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Technological Theory of Cloud Manufacturing

Sylvain Kubler, Luxembourg University, SnT - Interdisciplinary Centre for Security, Reliability & Trust
Jan Holmström, Aalto University, Department of Industrial Engineering and Management, Finland
Kary Främling, Aalto University, School of Science and Technology, Finland
Petra Turkama, Aalto University, Business School, Finland

UNIVERSITÉ DU LUXEMBOURG

SUMMARY

- Manufacturing Paradigms Through The Ages
- CMfg Taxonomy: Underlying Concepts & Technologies
- FI-WARE & Open Platform 3.0
- Conclusion

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- **CMfg Taxonomy: Underlying Concepts & Technologies**
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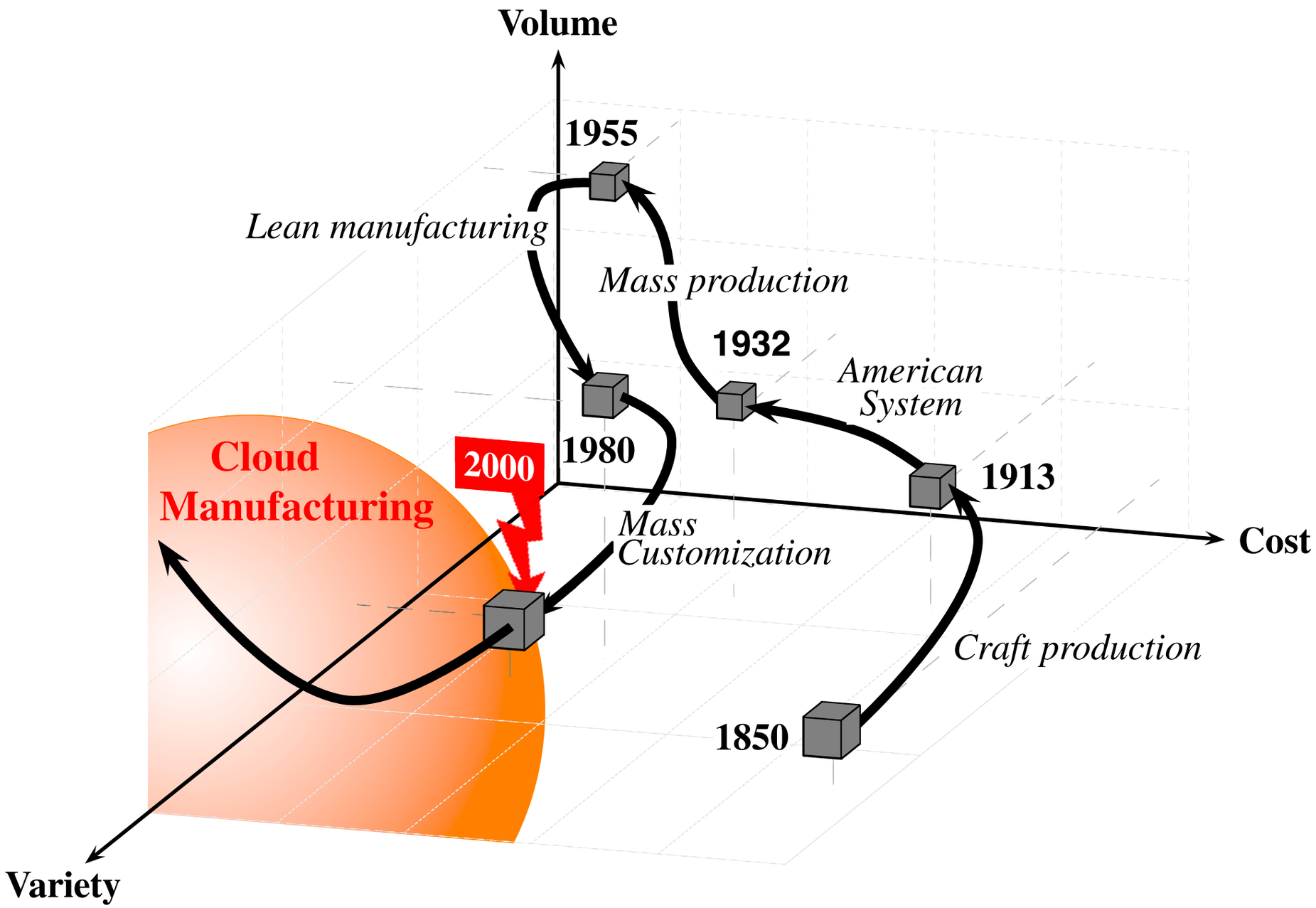
Manufacturing Paradigms Through The Ages

Volume-Variety-Cost relationship in manufacturing paradigms



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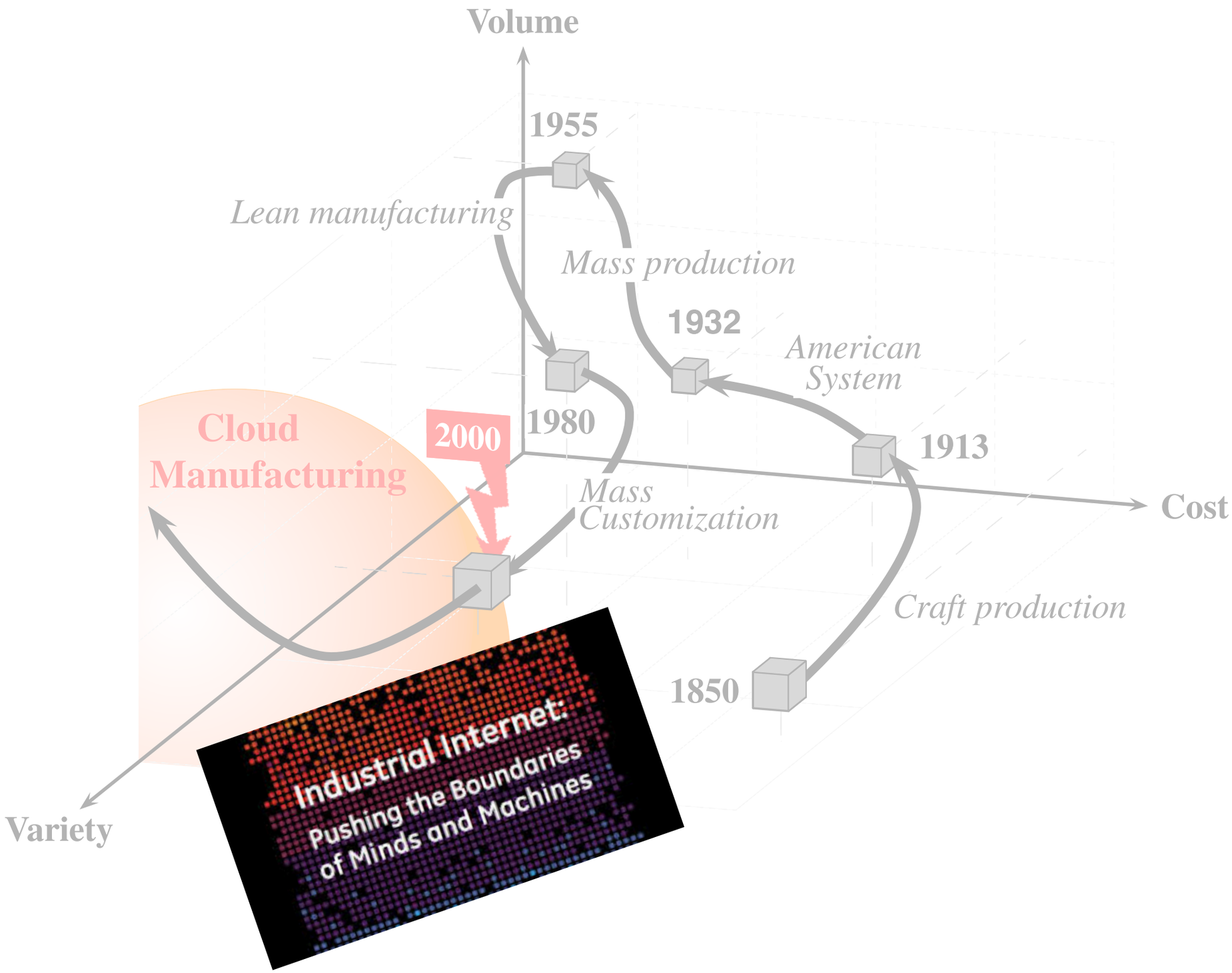

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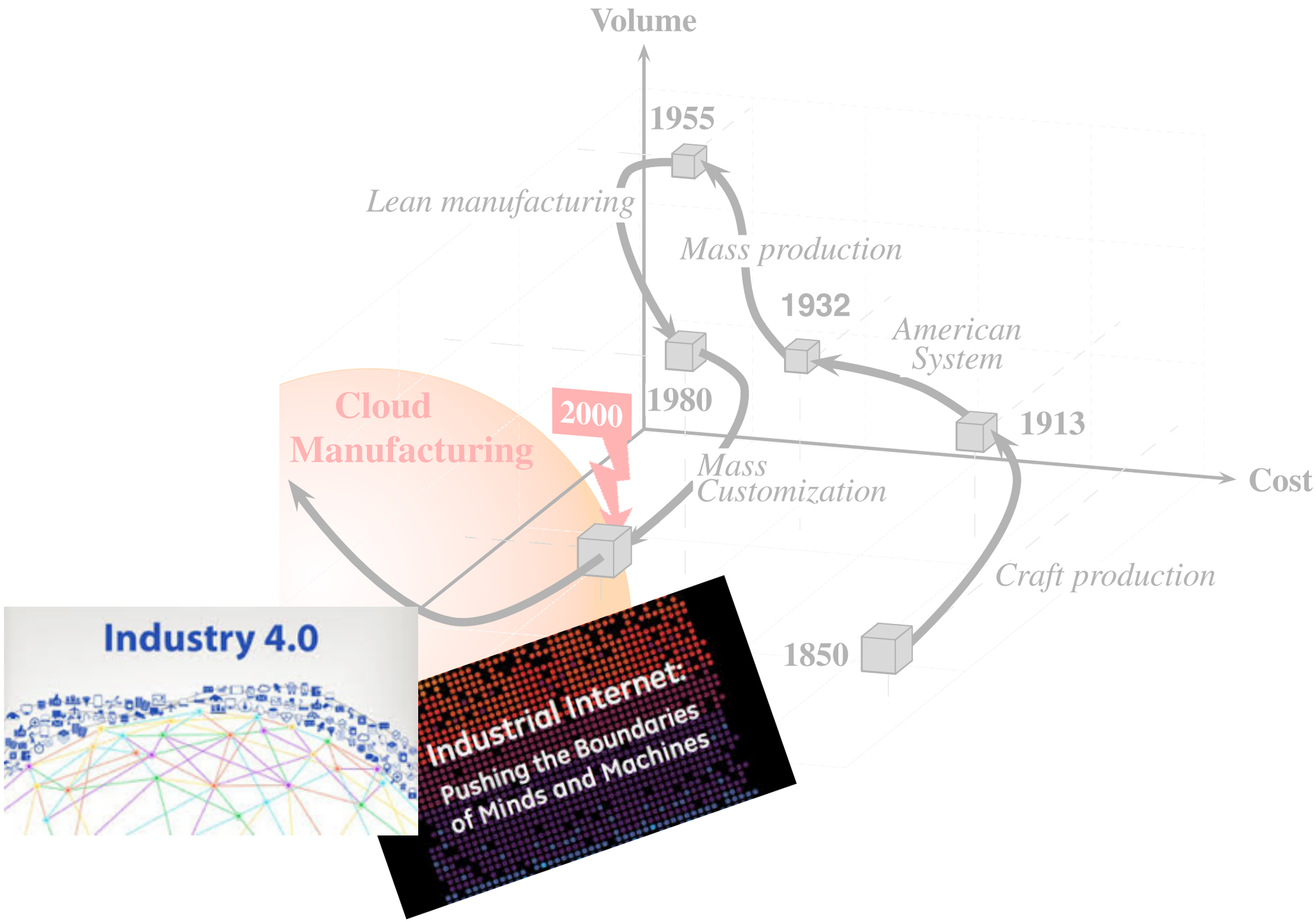

