Challenges and Contributions to Intelligent and Transformative Production

Before, During, and Beyond Pandemic Times

Plenary Presentation: Monday, July 18, 2021

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Our purpose:

The theme of this conference is "Intelligent and Transformative Production in Pandemic Times."

We explore the roles and challenges that production researchers

1. have been facing before and during this pandemic
2. how our contributions have enabled survival and continuity of operations / of life, now and beyond the pandemic times.

Outline

1. Survey of production research before and during the pandemic eruption
2. Focus on supply chain and supply network resilience and security
3. Focus on cyber collaborative production for disruption handling and control
4. Lessons learned and agenda for the future – “beyond pandemic times?”

As production researchers, we want to understand:

1. Have our emerging themes of future work, labs, factories and services been on target?
2. How about the cyber-collaborative, augmented factories, suppliers, and services; and the human-in-the-loop cyber physical production and service?
3. Have we been prepared to deliver on time and at scale what society and civilization need and expect?
4. Lessons learned and future research challenges.

Pandemic timeline

- **A pandemic is a disruption: Sad, bad, tragic**
- We want to survive, be productive

Previous pandemics, disasters Jan. 2020 Now . . . . future

- We thank the medical and healthcare researchers and providers

Production, e-Work, Cyber Physical Systems, and Disruptions

A simple definitions of disruption:

- A **disturbance** or **obstacle** that interrupts the normal operations, activities, and processes.

A pandemic is a series of disruptions that **propagate**, and cause damages.

Type 2 disruptions: Damaging Failures

- Examples in networks of production, supply, and services: machine failures, schedule failures, illness
- Typical vulnerabilities: Weakness, lack of preparedness, insufficient capacity, lack of training
- Scalability disruptions: More exposed nodes (in denser, larger networks)
- Weakness with longer distance and time delays (in sparser networks)
- Weaknesses with decrease in flexibility, in backup and redundancy

Type 1 disruptions: Disruptive Innovations

Innovative disruption	Legacy industry	Disrupter	Disrupted vulnerability
Automobiles	Horses	Cars, trucks	Accessibility
Sharing economy	Cars and trucks	Electric cars & bikes	Congestion; parking
Cyber-collaborative production	Vaccine R&D + Mfg. + Logistics	PANDEMIC ⇩ Cyber collaborative meetings; Telemedicine	Delays; shortages
Cyber-collaborative v-meetings	F2F Meetings		Accessibility

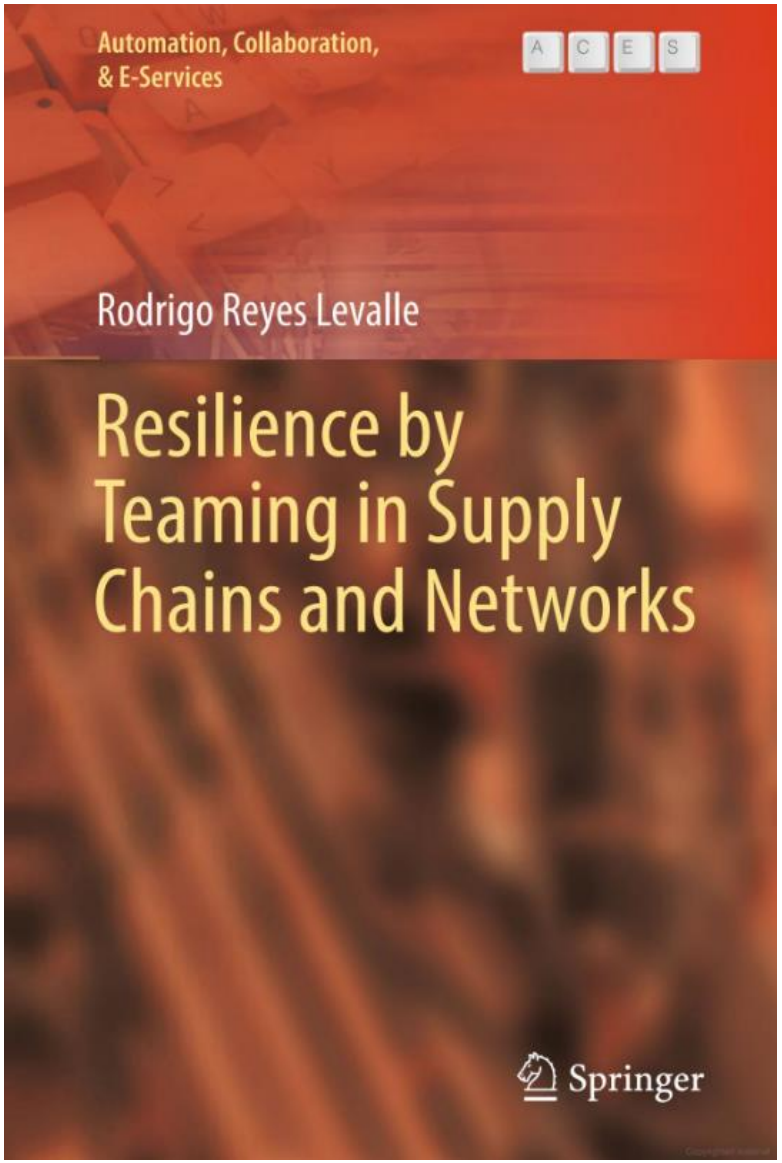
Disruptive Innovations: Vaccines, Treatments:

