



# FORCES Overview and Update

Larry Rohrbough, UC Berkeley  
Saurabh Amin, MIT



# Importance of Cyber-Infrastructures

- \* E-Commerce, Banking, Finance
  - \* Including move to mobile platforms
- \* Physical Infrastructures
  - \* Water, power, telecommunications
- \* Healthcare
  - \* Medical records, IT infrastructure
- \* Other Critical Infrastructures...
  - \* Transportation, agriculture, security



Most are **Cyber-Physical Systems (CPS)**: Computation, Control, Timing, Actuation

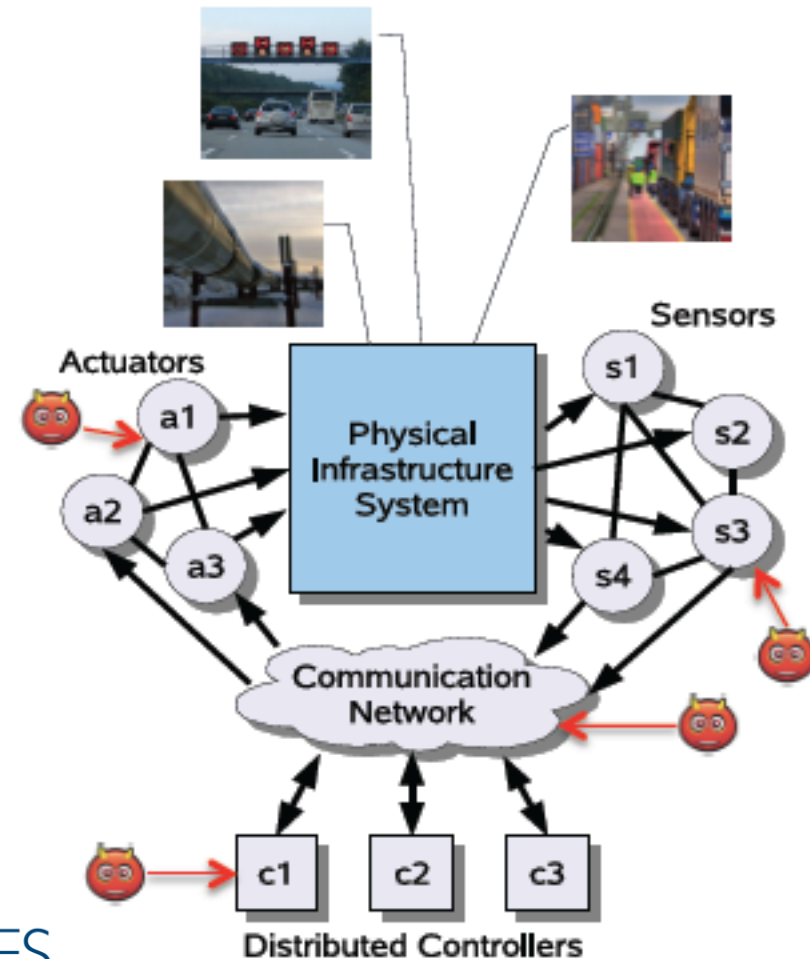
# Key Drivers for Resilient CPS

## \* Attributes of Resilience

- \* Functional correctness (by design)
- \* Robustness to *reliability* failures (faults)
- \* Survivability against *security* failures (attacks)