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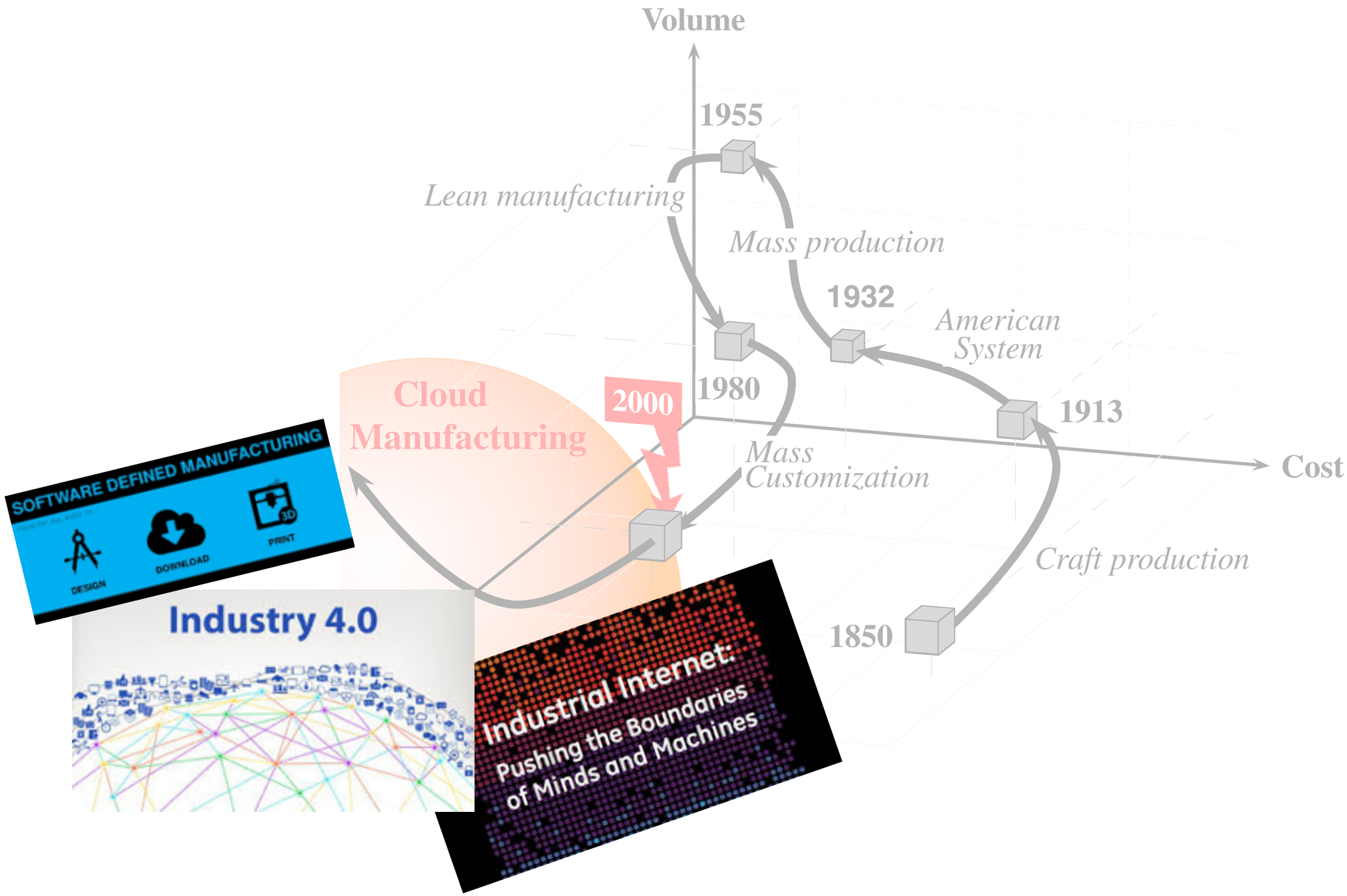

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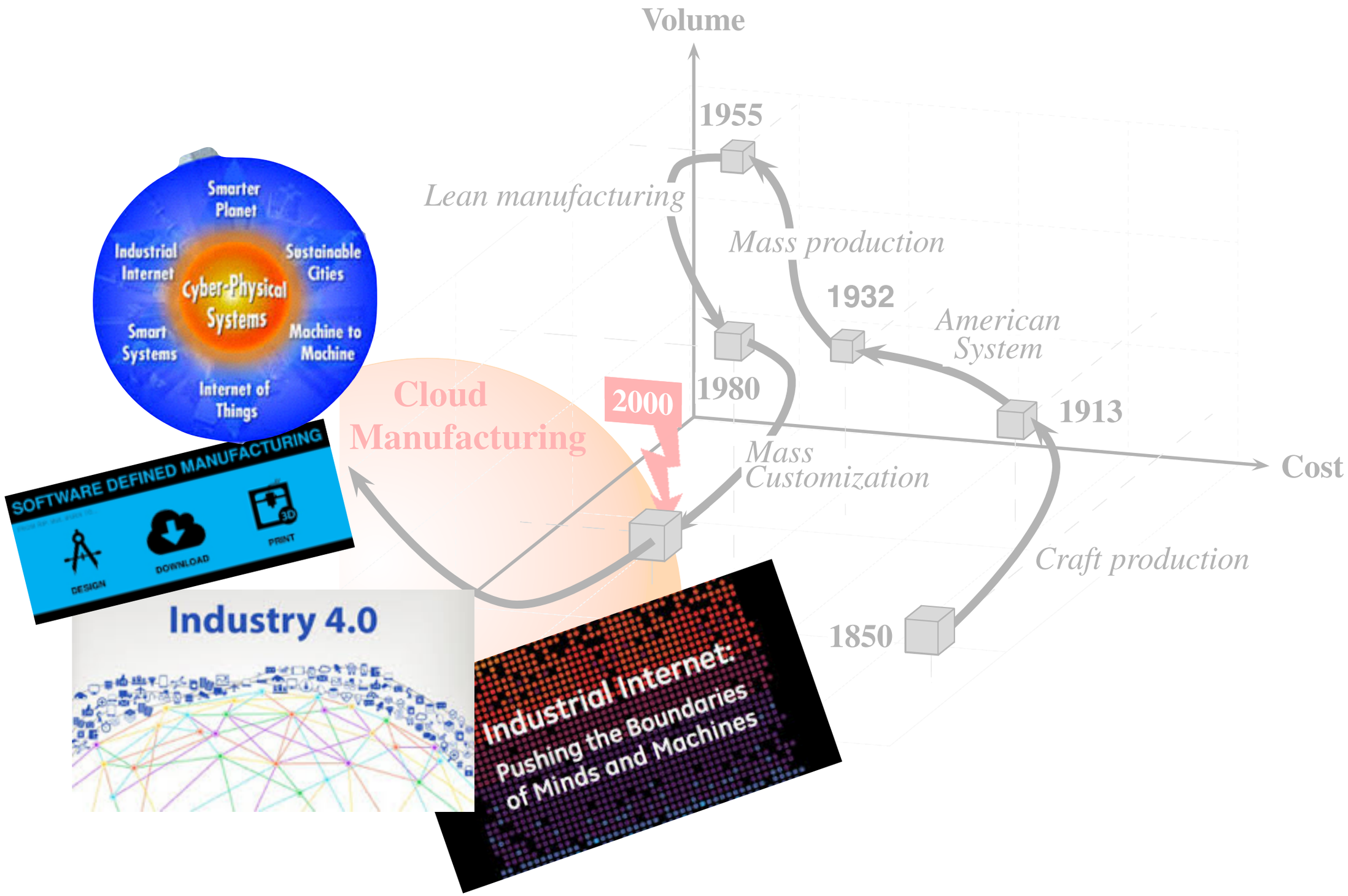

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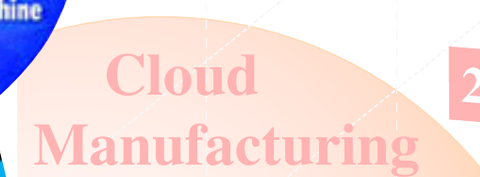

