Our Research on AI, Blockchains and Cybersecurity

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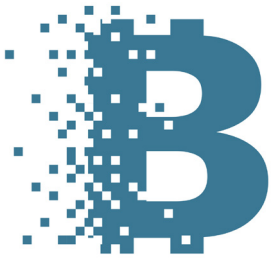


Raj Jain
Barbara J. and Jerome R. Cox, Jr. Professor
Department of Computer Science and Engineering
Jain@wustl.edu

Talk to visiting PhD Students
Washington University in Saint Louis, February 19, 2021

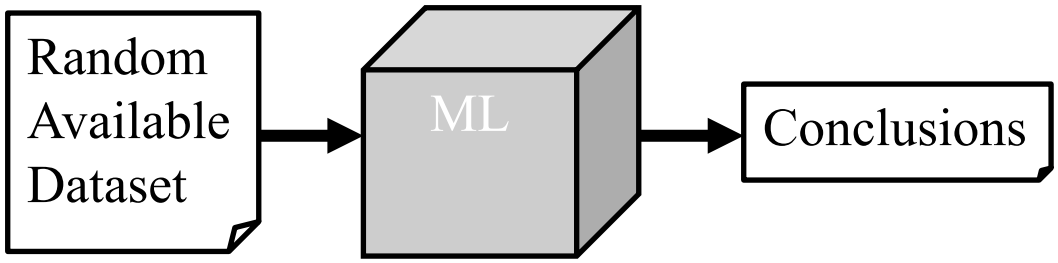
These slides and a video recording of this talk are at:
http://www.cse.wustl.edu/~jain/talks/Phdday21.htm

Overview

1. Trends in:
   - AI
   - Blockchain
   - Cybersecurity
2. Our Research Projects in these areas
3. Key distinction of our research

Machine Learning Challenges

- Machine learning is currently a black box
- ML algorithms are developed/used without domain expertise
- Data cleanliness, labeling, feature extractions, all require domain knowledge, e.g.,
  What is the distance between Port 80, Port 81, and Port 8080?
- Synthetic data is used ⇒ Garbage-In, Garbage-Out
- Results are stated without model validation.



AI for Security: Imbalance

- AI started with image analysis but needs to be extended for security
- Security data is very different from image data
  - Most security datasets are not representative of real world.
  - In most papers, 10-15% of the packets are attack packets
- In real-world, 1 in a billion packets is an attack packet
  - Mis-classify the attack packet ⇒ 99.9999% accuracy
  - Current metrics and methods not suitable for highly imbalanced data
- **Data imbalance** is a key issue in AI for security

1% attack =

Trend: AI to Explainable AI

- **Explainability issue**
  ⇒ No idea of why the results are what they are
  Can't discover bugs in ML model implementations

Machine Learning is what only machines can do, but human cannot do and cannot explain

- **Federated AI**: For large AI problems such as in global security

Ref: M. Zolanvari, M. A. Teixeira, R. Jain, "**Effect of Imbalanced Datasets on Security of Industrial IoT Using Machine Learning**," 2018 IEEE International Conference on Intelligence and Security Informatics (ISI), Miami FL, Nov. 9 - 11, 2018, 6 pp., http://www.cse.wustl.edu/~jain/papers/imb_isi.htm

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Blockchains

1. Satoshi Nakamoto invented Bitcoin
2. He used blockchains to make it decentralized
3. Since then blockchains have found numerous other applications
4. Blockchains are distributed, decentralized (no single point of control), trustless (no need to trust other parties), secure (Elliptic Curve Cryptography) with non-repudiation guarantee (all transactions are signed)

Trend: Centralized → Decentralized

- **Banks**: Allow money transfer between two accounts
- **City Records**: Wedding registers, Property ownership
- **Networks**: Certificate Authorities, DNS
- In all cases:
  - There is a central third party to be trusted
  - Central party maintains a large database ⇒ Attracts Hackers
  - Central party may be hacked ⇒ Affects millions
  - Central party is a single point of failure.
    Can malfunction or be bribed