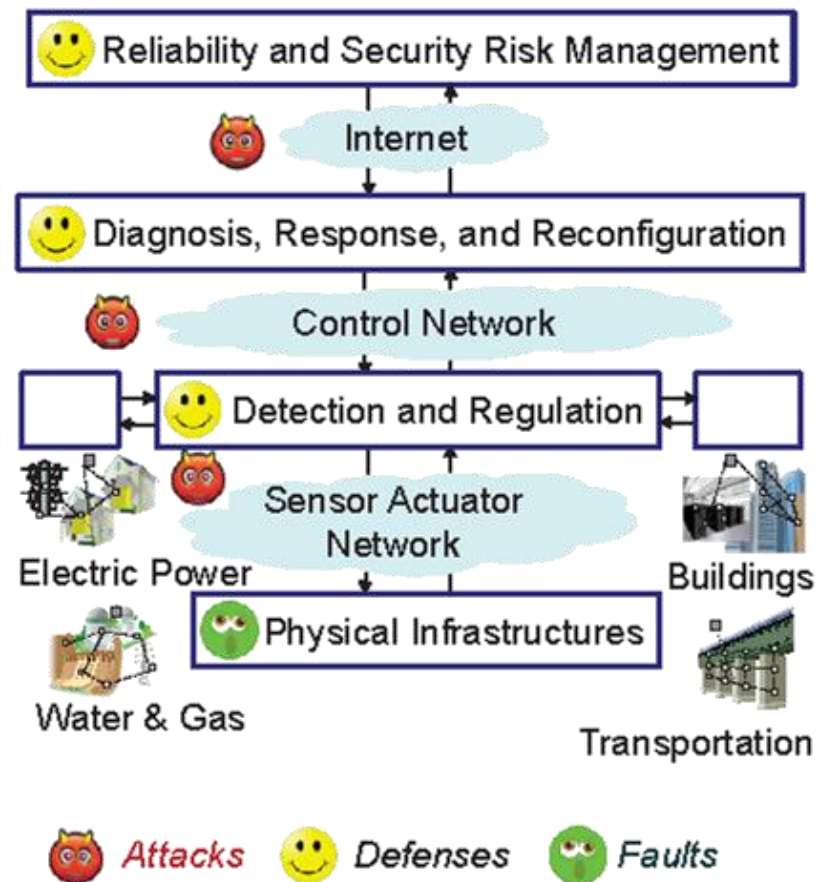
## \* Challenges to Resilience

- \* Spatio-temporal dynamics
- \* Many strategic interactions with network interdependencies
- \* Inherent uncertainties (public & private)
- \* Tightly coupled control and economic incentives



# FORCES Research Focus for CPS

- \* Resilient Control
  - \* Threat assessment & detection
  - \* Fault-tolerant & attack diagnostics
  - \* Real-time predictive response
  - \* Model-based design
- \* Economic Incentives
  - \* Incentive (game) theory for resilience
  - \* Mechanism design
  - \* Interdependent risk assessment
  - \* Insurance & risk distribution



# System Software Security

- \* Sophisticated malware targets various CPS...

- \* Current CPS often run legacy code

- \* CPS focus on safety, protecting against failures

- \* CPS software often does not protect against security attacks

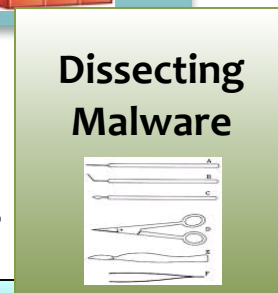
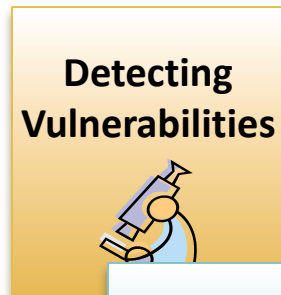
- \* Protocols often lack security, authentication, or privacy

- \* Attacker can extract or control information and computation



# BitBlaze for Software Security

- \* Analysis locates weaknesses in code
  - \* Allow a mix of binary only and source code
- \* Targeted patching of specific vulnerabilities
  - \* Mitigates a specific vulnerability
- \* Binary hardening: enforce general security policies
  - \* Protect against broad classes of vulnerabilities
  - \* Detect general attack and forces failsafe action
  - \* Protect control-flow and important data of devices
  - \* Look for low overhead, binary compatibility, completeness



**BitBlaze** Binary Analysis Infrastructure (<http://bitblaze.cs.berkeley.edu>)

# FORCES Education Activities

- \* Teaching and Training
  - \* New and enhanced courses that introduce concepts of resilient control and economic incentives:
    - \* Michigan (Hiskins)
    - \* MIT (Amin/Balakrishnan)
    - \* Vanderbilt (Sztipanovits)
  - \* Looking for commonality across the courses we teach.
  - \* Developing an integration plan for online modules.
- \* Young Researcher Advancement
  - \* Expanding opportunities for institutional exchange. Already exchanges between Berkeley-Michigan-MIT.
  - \* Engaging with students about other professional development.

# FORCES Education Activities (cont.)

- \* Undergraduate Research

- \* Supporting undergraduate research in labs during the year and in the summer.

- \* Examples in 2014

- \* Berkeley: Chaitanya Aluru

- \* Economic incentives and game theory

- \* MIT: David Ogutu

- \* Analytics-driven platform for CPS trustworthiness





# FORCES Outreach Activities

## \* Conferences

- \* CPSWeek 2014: Invited Keynote by Sastry “Towards a Theory of Resilient Cyber Physical Systems.”
- \* HiCoNS: Steering Committee, General Chairs, Program Chairs. Invited session “On Improving CPS Resilience by Integrating Robust Control and Theory of Incentives.”
- \* ICCPS: Program Chair. Special panel on “CPS Security.”