Preventive, Predictive, Responsive Maintenance

e-Maintenance integrates cooperation,
collaboration, and knowledge-sharing
to evolve existing maintenance processes towards
new enterprise concepts:

Extended enterprise,
supply-chain management,
lean maintenance,
distributed support and expertise centers.

Morel, Pétin, Johnson [2009]; Elsayed [2021]



- Complexity and resilience in supply networks: physical, digital, service, combined
- Novel approach: Fault tolerance by teaming (CCT, 2007)
- Levels and dimensions of resilience in supply chains and in supply networks

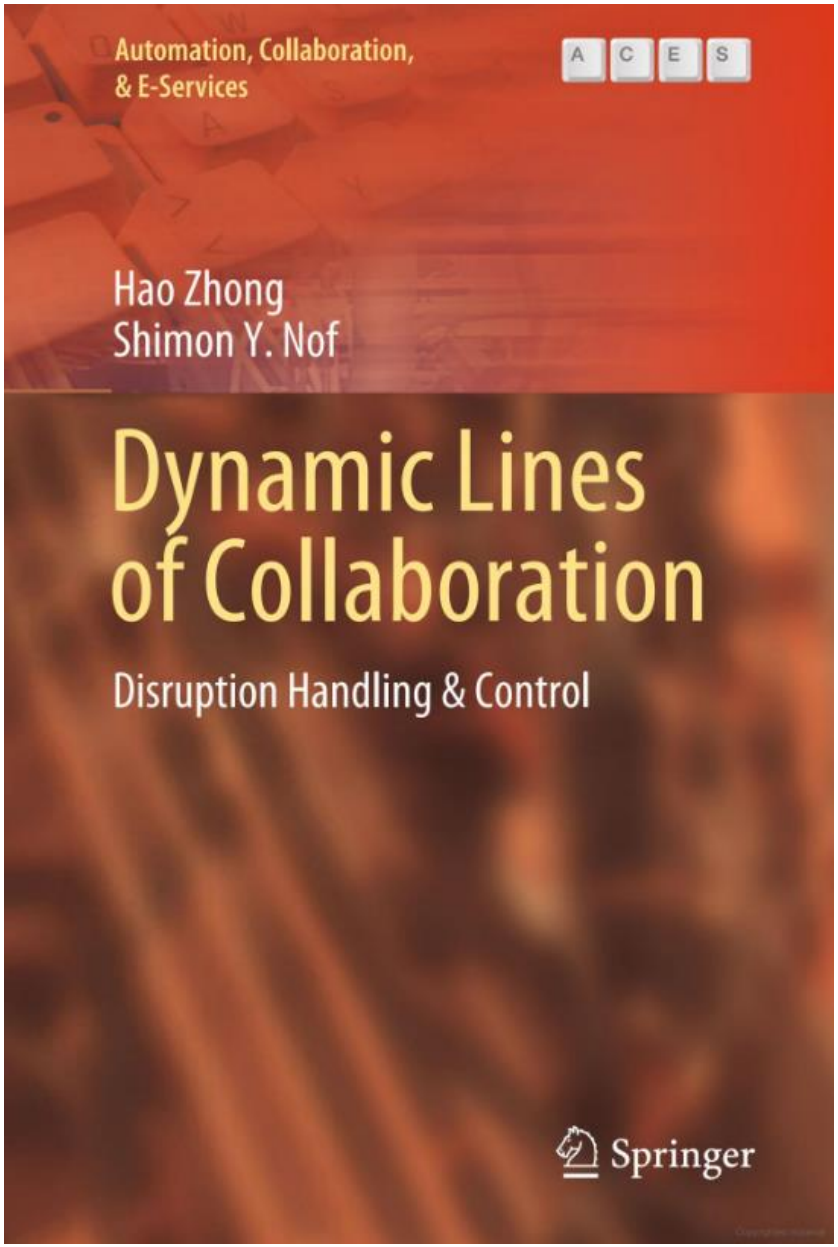
Contribution:

- Resilience by Teaming framework, task protocols, multi-agent teams
- Application examples in real supply chains and networks
- Preparedness for supply problems.

