systems



POWERED BY LabVIEW

Edward A. Lee

Sanjit A. Seshia

Jeff C. Jensen

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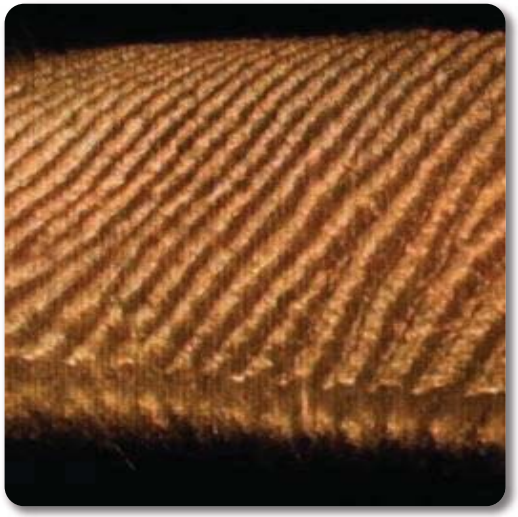
National Instruments – Our Commitment

We equip engineers and scientists with tools that accelerate productivity, innovation, and discovery.




Do Cyber
Do Physical
Do Engineering
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