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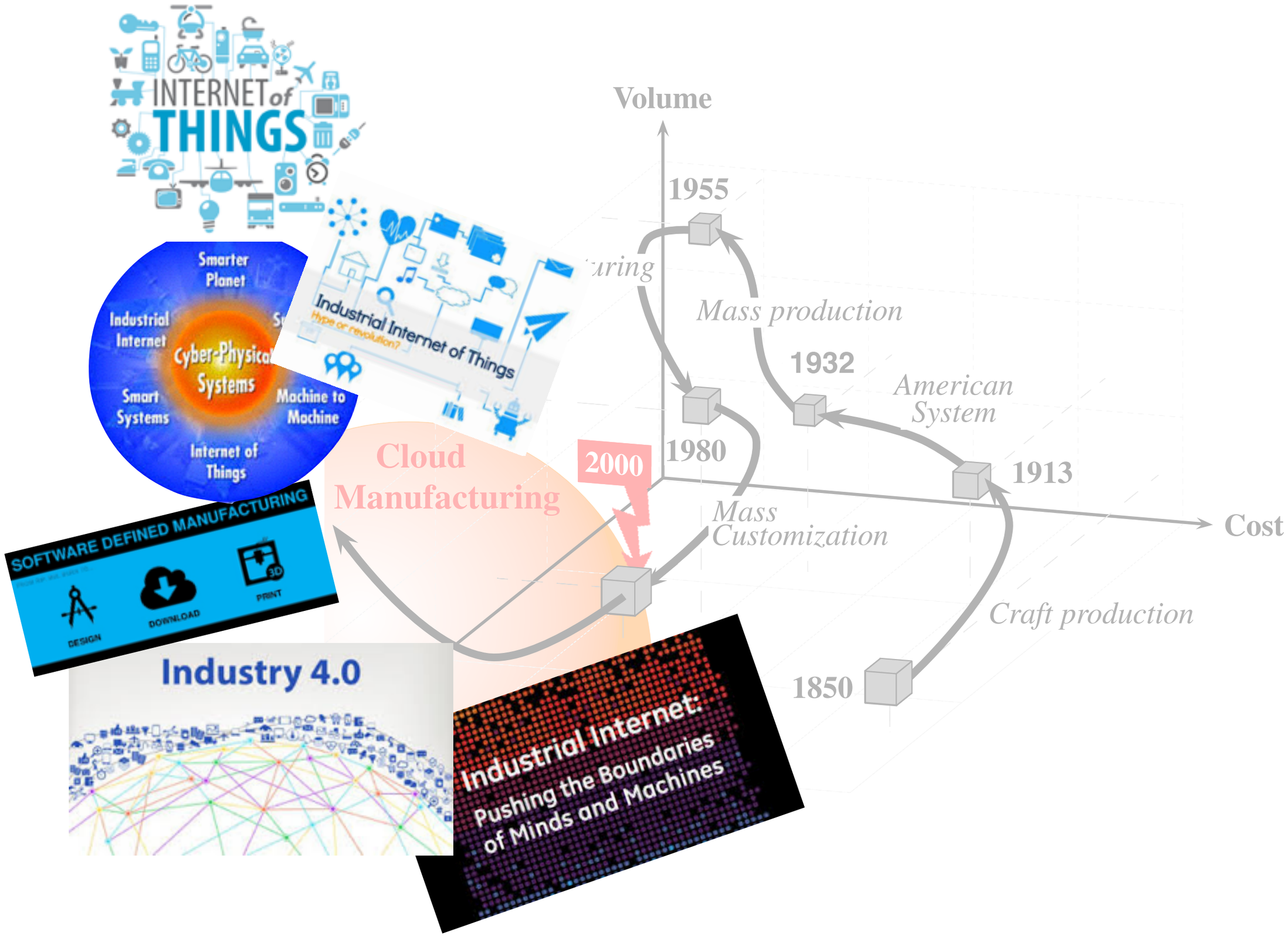

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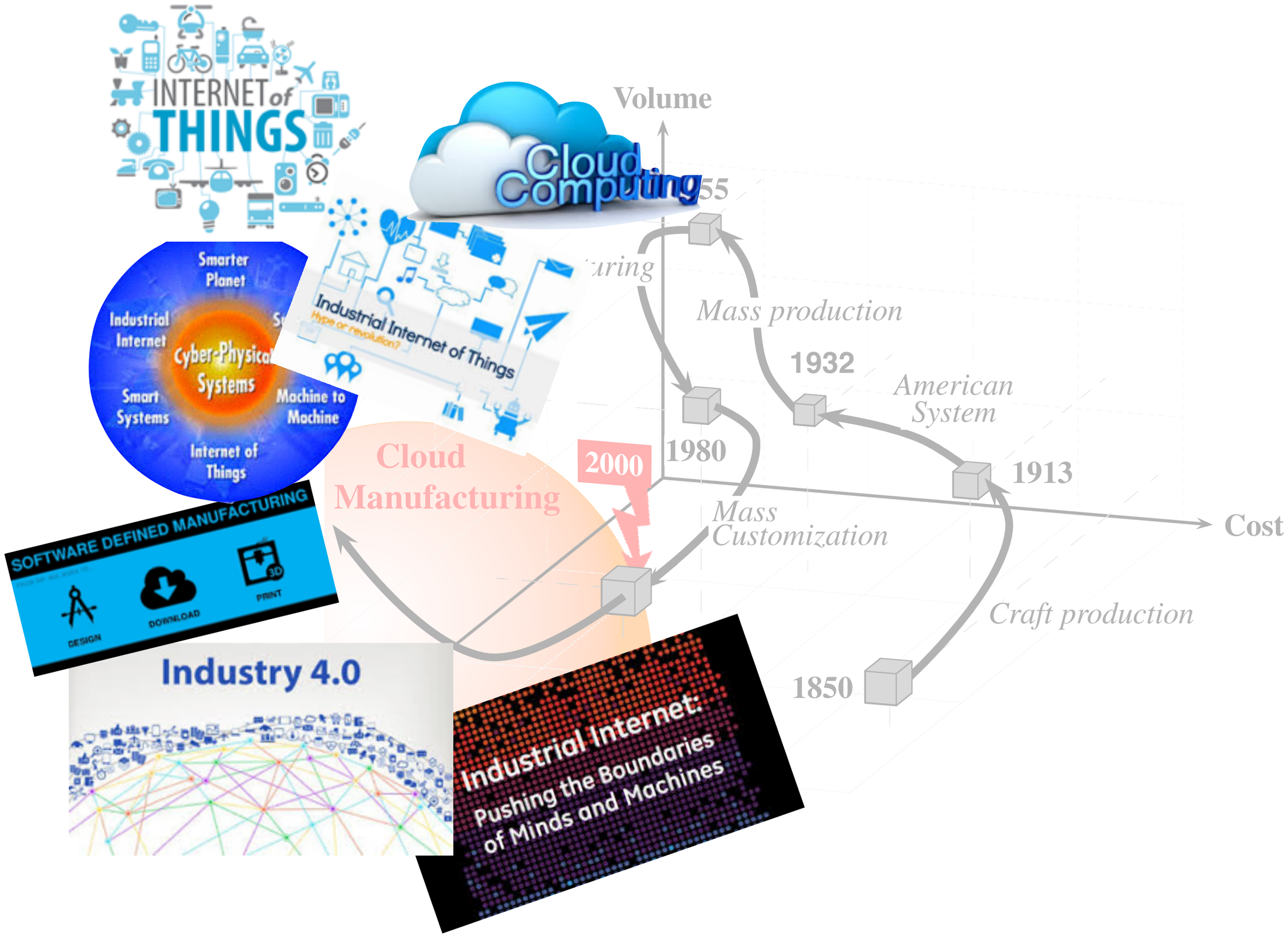

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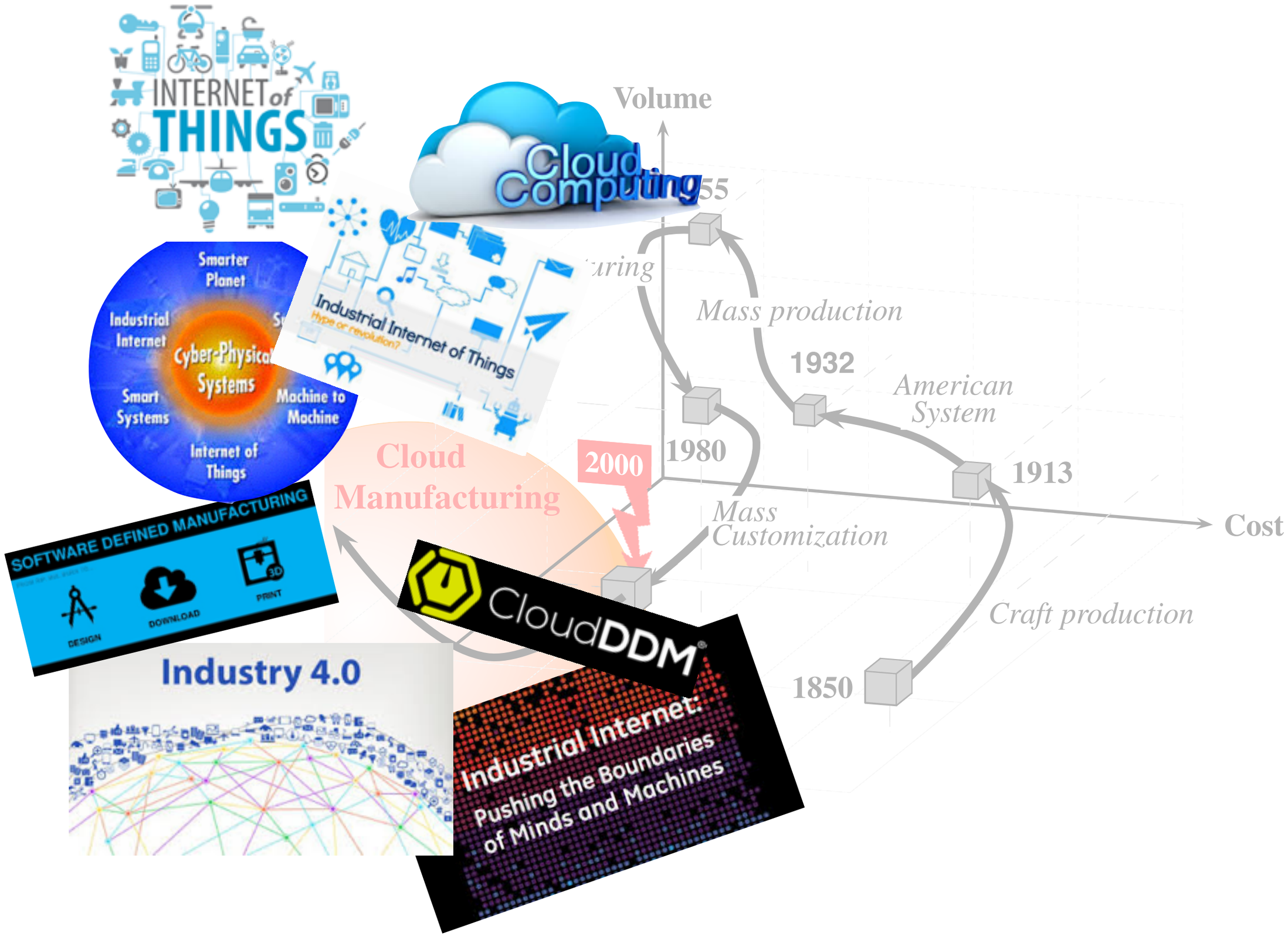