2018

Supply chain / Supply network Resilience and Security: Recent Research

Multi-sensor task allocation framework for **supply networks security** using task administration protocols	*Tkach et al., 2017*
Resilience and agility: the crucial properties of humanitarian supply chain	*Dubey, 2019*
Viable supply chain model: integrating agility, **resilience and sustainability** perspectives—lessons from and thinking beyond the COVID-19 pandemic	*Ivanov, 2020*
Supply chain resilience for vaccines: review of modeling approaches in the context of the COVID-19 pandemic	*Golan et al., 2021*



- Cyber physical systems and disruptions
- Types of disruptions and of mitigation
- Novel approach: Network-to-network (N2N) model of collaborative e-Work for prevention, repair, recovery, response.

Contribution:

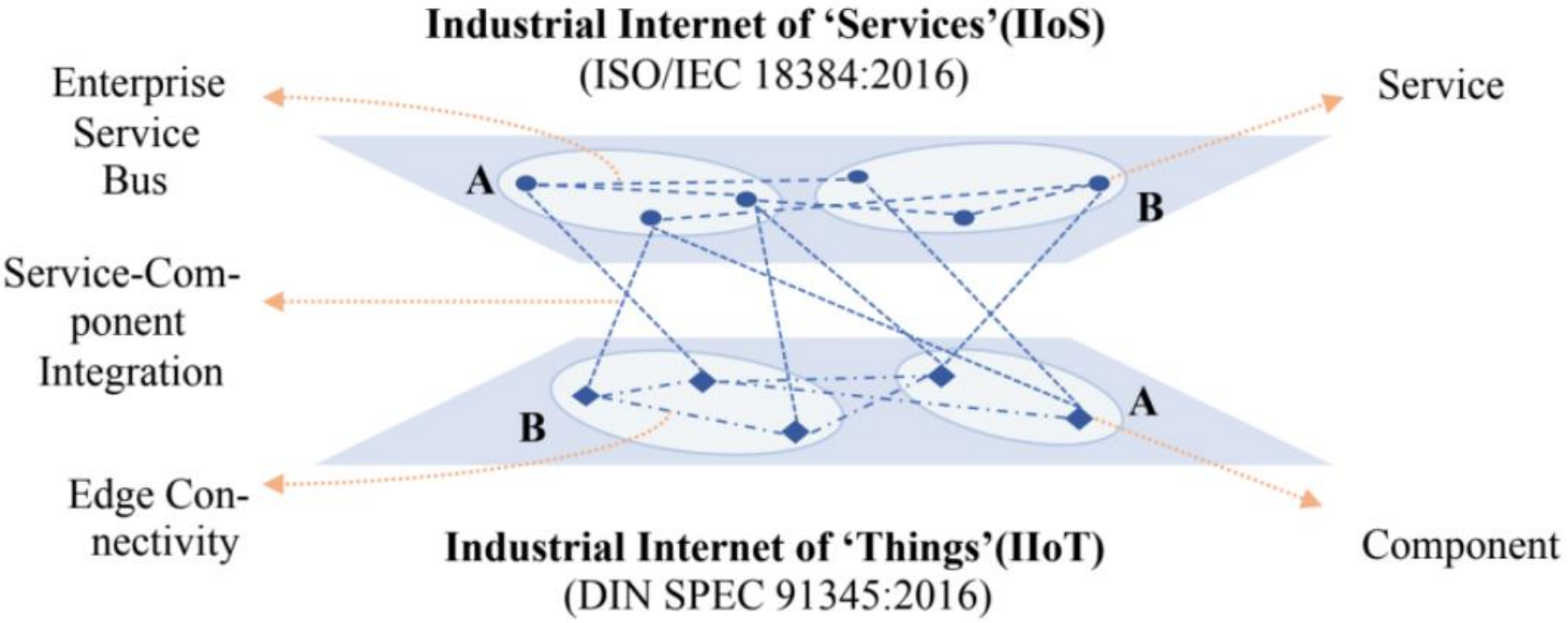
- The DLOC model & protocols; network scheduling; critical performance metrics
- Applications with real disruptions
- Preparedness for disruptions.

