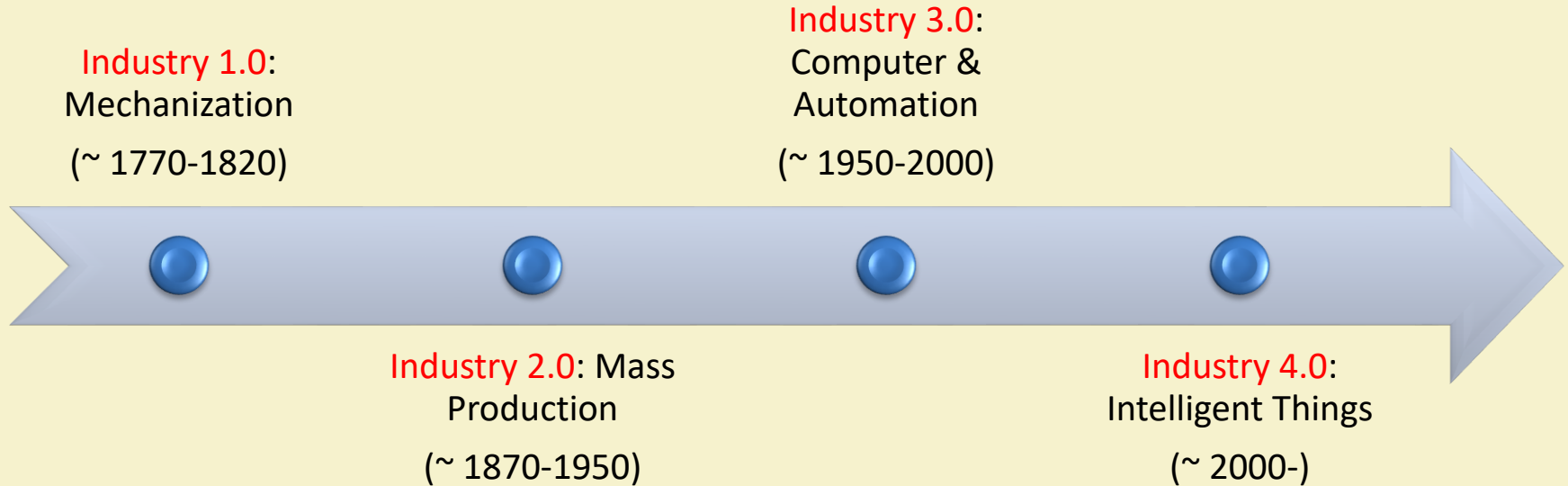
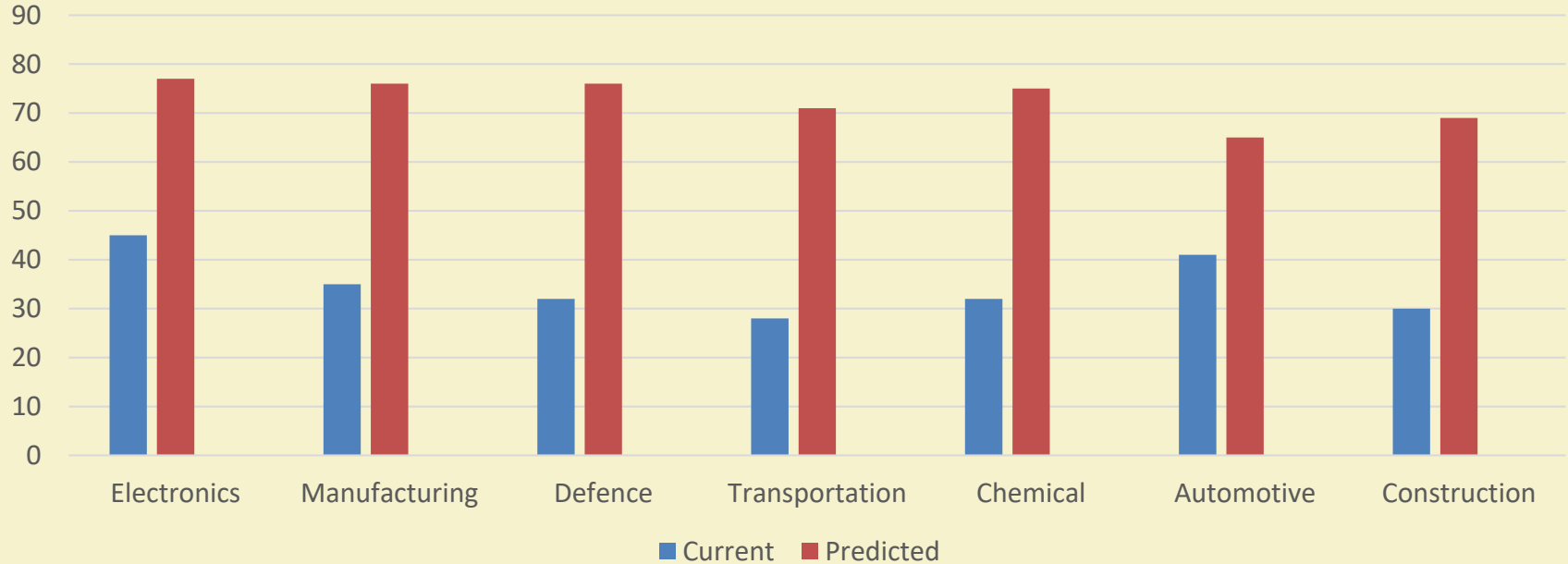