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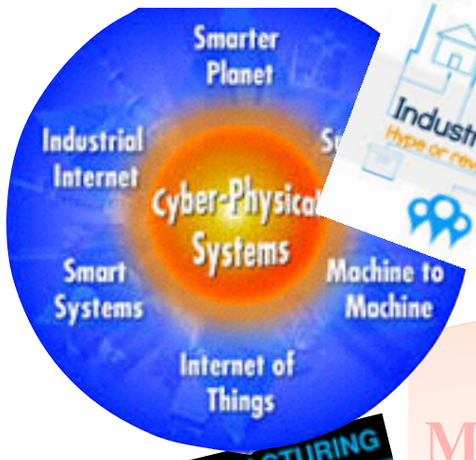
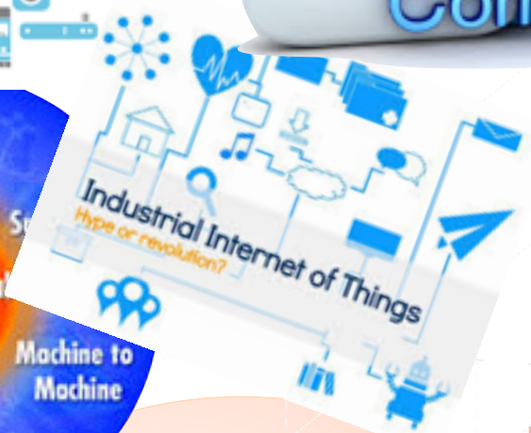
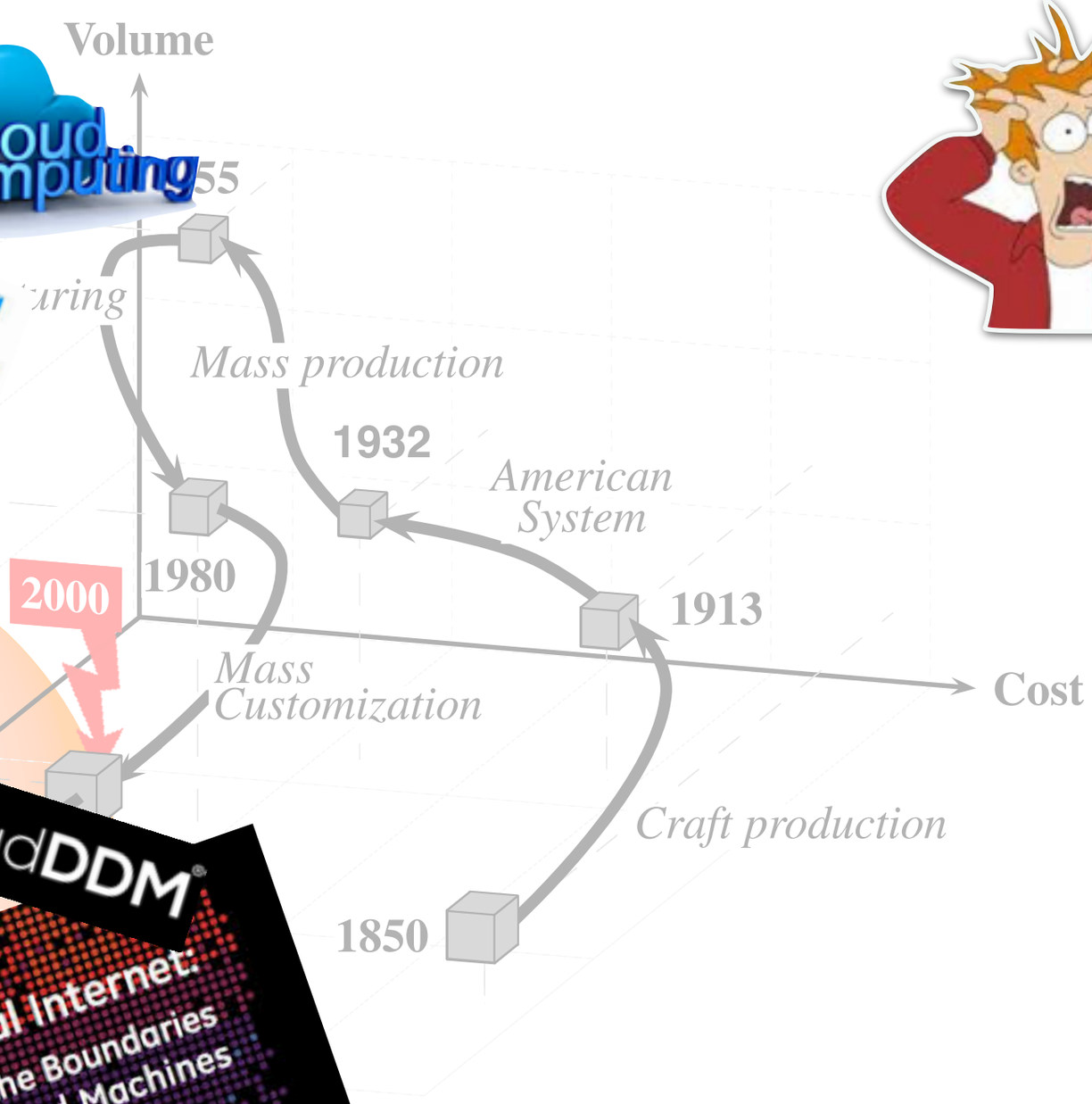


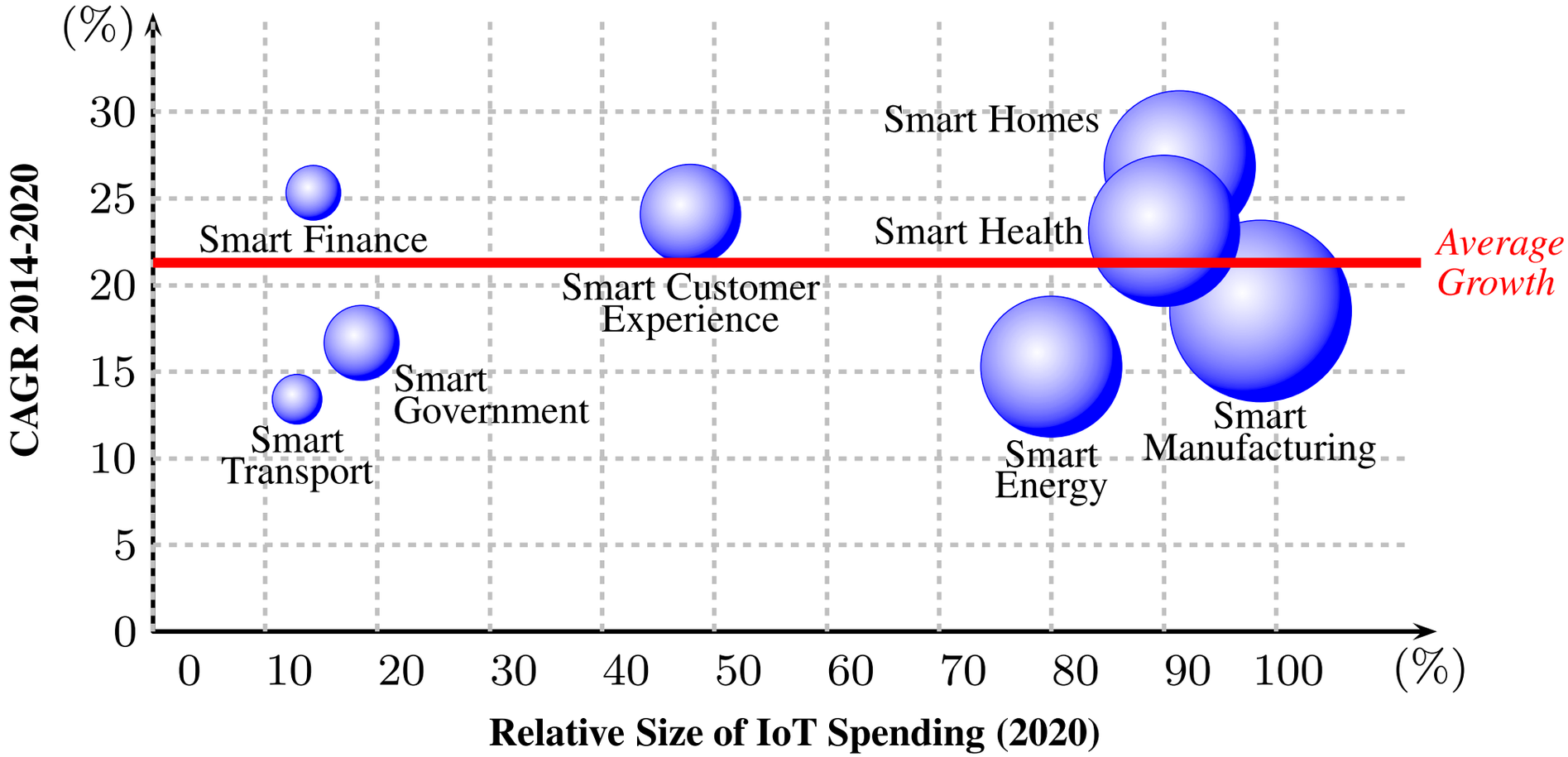




Manufacturing Paradigms Through The Ages

Volume-Variety-Cost relationship in manufacturing paradigms

*Source: Definition of a R&I strategy leveraging The combination of **IoT & Cloud** for DG CONNECT*



CAGR: Compound Annual Growth Rate

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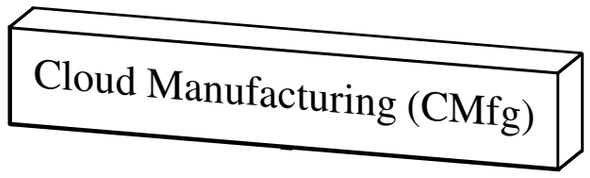
Cloud Manufacturing (CMfg) Taxonomy