Jan. 2020

Collaborative / augmentative production for Disruption Handling and Control: Recent Research

Handling disruptions in manufacturing systems: An immune perspective	*Darmoul et al., 2013*
Design of a reliable hierarchical **location-allocation model under disruptions** for health service networks: A two-stage robust approach	*Zarrinpoor, 2017*
Strategic lines of collaboration in **response to disruption propagation through cyber-physical systems**	*Nguyen et al., 2020*
Forecasting and planning during a pandemic: COVID-19 growth rates, **supply chain disruptions**, and governmental decisions	*Nikolopoulos, K., et al., 2021*

Service - Component Matching & Integration in a cloud service for collaborative network of organizations, *A* and *B*



Moghaddam and Nof, 2018

Disruptive Innovations: Networked Tele-health

Transforming the Industry based on Sustainable Computing

AI and Cloud+Edge Unification – PANDEMIC USE CASES

Cesar Martinez Spessot, Sr. Director of Engineering – Internet of Things Group

Presented with permission from Intel Co.

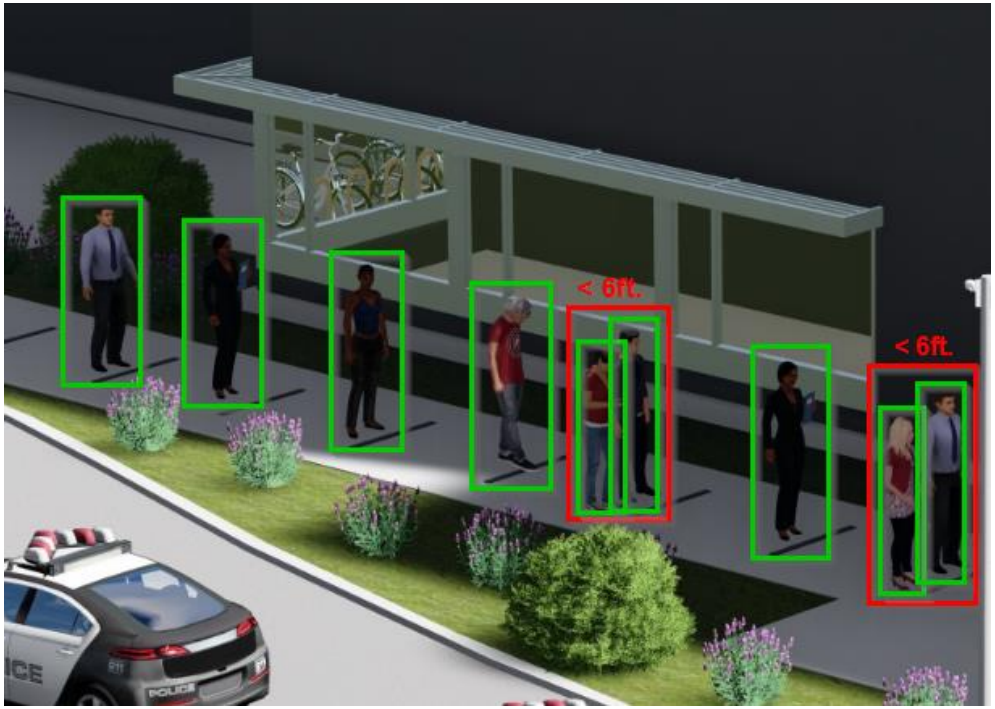
Social distance enforcement

- Allows company/government policy enforcement and/or logistic plan improvement

- Distance between people analysis.
- Multiple camera video stream processed per area

OpenVINO pre-trained models detect persons, measure distances, and generate alerts.