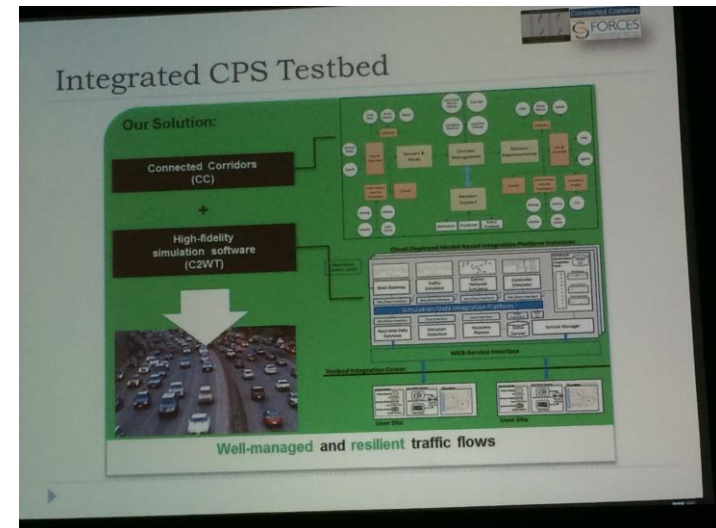
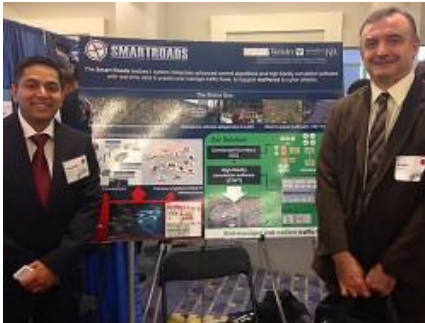
## \* Workshops

- \* Amin & Balarkishnan proposal to IEEE CDC 2014 on Resilient Control of CPS.
- \* Amin and Schwartz organizing a summer school Cyber-Physical Security at Institute for Pure & Applied Mathematics (IAPM) in Summer 2015.

# FORCES Outreach Activities (cont.)

- \* SmartAmerica Challenge

- \* Berkeley/Vanderbilt project on resilient transportation networks, impacts of cyber attacks.
- \* Integrated demonstration June 11 in Washington, DC.
- \* More on this tomorrow...





# FORCES Integration

Saurabh Amin, MIT



# Integration plans

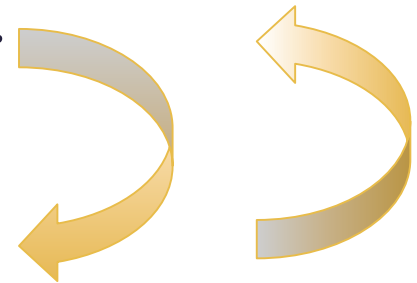
- \* **Societal component is the most important aspect of FORCES, in particular the integration of technology (RC) & Economics (EI)**
  - \* Unconventional ideas, out-of-the-box solutions
  - \* Concrete plans and efforts
- \* Build on prior strengths (and not forget them!)
  - \* Existing testbeds, tools, case studies and their FORCES extensions
- \* Foster and sustain collaboration with industry
  - \* Testbeds: simulators and platforms
  - \* Data and use cases / case studies

# Integration efforts

	RC				EI			
	Diagnostics (F&A)	Robust/Stoch. control	Model-based design	Secure design/ ops.	Game theory	Mechanism design	CPS risks mgmt.	Human in loop
Road (on/side)	★							
Air (space/port)								
Electricity (trans/dist)								
Energy (Ren./hybrid)								
CPS Sec. (Reliability/Resilience)								
Codesign								★

# Measures of success

- \* Short-term goals that can lead us to success:
  - \* New models, analysis, design results on RC+EI
  - \* Novel abstractions and understanding of h-CPS
  - \* Surprising / counterintuitive results, Aha moments,...
  - \* Resilient algorithms, better guarantees
- \* Validation of applicability to one or more FORCES domains
- \* New data sets, prototypes, code, design tool,..
- \* Demos on traditional/new CPS platforms
- \* Adoption of concepts / tools, direct relevance/ use by industry



# Highlights

- \* Smart America Challenge:
  - \* FORCES integration of Mobile Millennium and ISIS
- \* Industry collaboration:
  - \* Knowledge transfer session by Speranzon (UTRC), Ohlsson & Ratliff (UCB)
- \* Education efforts:
  - \* Young researcher talks
  - \* Course modules, UROPs, conference workshops
- \* Team efforts:
  - \* Active collaborations between students and faculty of four campuses
  - \* First set of papers out!
- \* Big picture discussions:
  - \* Illustrations and case studies
  - \* Informal conversations

# Moving forward

- \* Proactive participation in team-wide FORCES meetings
  - \* Explicit discussion about integration efforts and plans
  - \* “So what?” questions, next steps, and limitations!
- \* FORCES website and CPS-VO
  - \* Post publications, video, data sets, code
  - \* Quarterly revisions to the website, highlights, news
  - \* Communicate updates to NSF PMs, IABs, broader CPS community
- \* Representing the team in meetings, workshops
  - \* Participation at CPSWeek, CPS PI meetings, NSF workshops
  - \* Proposed workshops at IEEE CDC
  - \* Invited lectures at major conferences
- \* In progress:
  - \* New benchmark problems, comparison of techniques, data sharing
  - \* Short-term visits, touch-base between FORCES gatherings