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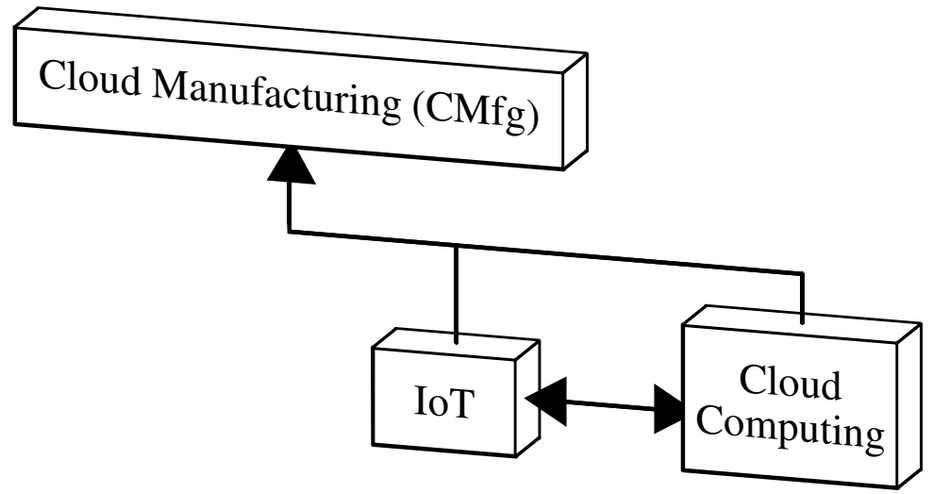
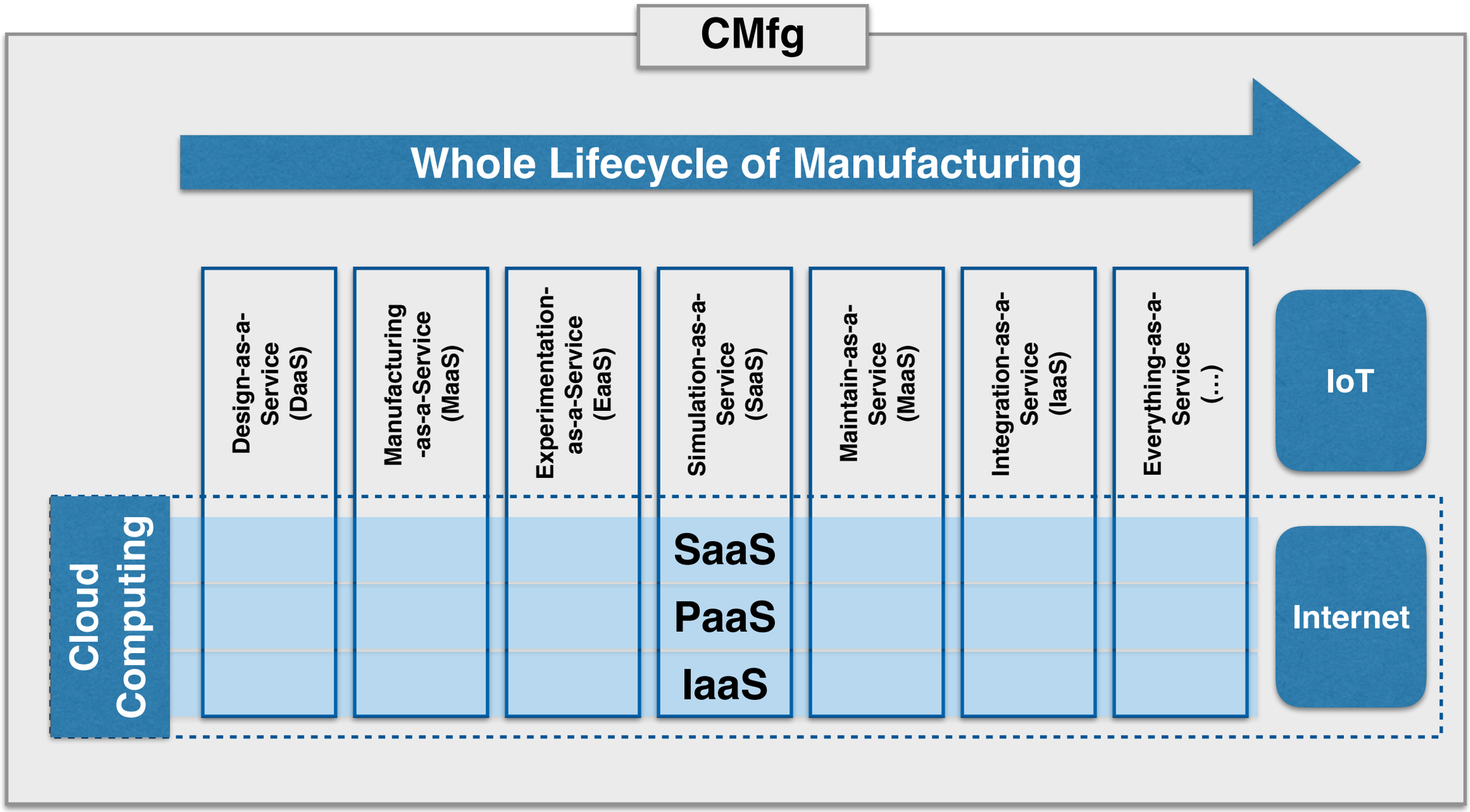


Cloud Manufacturing (CMfg) Taxonomy

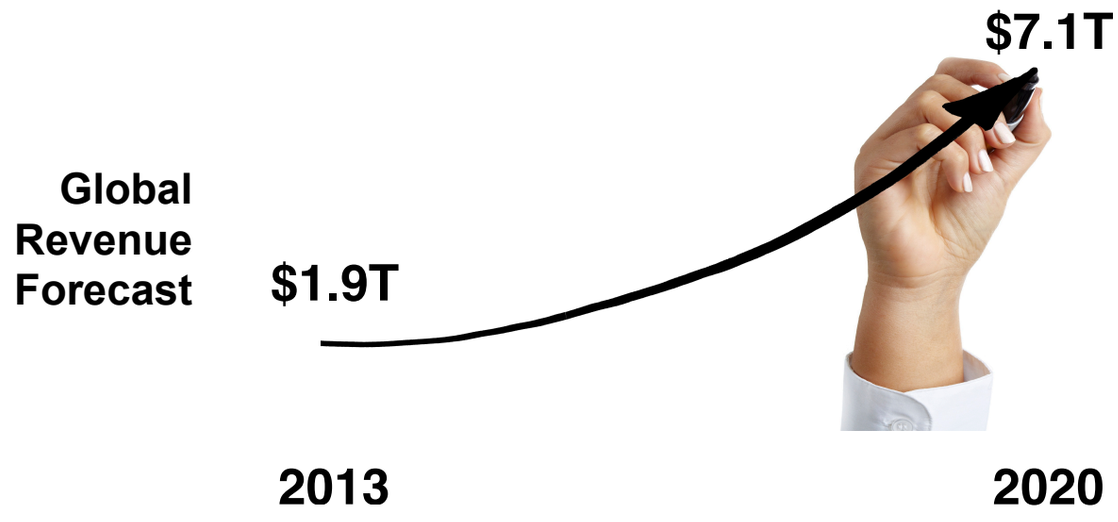
Relationship between Cloud computing, IoT and CMfg



Tao, F. et al (2011) Cloud manufacturing: a computing and service- oriented manufacturing model, Proc. IMechE Vol. 225 Part B: J. Engineering Manufacture

Cloud Manufacturing (CMfg) Taxonomy

Forecasting the Future of the Internet of Things in EU (according to IDC-DG Connect)

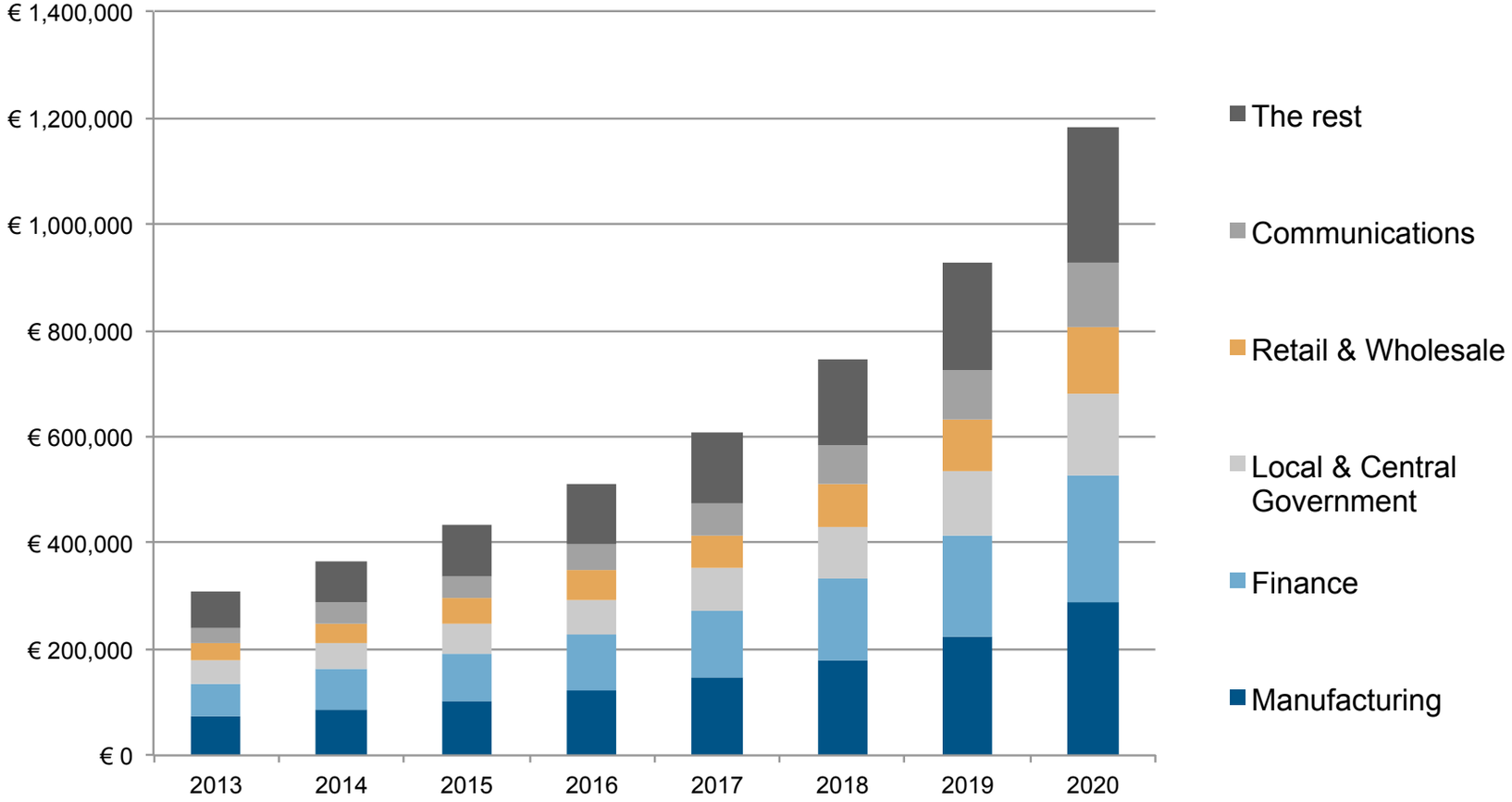


Cloud Manufacturing (CMfg) Taxonomy

Forecasting the Future of the Internet of Things in EU (according to IDC-DG Connect)