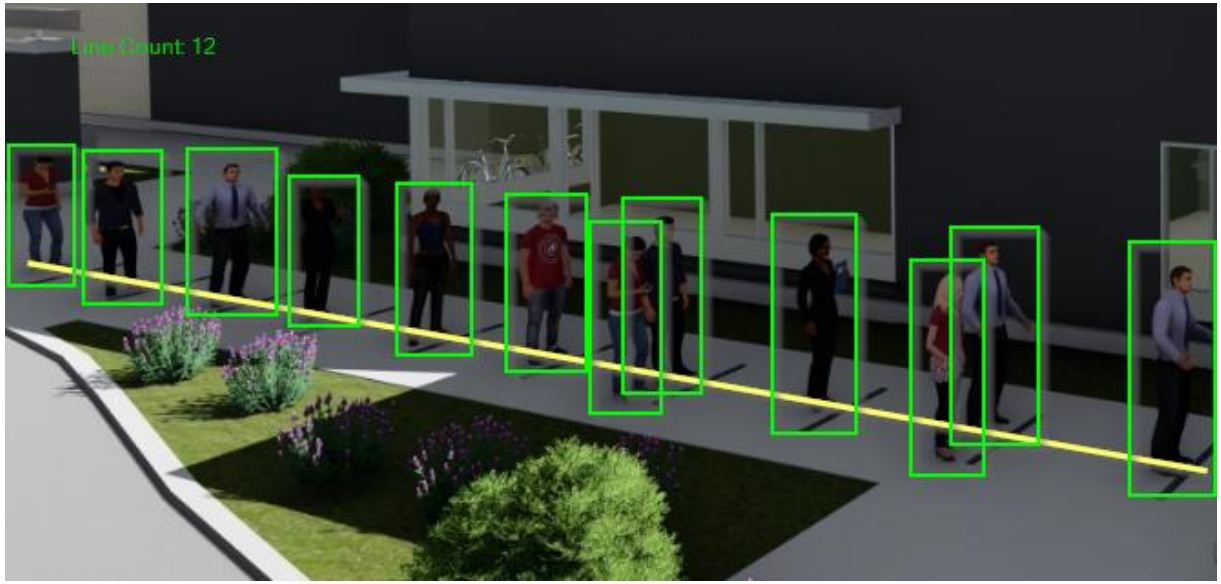
Considering cases like mom-son together.



Line monitoring

- Real time entry lines monitoring

- People in line detection
- Distance monitoring
- Real time queue line reporting
- Queue line forecasting



One way aisles

- Allows company to enforce policies

- Alerts security personnel or triggers alarm when pedestrian/shopper direction is not right.
- Multiple camera video stream processed per area
- OpenVINO pre-trained models track persons direction and generate alerts.