Timeline of Industrial Revolution



Source: "Industry 4.0 and Maintenance", Norsk Forening for Vedlikehold (NFV)

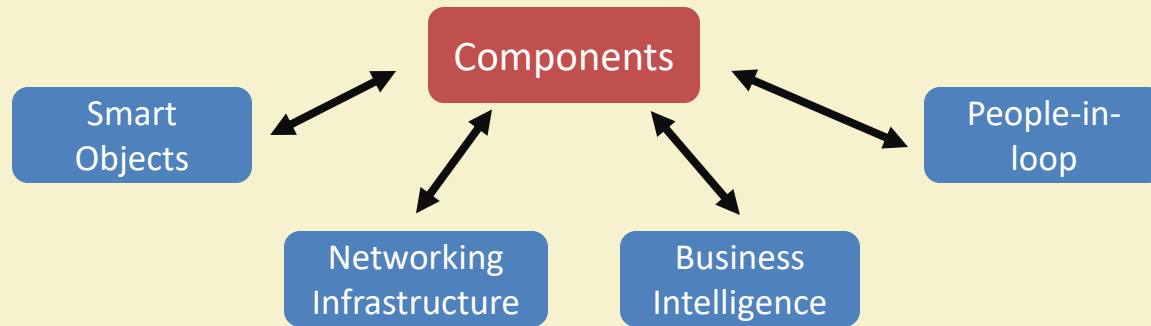
Predicted Growth in Industrial Sectors



Source: "Industry 4.0: Building the Digital Enterprise", PwC, *Global Industry 4.0 Survey*, 2016.