Global Revenue Forecast

IoT Forecast Revenues by sector (EU Baseline scenario)

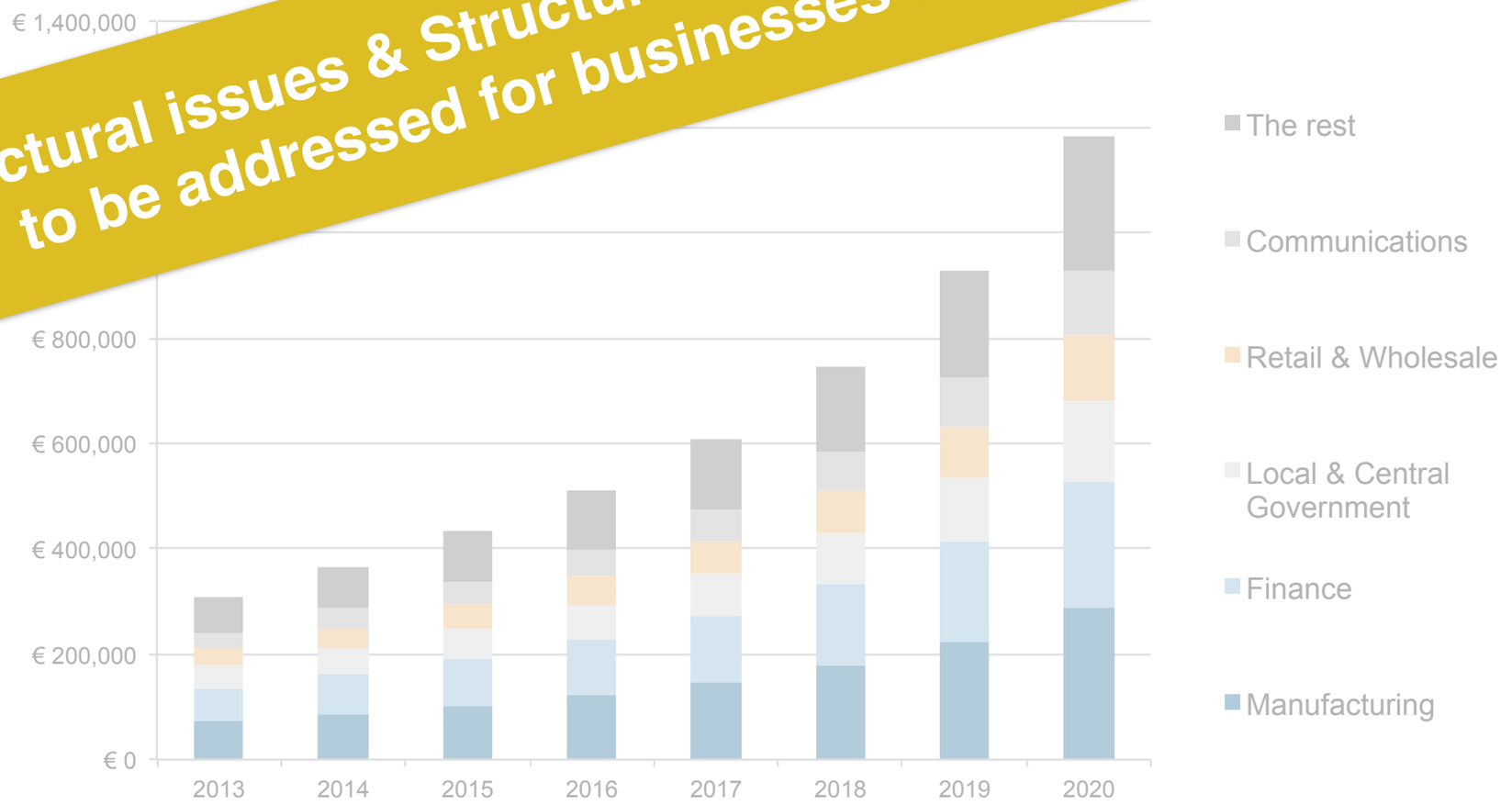


Cloud Manufacturing (CMfg) Taxonomy

Forecasting the Future of the Internet of Things in EU (according to IDC-DG Connect)

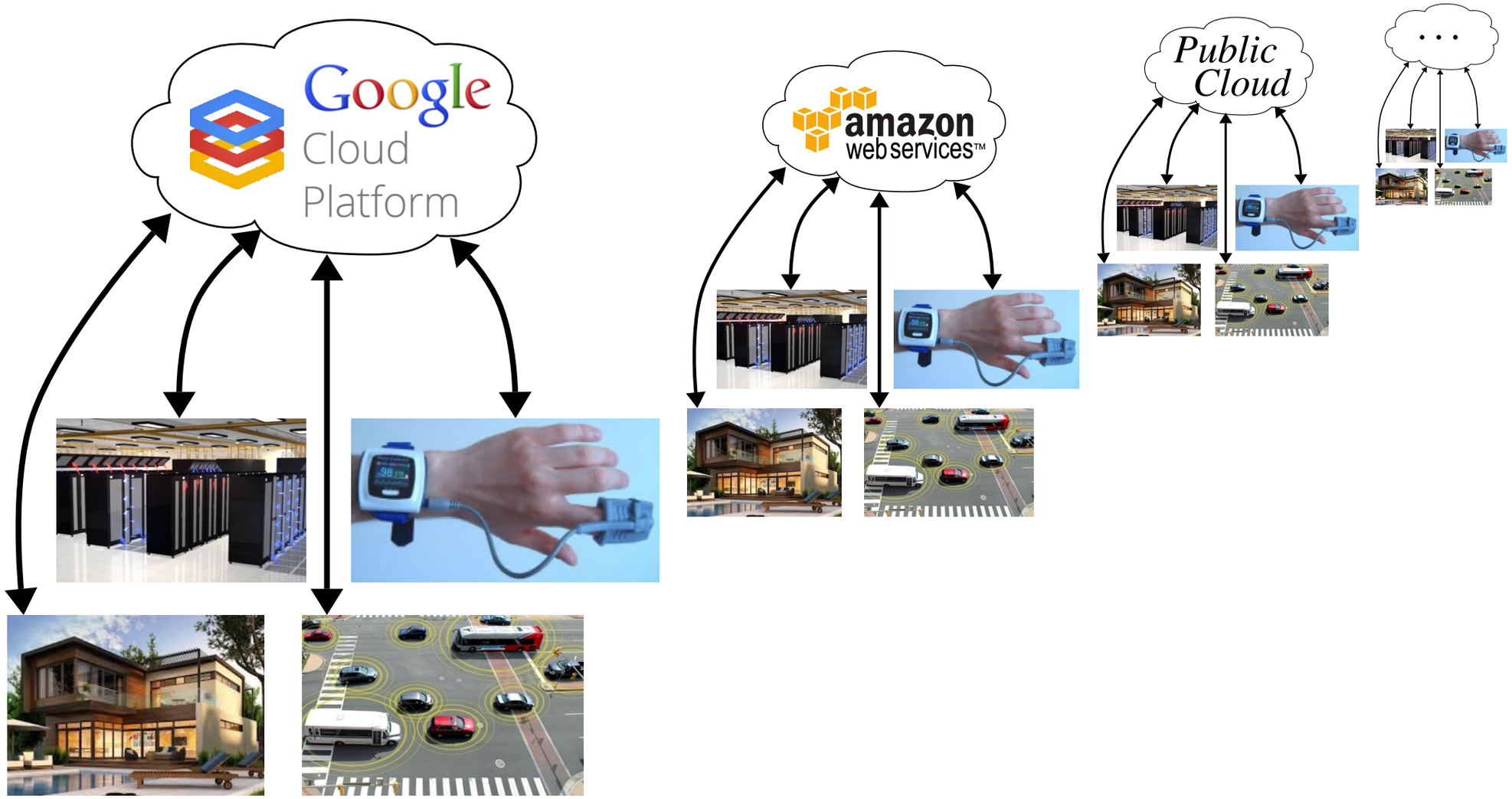
Architectural issues & Structural considerations still need to be addressed for businesses to benefit !

Revel… by sector (EU Baseline scenario)



Cloud Manufacturing (CMfg) Taxonomy

Today's Cloud-based IoT landscape: Vertical Silos' issue



Legend

⟷ Today's IoT : Data collected into vertical silos (pushed to vertical servers)