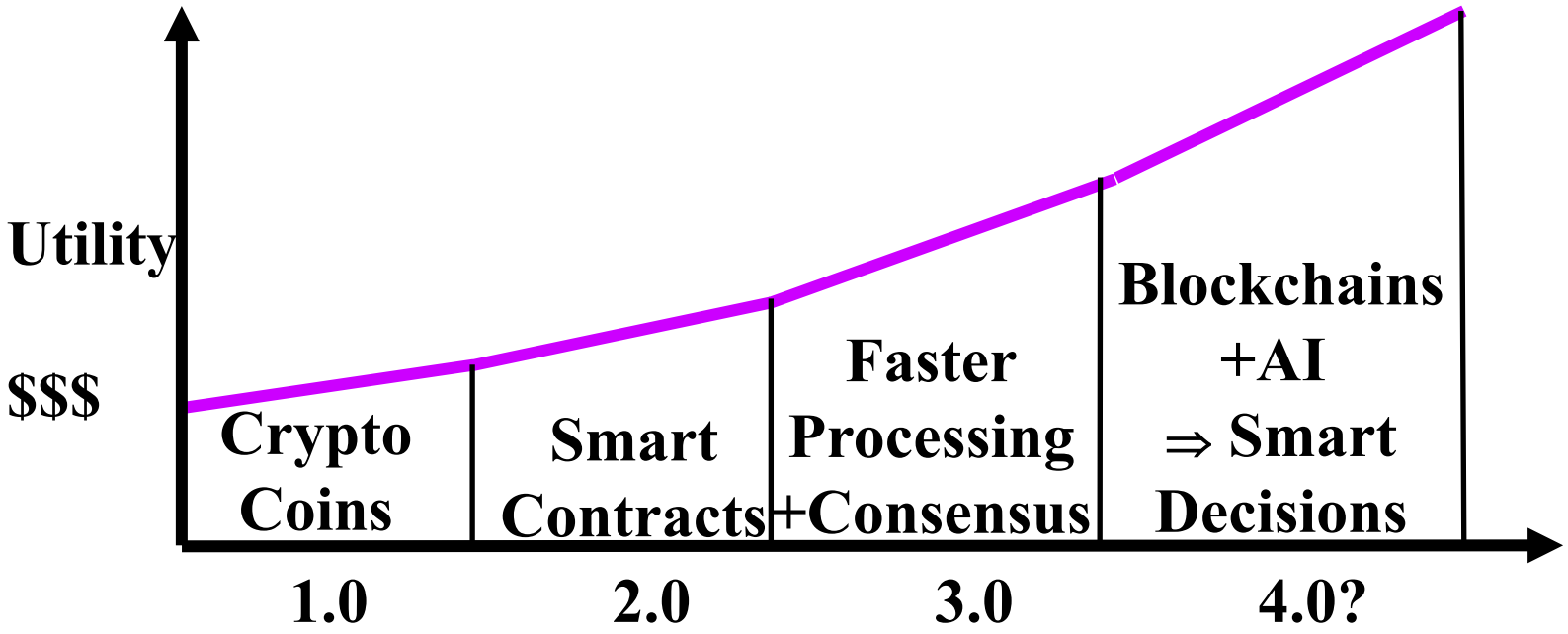
Our Goal

- Moving the chain from deterministic to **probabilistic**
- Moving the chain from storage to **computation**
- Moving the chain from data to **knowledge**
- Moving the chain from information to **decision making**

⇒A blockchain that provides knowledge

– A **knowledge chain** would be more useful

Blockchain Generations



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Trend: Intelligent and Secure IoT/CPS

Smart Watch

Smart TV

Smart Kegs

Smart Health

Smart Home

Smart Car

Smart Space

Smart Industries

Smart Cities

Our Research Projects

1. Industrial IoT Security
2. Medical IoT Security
3. Fault and Security of Datacenters using Deep Learning
4. Blockchains with AI for Security
5. AI Institute