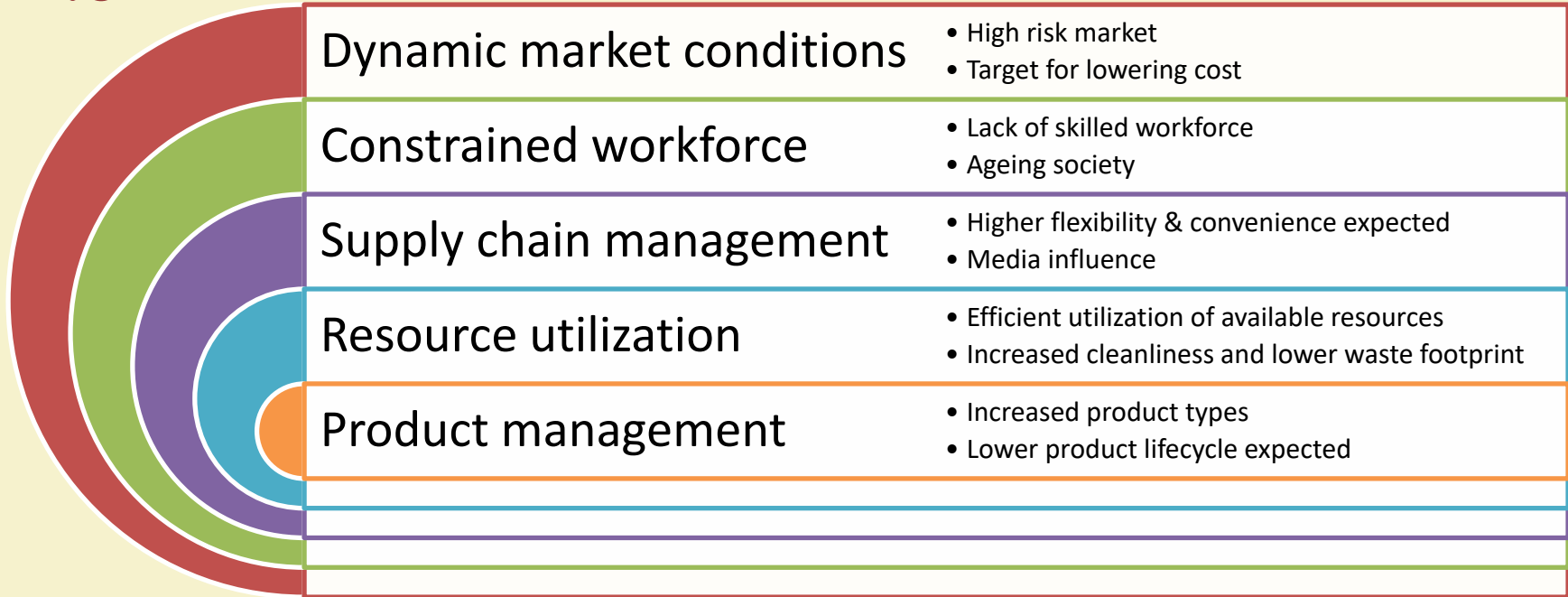
Industrial Internet of Things (IIoT)

- Network of objects (“things”) embedded with computation and communication facilities to achieve industrial jobs by exchanging information among themselves