Disruptive Innovations: Networked Telemedicine

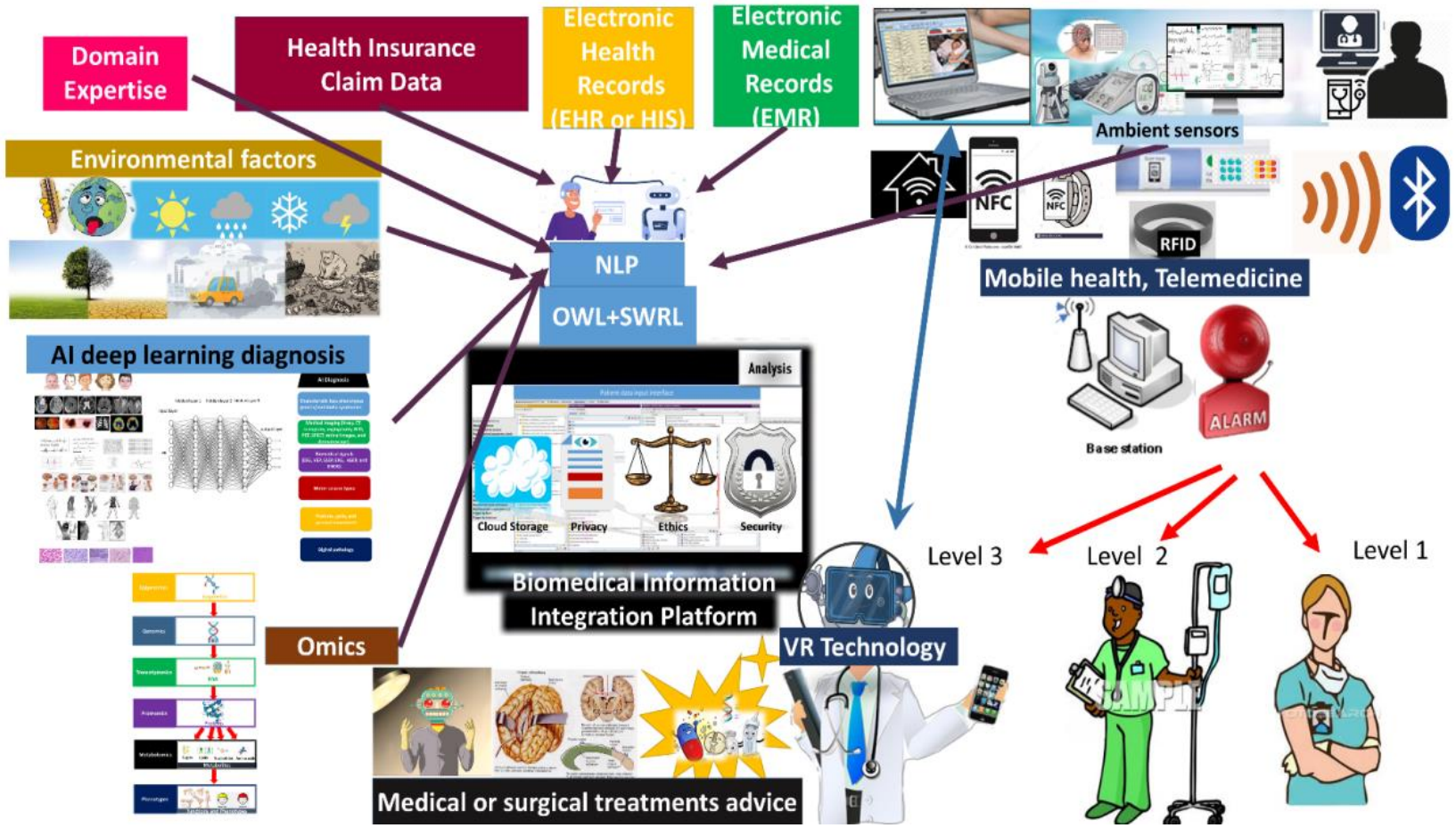
(a) Patient in the rural hospital

(b) Expertise advice given from the medical center

Telemedicine Case in Central Taiwan (courtesy of Taichung Veterans General

Chiang and Huang, 2021

Disruptive Innovations: Future Telemedicine



Illustrated telemedicine and tele-critical care model for the future

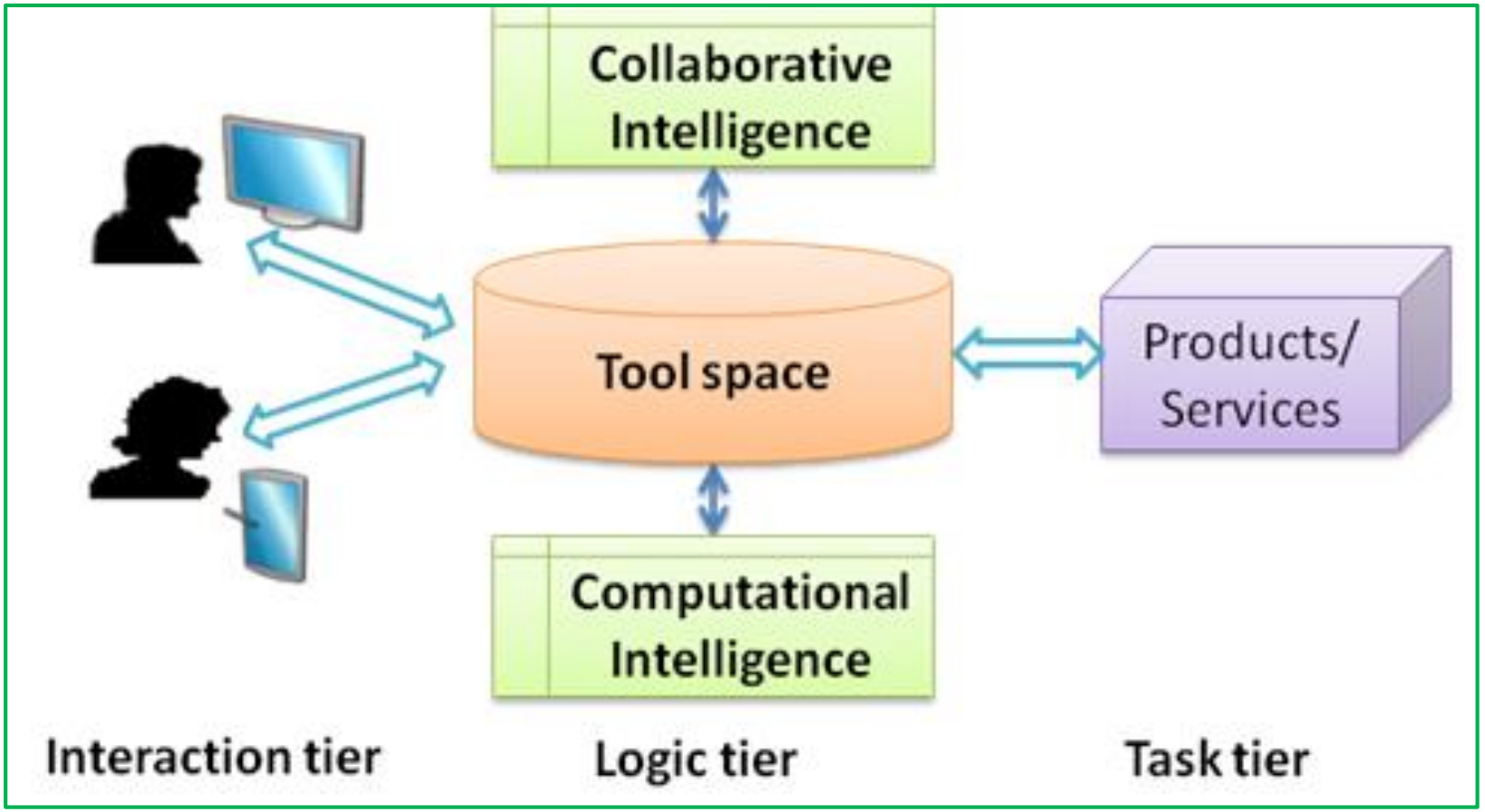
Chiang and Huang, 2021

Prepared? Three slides from ICPR24-Poland, 2017