3 Funded Research Projects

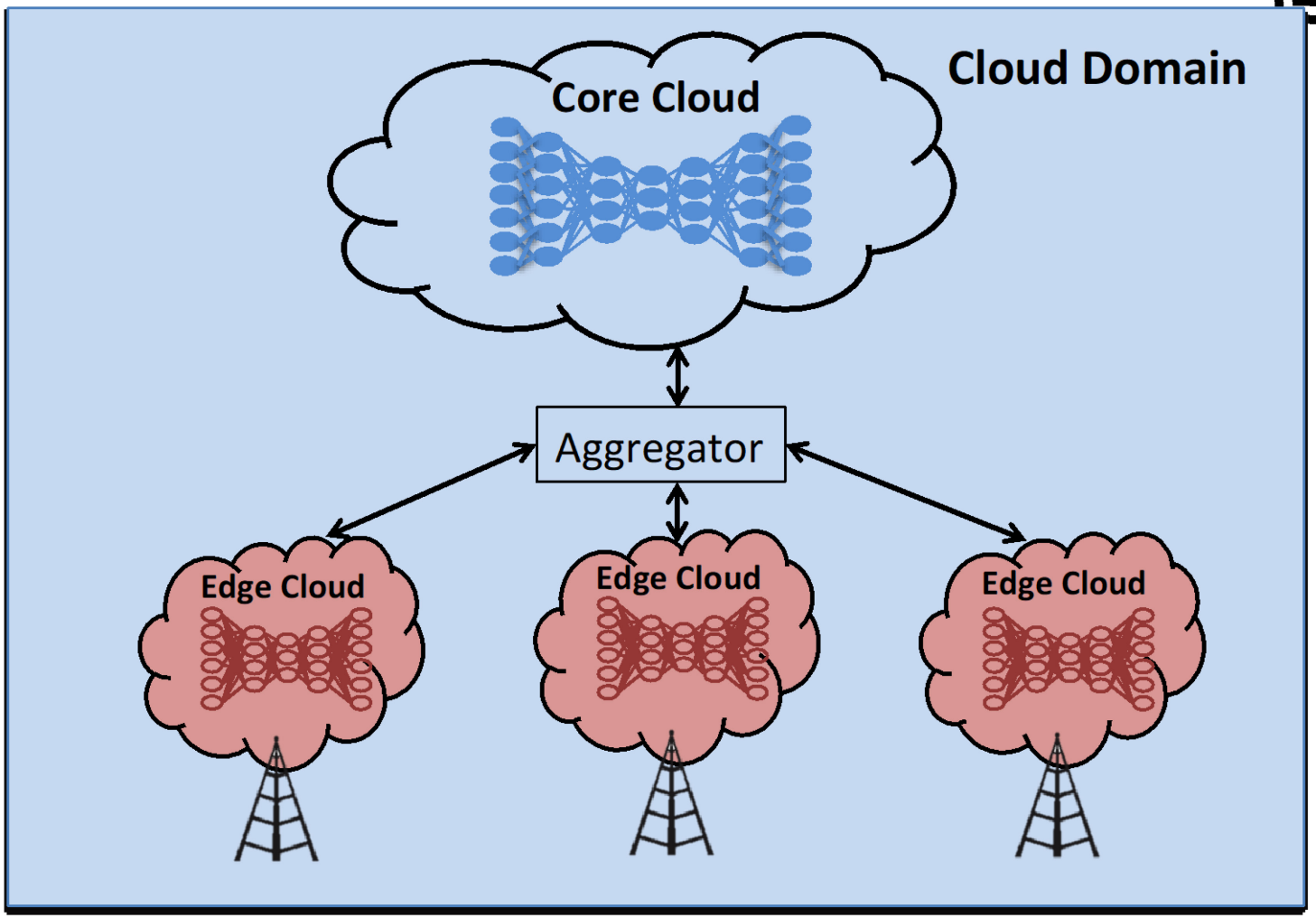