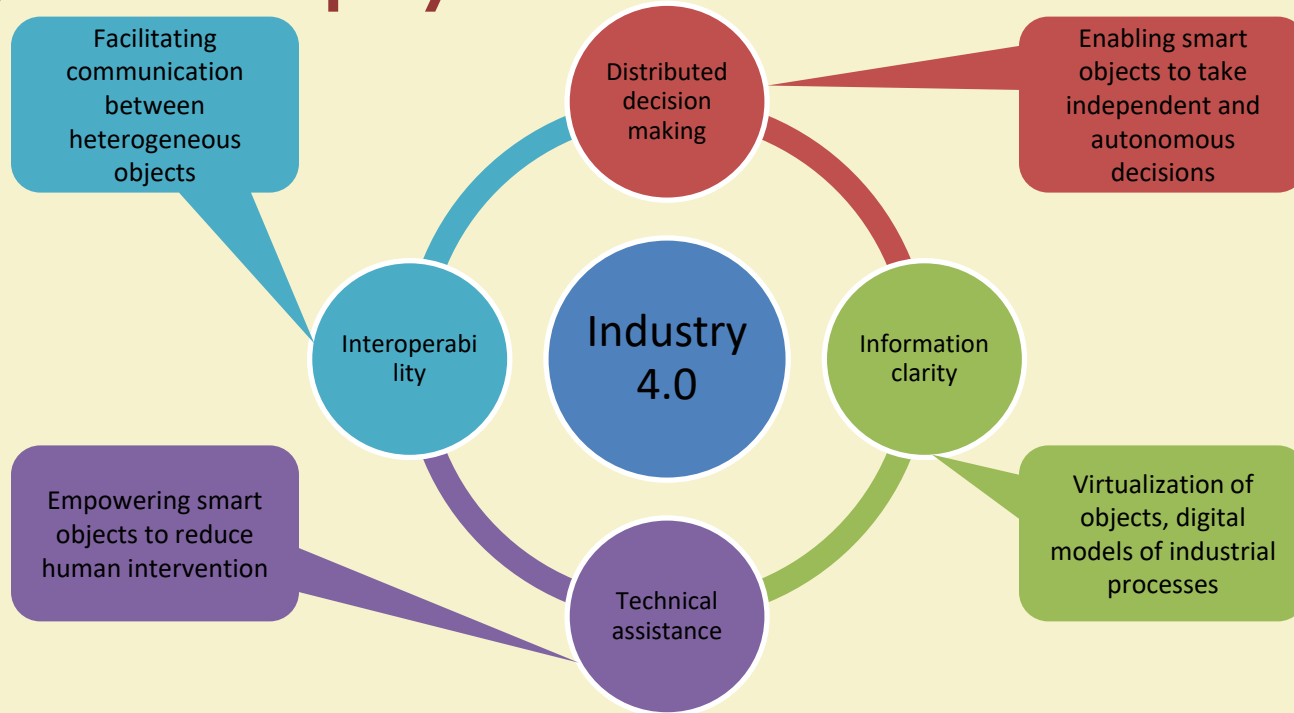
Source: Xu et al., 2014

Challenges for Industrial Processes in Industry 4.0



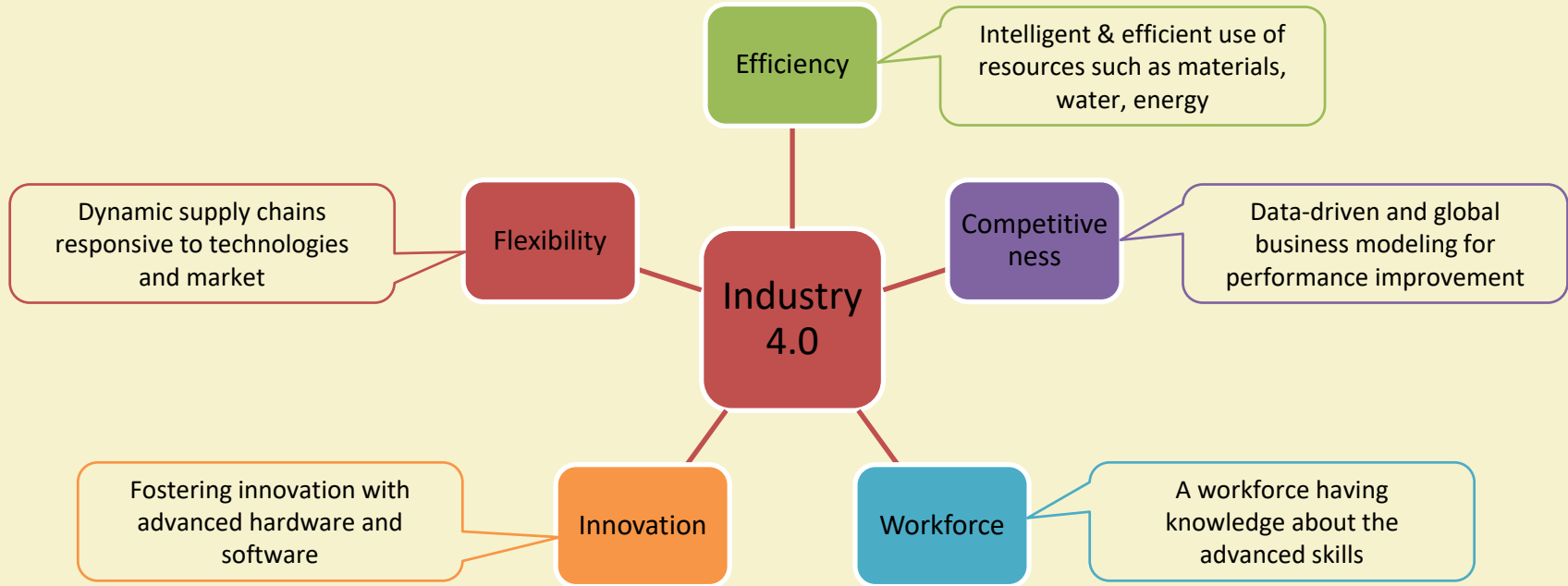
Source: "Industry 4.0", Wikipedia

Design Philosophy: IIoT for Industrial Processes



Source: "Industry 4.0", Wikipedia