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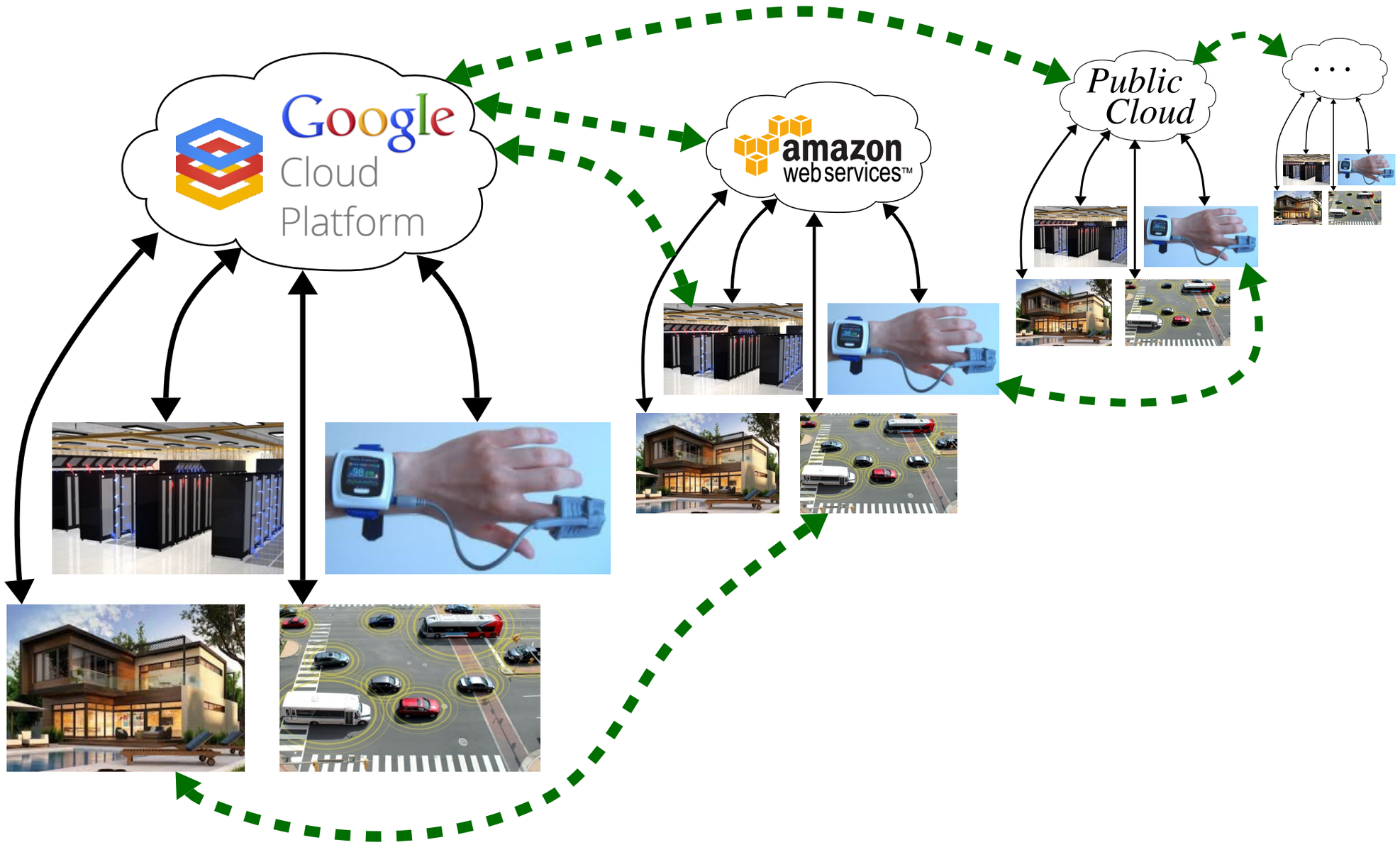
Today's Cloud-based IoT landscape: Vertical Silos' issue



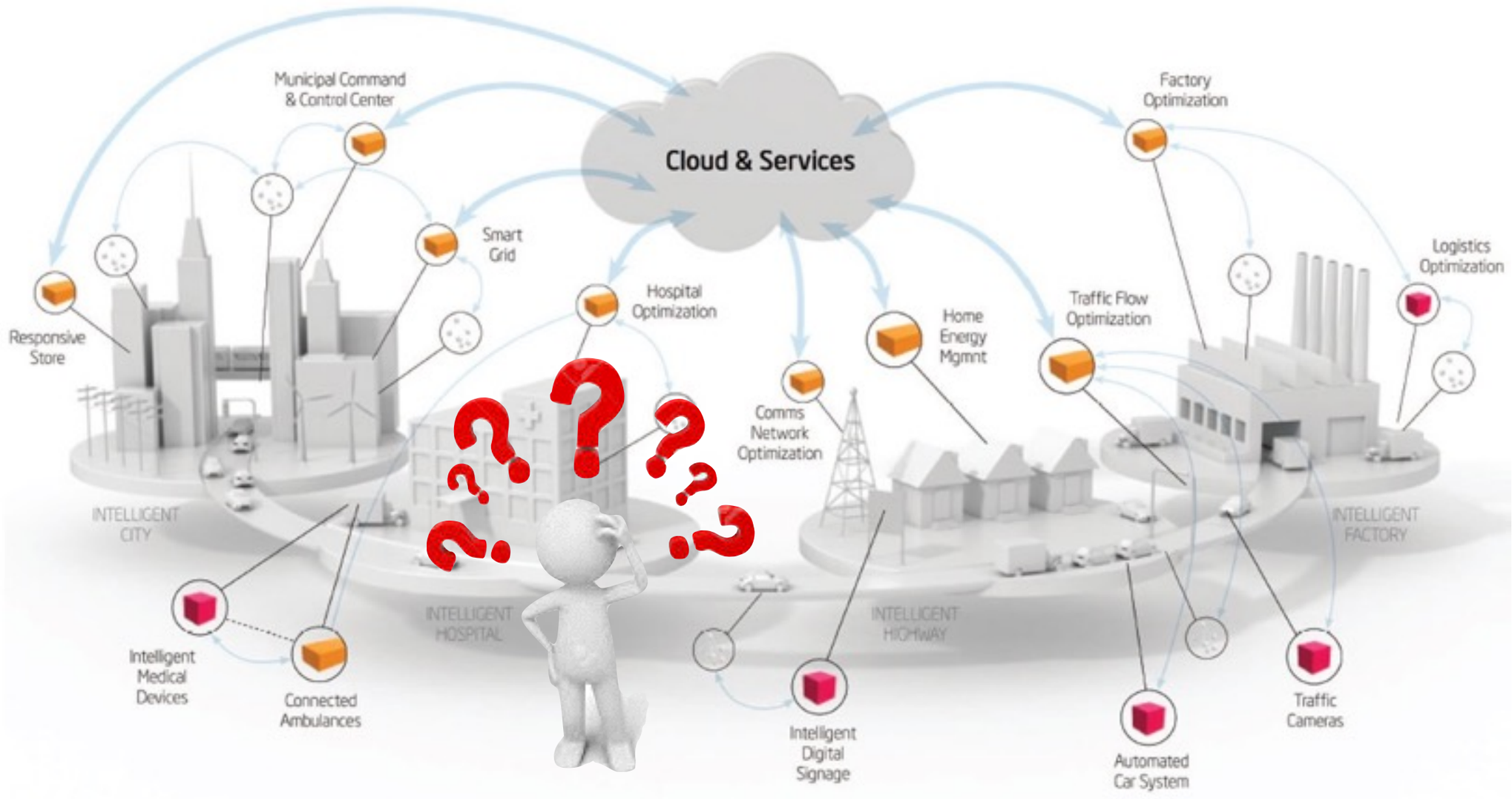
Legend

Today's IoT : Data collected into vertical silos (pushed to vertical servers)

Ideal IoT : Communication allowed between vertically-oriented closed systems

Cloud Manufacturing (CMfg) Taxonomy

Today's Cloud-based IoT landscape: People may be reluctant to step into the IoT arena



- Major ICT players hand over customer data and are not willing to let the customers have a full end-to-end control, resulting in user frustration;

- The non-maturity of the IoT makes it challenging to develop a clear approach to foster innovation, trust and ownership of data, while at the same time respecting security and privacy in complex environments.

Project Coordinator

Aalto University (Finland)

Prof. Kary FRÄMLING
School of Science and Technology
P.O. Box 15400, FI-00076 AALTO, Finland
✉ kary.framling@aalto.fi ☎ +358 505 980 451

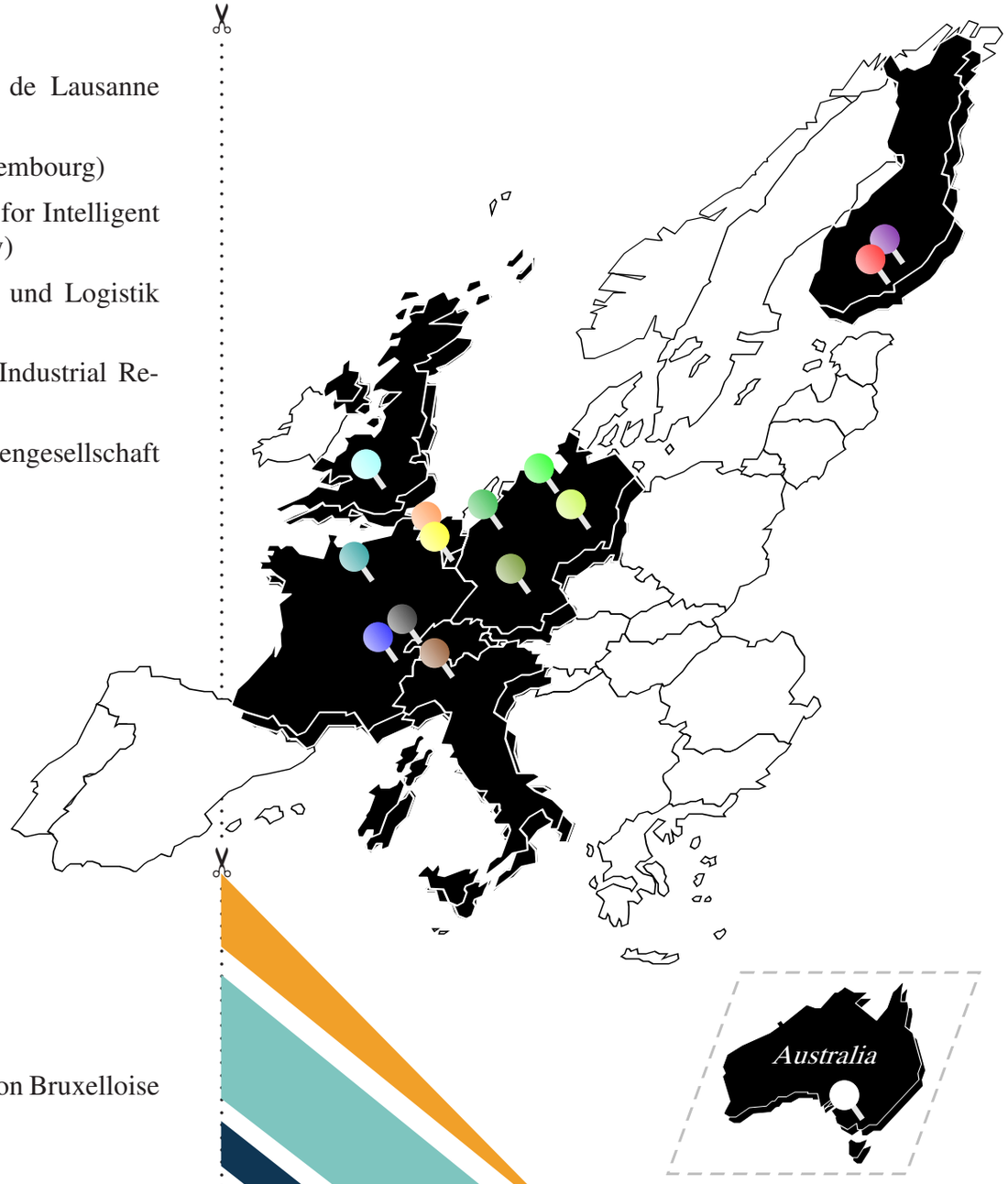
Project Consortium

- **EPFL:** École Polytechnique Fédérale de Lausanne (Switzerland)
- **Uni.lu:** University of Luxembourg (Luxembourg)
- **Fraunhofer IAIS:** Fraunhofer Institute for Intelligent Analysis and Information Systems (Germany)
- **BIBA:** Bremer Institut für Produktion und Logistik GmbH (Germany)
- **CSIRO:** Commonwealth Scientific & Industrial Research Organisation (Australia)
- **BMW:** Bayerische Motoren Werke Aktiengesellschaft (Germany)
- **TOG:** The Open Group (UK)
- **eccenca GmbH** (Germany)
- **OpenDataSoft** (France)
- **Cityzen Data** (France)
- **Holonix** (Italy)
- **itrust consulting** (Luxembourg)
- **Enervent Oy** (Finland)
- **ControlThings** (Finland)
- **IS-Practice** (Belgium)
- **Forum Virium Helsinki** (Finland)
- **Grand Lyon La Métropole** (France)
- **IRISnet** (Belgium)
- **CIRB:** Centre Informatique pour la Région Bruxelloise (Belgium)
- **Brussels Mobility** (Belgium)