} Approved

} Pending

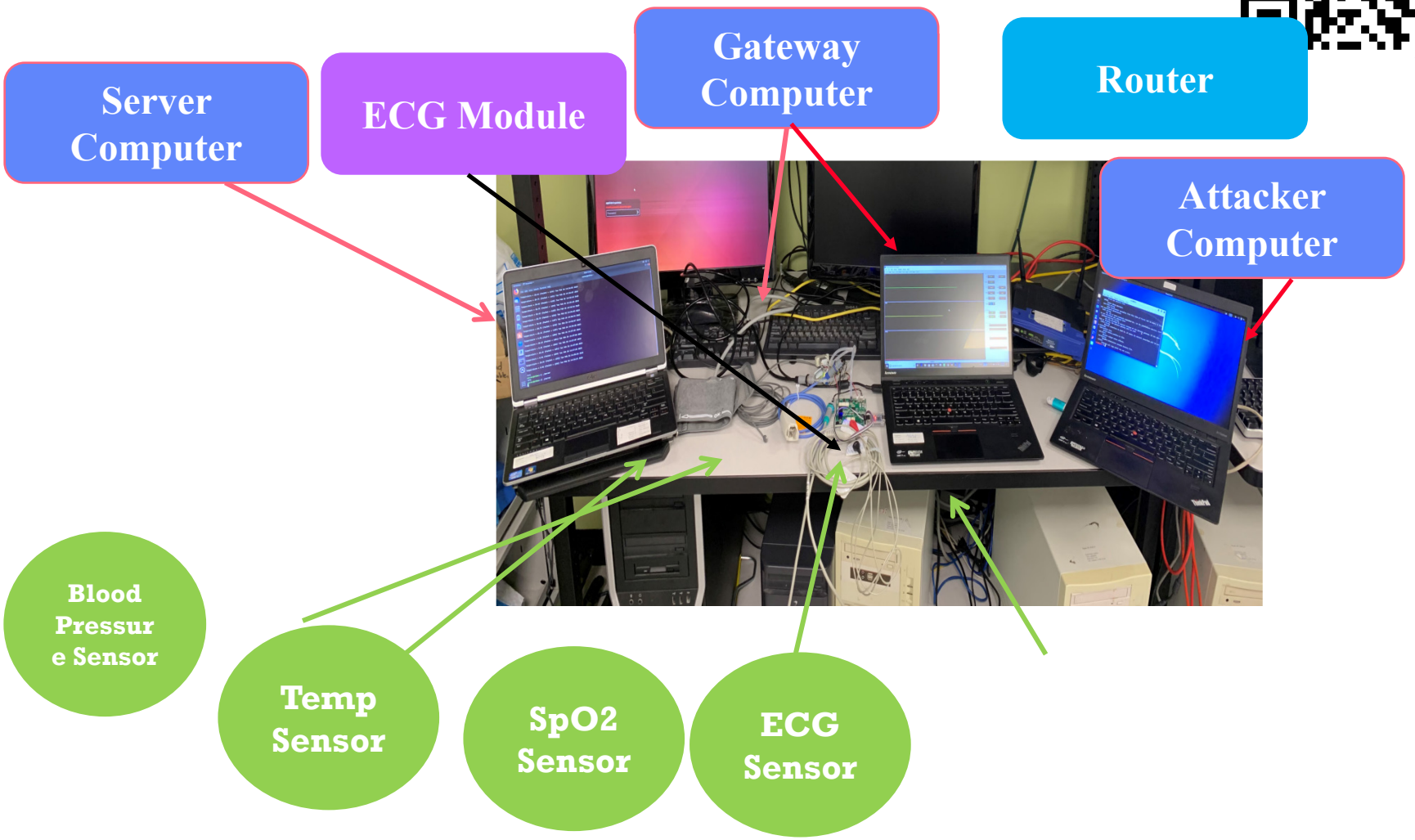
Techniques:

1. Explainable and Federated AI
2. Blockchains with AI
3. Security using Blockchains and AI

Innovations in Multi-Cloud Hierarchical AI Model with Layer Reuse



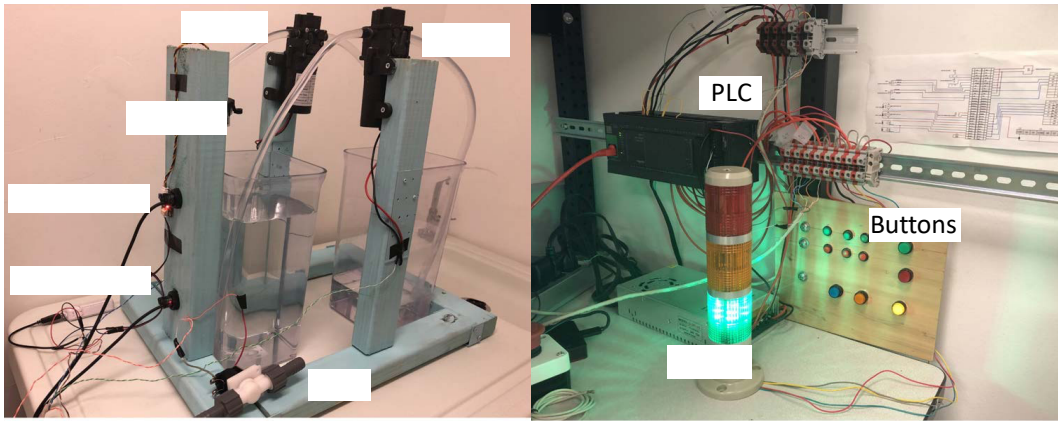
Hospital on a Desk Testbed

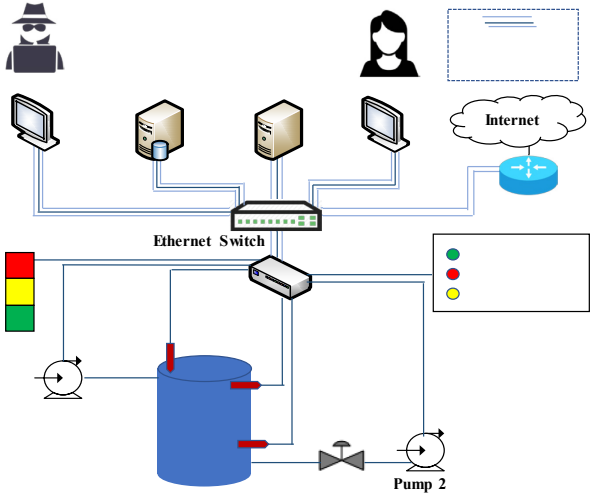


Ref: Anar A. Hady, Ali H. Ghubaish, Tara Salman, Devrim Unal, Raj Jain, "Secure Healthcare Monitoring System using Machine Learning," Submitted.

Industrial Control Systems Security

- Extremely critical infrastructure
- Nation state level attacks
- Any weakness in the lifetime management, installation, or upgrades, may lead to attacks



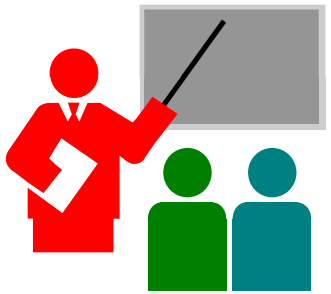


Ref: Marcio Andrey Teixeira, Tara Salman, Maede Zolanvari, Raj Jain, Nader Meskin, and Mohammed Samaka, "SCADA System Testbed for Cybersecurity Research Using Machine Learning Approach," Future Internet 2018, 10(8), 76, http://www.cse.wustl.edu/~jain/papers/ics_ml.htm

Key Distinction of Our Research

- Goal: Impact to the real-world
  DECbit congestion indication in almost all networking architectures since its invention
- Funded by industry partners:
  Intel, Cisco, Broadcom, Boeing, …
- Impact real-world by participating in standards organizations and industry forums:
  ATM Forum, IEEE Standards, American National Standards Institute (ANSI), Internet Engineering Task Force (IETF), WiMAX Forum
- Work on long term as well as short term research

Summary



1. AI → Explainable AI → Federated AI
2. Blockchains
   → Blockchains with AI = Knowledge Chains
3. IoT Intelligent IoT Secure and Intelligent IoT
   - Industrial systems
   - Medical systems
   - Agriculture Systems
4. Research for Impact

References: Class Recordings

- Recordings of all of my classes and talks are available on YouTube and on my website:

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2. CSE 571S: Network Security, http://www.cse.wustl.edu/~jain/cse571-17/index.html
3. CSE 574S: Wireless Networks, http://www.cse.wustl.edu/~jain/cse574-20/index.html
4. CSE 567: Computer Systems Analysis http://www.cse.wustl.edu/~jain/cse567-17/index.html
5. CSE 570: Recent Advances in Networking http://www.cse.wustl.edu/~jain/cse570-19/index.html

Our Publications on AI

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Our Publications on Healthcare Security

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Acronyms

- 3GPP — Third Generation Partnership Project
- AI — Artificial Intelligence
- ANSI — American National Standards Institute
- AT&T — American Telephone and Telegraph
- BSS — Business Support Services
- CA — California
- CGNAT — Carrier Grade Network Address Translator
- CSE — Computer Science and Engineering
- DECbit — Digital Equipment Corporation Bit
- IEEE — Institution of Electrical and Electronic Engineering
- IoT — Internet of Things
- ML — Machine Learning
- MO — Missouri
- MS — Master of Science
- NFV — Network Function Virtualization
- NTT — Nippon Telephone and Telegraph

Acronyms (Cont)

- OpenADN Open Application Delivery Networking
- OSS Operations Support Services
- SON Self-Organizing Networks
- TV Television
- UK United Kingdom
- US United States
- VC Venture Capital
- WAN Wide Area Network
- WiMAX Worldwide Interoperability for Microwave Access
- WUSTL Washington University in St. Louis

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Our Courses on YouTube

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