Expected Features of Industrial Processes with Industry 4.0



Source: "Industry 4.0", Wikipedia; "Industry 4.0: the fourth industrial revolution – guide to Industrie 4.0", i-Scoop

Futuristic Industrial Plant

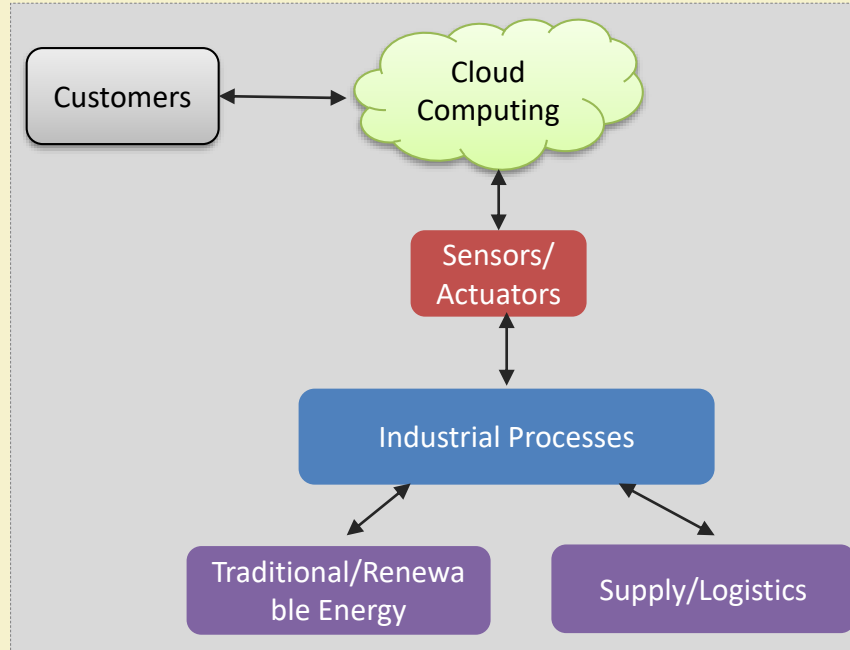
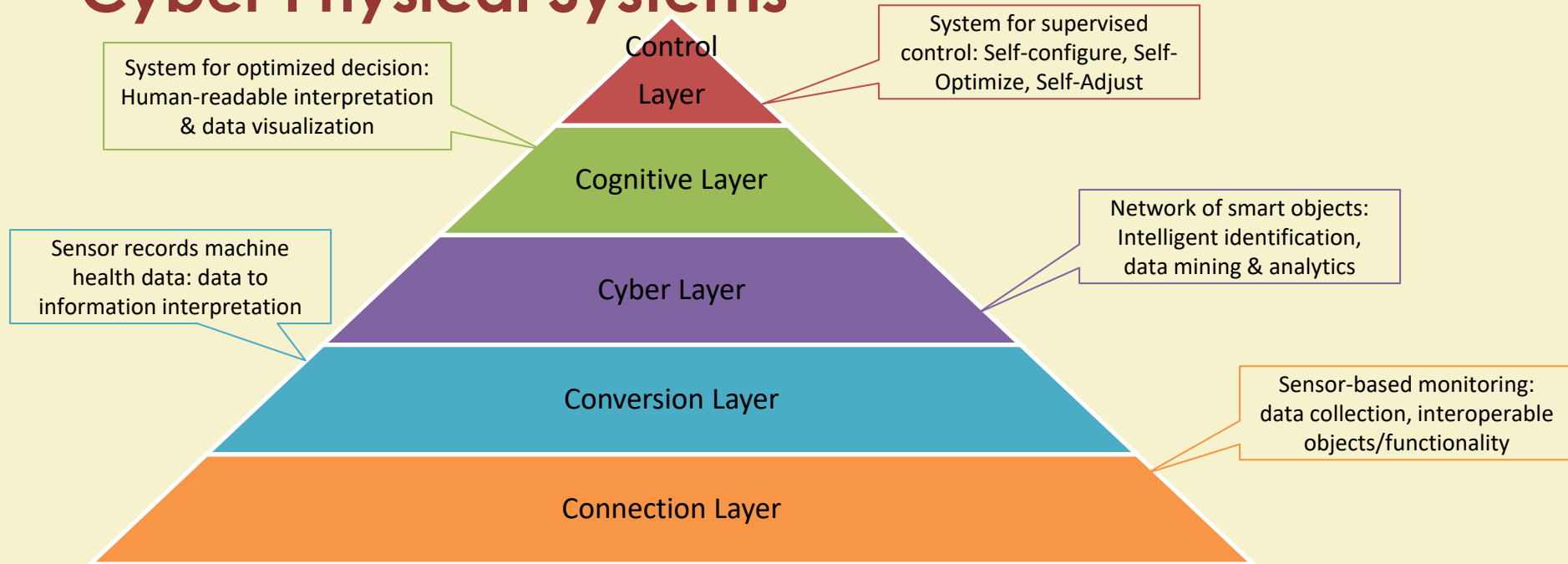