1. Features required for Disruption Response

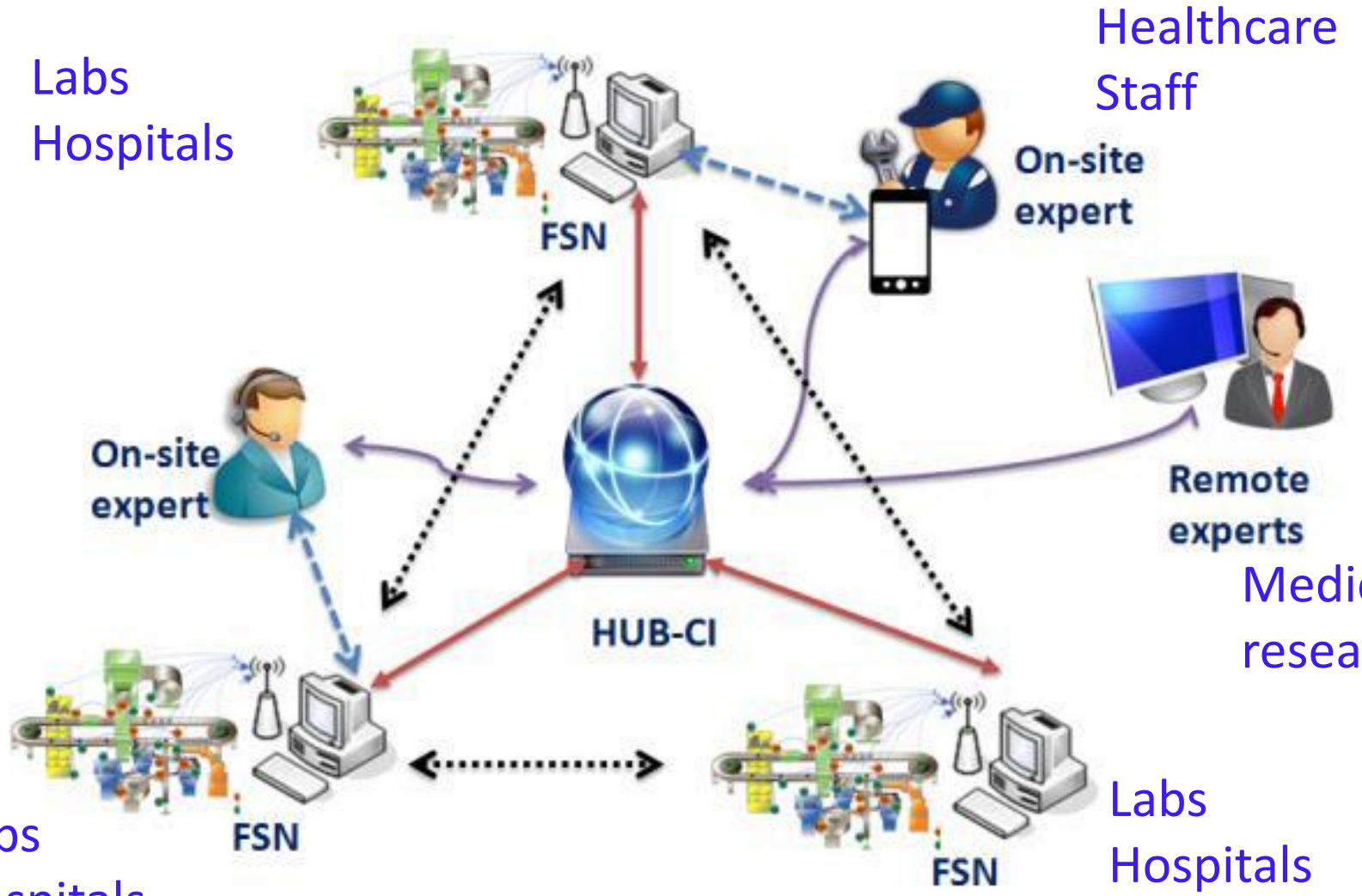
- Interdependent Supply and Rescue Networks are emerging with Cyber-Physical Systems to improve control, communication, and collaboration.
- **Methods to stop Cascading failures**
- Dynamic response task protocols can improve the *efficiency and effectiveness* of resource deployment.
- **Cyber augmentation of Responders-Agents collaboration is required in response to complicated disruptions.**