Figure: Components of Futuristic Industrial Plant in Industry 4.0

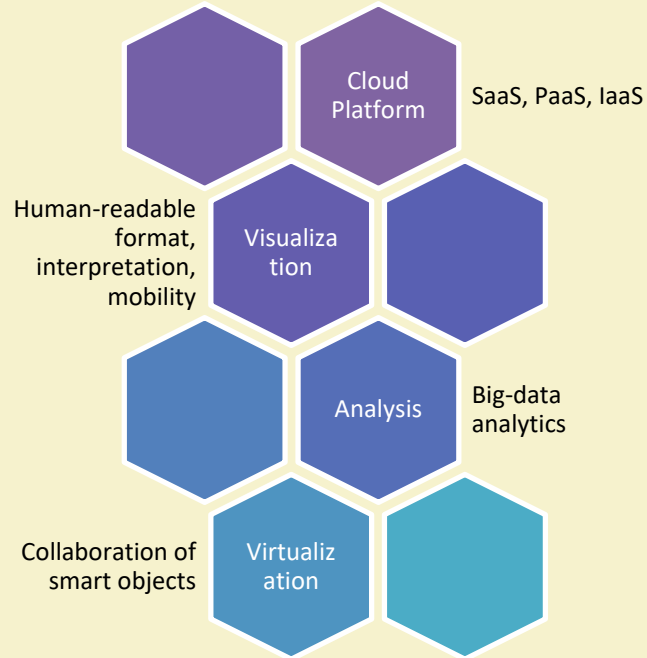
Source: Aazam et al., 2018.

Futuristic Industrial Plant: 5C Architecture for Cyber Physical Systems



Source: Lee et al., 2015; Aazam et al., 2018.

Industrial Processes Enablers



Source: Aazam et al., 2018.

Industrial Process 4.0: Operation Efficiency

➤ Benefits

- Improved resource utilization
- Increased productivity
- Cost reduction

Smart Water Management by *Thames Water*

- Sensor-based equipment status monitoring
- Failure detection
- Critical condition monitoring
- Dynamic response to critical conditions

Oil & Gas Industry Maintenance by *Apache*

- Sensor-based leak detection in pipe lines
- Failure detection in pumps
- Production monitoring
- Predictive analysis of loss

Source: Thames Water, "Draft Water Resources Management Plan 2019"
MapR Technologies, "Big Data and Apache Hadoop for the Oil and Gas Industry"

Industrial Process 4.0: Product Innovation

➤ Benefits

- Service-oriented deployment
- Data monetization
- Pay-per-use

Augmented Maintenance by Volkswagen

- Sensors collect data from automotive
- Augmented Reality-based app provide visual interpretation of on-board problem
- Problem analysis & diagnosis

Source: Volkswagen AG

Industrial Process 4.0: Enhanced Ecosystem

➤ Benefits

- Connected ecosystem
- Innovative product lines
- Dynamic marketplace
- Pay-per-outcome

Increased Renewable Energy Production by *General Electric*

- Controlled power generation by using weather forecast
- Sensor-controlled maintenance
- Lower operation cost by analyzing collected data

Increased reliability in aircraft engines by *Rolls-Royce*

- Sensor-based remote analytics tools
- Predictive maintenance
- TotalCare program increases the engine reliability

Source: GE Renewable Energy; Rolls-Royce plc

Industrial Process 4.0: Autonomous Pull Economy

➤ Benefits

- End-to-end automation facility
- Updated demand information
- Low waste generation
- Better resource optimization

Factory Maintenance by *General Electric*

- *Predix* platform for Cloud-as-a-Service
- Pay-per-use pricing model
- Secure and compatible environment
- Analytical services helps in service optimization

Source: General Electric Inc.

Smart Factory of Future

- *Application areas*
 - Facility management
 - Connected factory
 - Inventory management
 - Production line management
 - Process safety and security
 - Service quality control
 - Supply chain optimization
 - Packaging management

Source: "8 Uses, Applications, and Benefits of Industrial IoT in Manufacturing", New Generation Applications Pvt Ltd,

Smart Factory of Future (contd.)

Facility Management

- Sensor-equipped manufacturing facility
- Provision for condition-based monitoring
- Machinery health monitoring
- Optimization & remote functional control
- Higher efficiency, lower cost & energy expense

Connected Factory

- Connected components of factory – machinery, engineers, and manufacturers
- Enables automation and optimization
- Remote control and management
- Ease of command and control
- Facilitate identification of Key Result Areas (KRAs)

Source: "8 Uses, Applications, and Benefits of Industrial IoT in Manufacturing", New Generation Applications Pvt Ltd,

Smart Factory of Future (contd.)

Inventory management

- Tracking of items by monitoring events in supply chain
- Global inter-connectivity facilitates real-time updates
- Higher visibility & transparency
- Realistic and fail-safe estimate for customers
- Supply optimization & cost reduction

Production line management

- End-to-end production line management with sensors
- Ease of process re-adjustment facility
- Detailed understanding of production delay & failures
- Process flow analytics

Source: "8 Uses, Applications, and Benefits of Industrial IoT in Manufacturing", New Generation Applications Pvt Ltd,

Smart Factory of Future (contd.)

Process safety and security

- Safe & secure working environment
- Complete record & analytics on accidents, injuries & causes
- Optimized financial planning & insurance schemes
- Ensured precautions for safe environments

Service quality control

- End-to-end product cycle monitoring
- Provision to ensure quality for raw materials, factory environment
- Waste management
- Multi-level product quality check
- Enabling feedbacks from customers
- Holistic analytics

Source: "8 Uses, Applications, and Benefits of Industrial IoT in Manufacturing", New Generation Applications Pvt Ltd,

Smart Factory of Future (contd.)