2. Resilience by HUB-CI infrastructure for cyber-collaborative production & augmentation best matching



IOT/CPS **IOS** **PREVENT & RESPOND**

3. Resilience by Disruptions Response



Zhong, Nof, Filip, 2014

Summary and Future Challenges

Five realizations on disruptive pandemics, failures

1. We can never assume there is no disruption coming just around the corner. Or that it will take another 100 years to occur.
2. Our civilization knows how to survive when terrible events happen. (We hope.)
3. Disruptions can have negative impacts, and can have positive effects.
4. Being *prepared ahead of time* for uncertain yet eventual disasters is preferred.
5. Production researchers have been prepared.

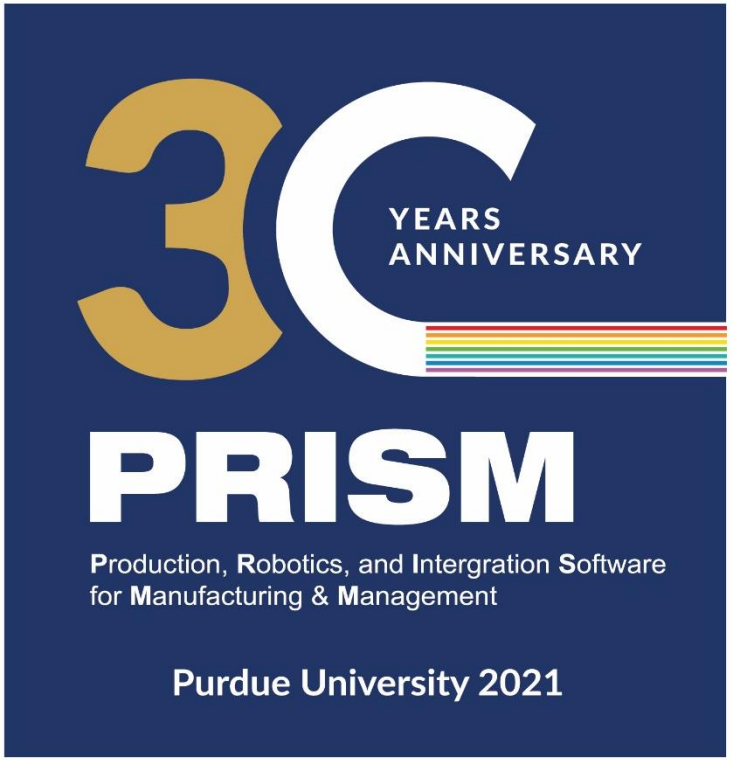
   Let's continue being prepared.

Acknowledgements

This research has been developed with partial support from the Production, Robotics, and Integration Software for Manufacturing & Management (PRISM) Center at Purdue University; BARD project Grant# IS-4886-16R; NSF project Grant# 1839971.

Collaboration with production researchers from PGRN, the PRISM Global Research Network, is also acknowledged.

Invitation: “PRISM 30” special 30th Anniversary Celebration Sessions



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What is the Motivation for CPS production and supply?

Apply cybernetics/AI for significant value in three main dimensions:

1. **Reach** and **engage** workers, consumers, clients, and customers, including physical devices, and at remote locations, more effectively
2. Boost worker's / employee's ***productivity & safety***
3. Optimize operating ***efficiency & effectiveness***

Resilience & Sustainability

Motivation: Improve work / business / service processes by using computing & communication science & cyber technology → *Economic supply of needed services*

Digital & Cyber in Production Automation:

Augments abilities of workers, robots, and organizations

CYBER (Cybernetics) = Computing + Communication + Real-time control + Brain models for collaboration protocols

Increasing levels of computers, communication, mobility, and computational intelligence lead to higher levels of automation intelligence, and of resilience to internal and external disruptions.

Digital & Cyber Augmentation	
1.0	Computerized
2.0	Computer Integrated
3.0	Internetworked + Mobile
4.0	Cloud-Based + Machine Learning
5.0	Cyber-Physical + Cybernetics