Supply chain optimization

- Real-time monitoring of supply chain elements in multiple dimensions
- Ease & transparency for related personnel
- Identification of inter-block dependency

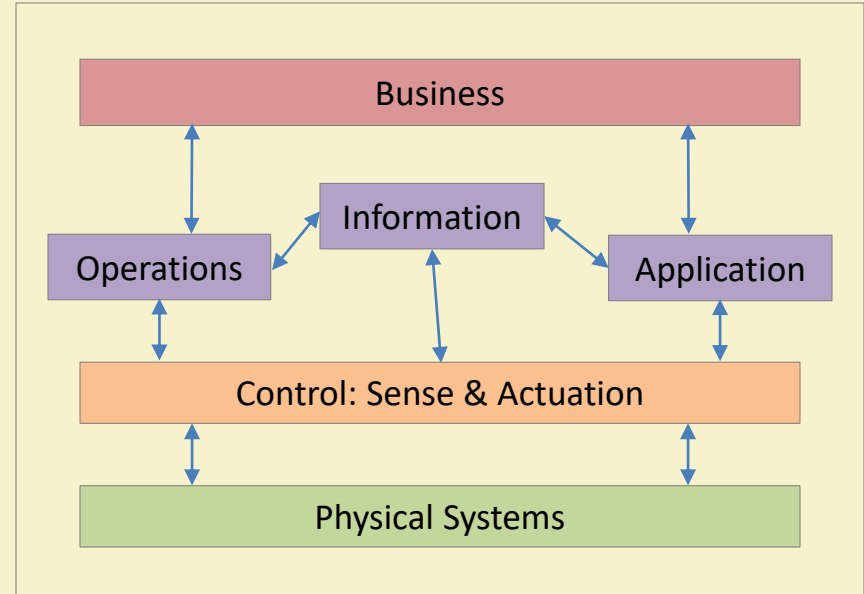
Packaging management

- Sensor-based packaging facility
- Real-time monitoring
- Detailed analytics on customers usage patterns
- Multi-point trace enables package condition monitoring
- Continued customer satisfaction & reduced cost

Source: "8 Uses, Applications, and Benefits of Industrial IoT in Manufacturing", New Generation Applications Pvt Ltd,

Functional Viewpoint of Industrial Processes

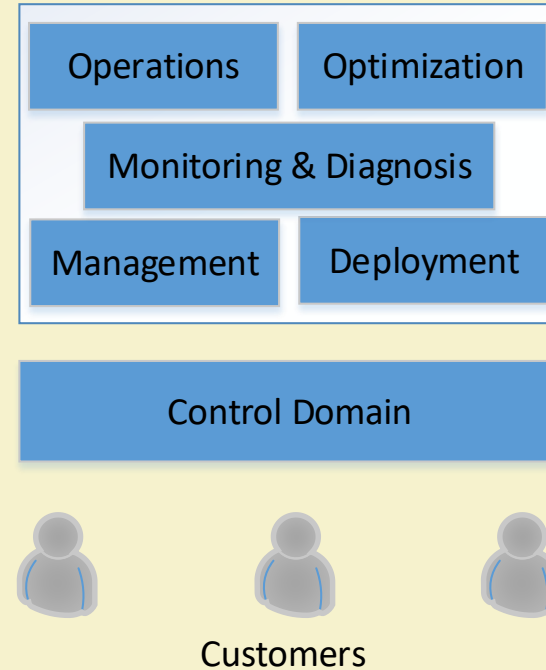
- Highlights the stakeholder's concerns regarding the industrial processes
- Flexible & applicable to various types of industrial processes
- Importance to specific domain varies across industries



Source: A. Gilchrist, "Industry 4.0 - The Industrial Internet of Things", APress

Operational Domain of Industrial Processes

- Cross-environment interconnected control system
- Intra and Inter factory communication
- Distributed analysis & learning



Source: A. Gilchrist, "Industry 4.0 - The Industrial Internet of Things", APress

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Thank You!!