This project has received funding from the European Union's H2020 Programme for research, technological development and demonstration under grant agreement n^o 688203.

Visit & Join us

- http://biotope-h2020.eu
- ...

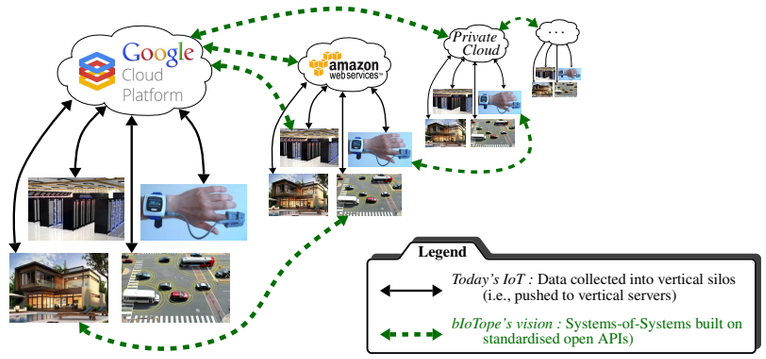


Building an IoT OPen innovation Ecosystem for connected smart objects

bIoTope

Scope & Objectives

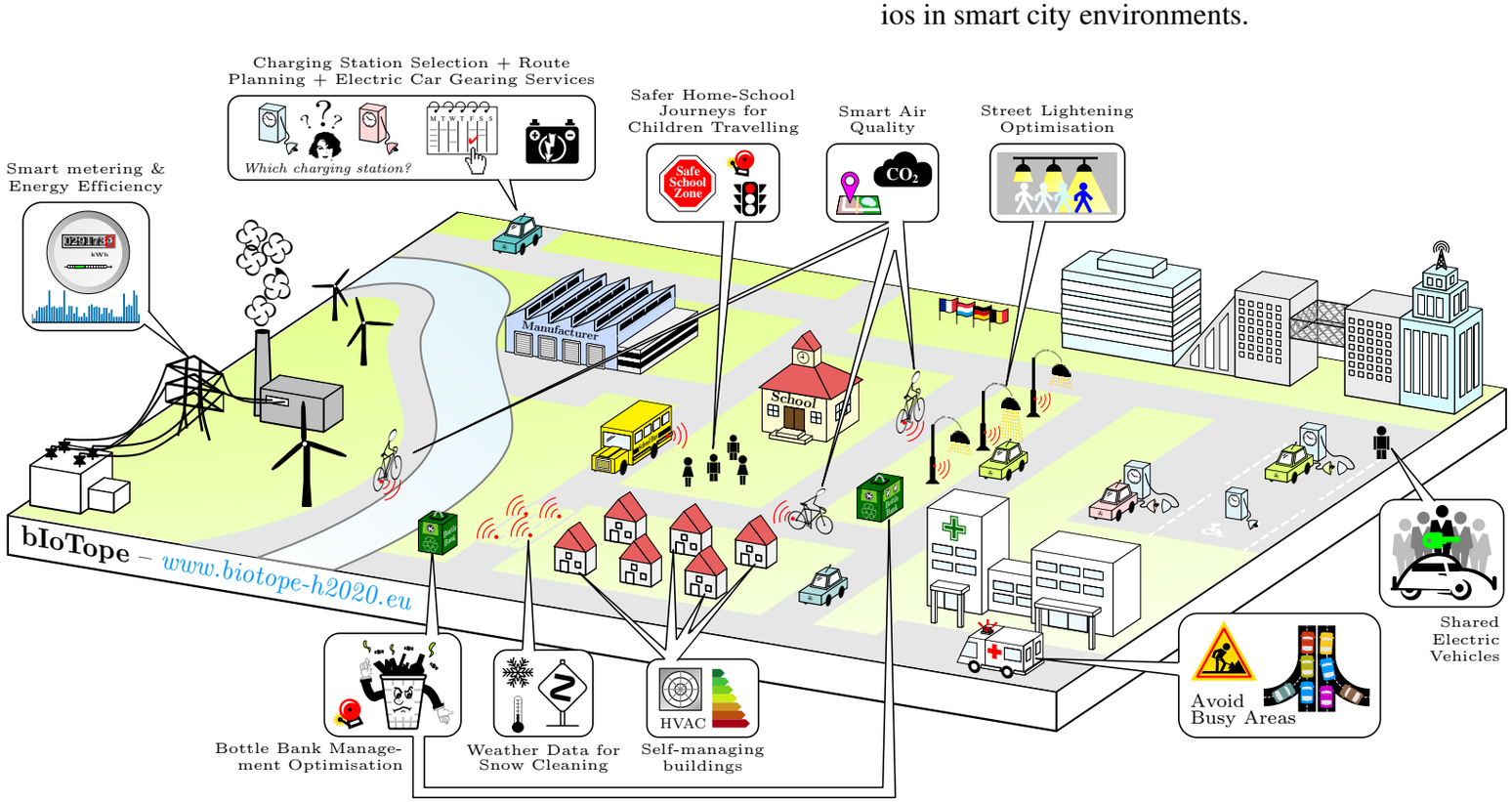
The Internet of Things (IoT) brings opportunities to create new services and products, reducing costs for societies, and changing how services are sold and consumed. Despite this, one of the most critical obstacles are the "vertical silos" that shape today's IoT (*cf.* solid/black arrows in the below figure). Indeed, such silos constitute a serious impediment to the creation of cross-domain, cross-platform and cross-organisational services due to the lack of interoperability and openness.



bIoTope aims to lay the foundation for open innovation ecosystems, where companies can – *with minimal investment* – innovate by creating new **Systems-of-Systems (SoS) platforms** for connected smart objects (*cf.* dashed/green arrows in the above figure).

bIoTope Objectives

- Provide the necessary **standardised Open APIs** to enable horizontal interoperability between vertical silos;
- Enable **new forms of co-creation of services** ranging from simple data collection, processing, to context-driven, intelligent and self-adaptive support of consumers' everyday work and life;
- Establish a clear framework for **security, privacy & trust** that facilitates the responsible access, use, and ownership of data in the IoT;
- Develop **large-scale pilots in smart cities** to provide social, technical and business proofs-of-concept of bIoTope enabled-SoS ecosystems;
- To maintain, grow & sustain the socio-technical and business-wise bIoTope ecosystem, e.g. by establishing an **end-to-end governance roadmap for ecosystem orchestration**.



Universal Messaging Standards for the IoT

bIoTope enables the publication, consumption and composition of heterogeneous information sources and services from across various platforms, including OpenIoT, FI-WARE, bIoTope partner's platforms (e.g., city dashboards), *etc.* To this end, bIoTope takes full advantage of recent Open API standards for the IoT, notably **O-MI[1] (Open Messaging Interface)** and **O-DF[2] (Open Data Format)**, which can be extended with more specific vocabularies, e.g. using Semantic Web & Ontology technologies.

bIoTope Large-Scale Pilots

Two categories of pilots are defined to prove the effectiveness of the bIoTope SoS platform for IoT, namely:

- **Domain-specific pilots:** ensure innovation and exploitation impact through the involved bIoTope partners (e.g., through well-established customer networks);
- **Cross-domain smart city pilots:** provide concrete proofs-of-concept of horizontal interoperability scenarios in smart city environments.

A dozen of smart city pilots will be set up during the project (*cf.* figure bottom/left), implemented in three distinct cities/regions (see table below). In order to engage local developer communities, a set of **Open Calls** will be organized from **June to December 2017**.

	Helsinki city	Brussels Region	Grand Lyon	
Smart Metering & Energy Efficiency	*Involving local third parties (via Open Calls)*			FORUM VIRIUM HELSINKI, A!, uni.lu
Shared Electric Vehicles				FORUM VIRIUM HELSINKI, BMW, MINI, A!
Smart Parking Guidance		*Involving local third parties (via Open Calls)*		FORUM VIRIUM HELSINKI, A!, IRISNET, cibg.brussels
Smart Mobility for Emergency Services				OpenDataSoft, IRISNET, cibg.brussels
Safer Home-School Journeys for Children Travelling				OpenDataSoft, IRISNET, cibg.brussels
Bottle Bank Management			*Involving local third parties (via Open Calls)*	GRANDLYON la métropole, EPFL, Cityzen Data
Street Lightening Optimisation				GRANDLYON la métropole, EPFL, Cityzen Data
Weather Data for Snow Cleaning				GRANDLYON la métropole, EPFL, Cityzen Data
Charging Station Selection + Route Planning + Electric Car Gearing Services	*Potentially implementable in any of the involved cities*			BMW, MINI, eccenca, Fraunhofer IAIS, BIBA
Self-Managing Buildings & Equipment				enervent, HOLONIX, A!, ControlThings
Smart Air Quality	*Potentially implementable in Melbourne (via Open Calls)*			CSIRO, uni.lu, itrust consulting

Standardisation Body : The Open Group

[1]The Open Group, "Open Messaging Interface Technical Standard (O-MI), "https://www2.opengroup.org/ogsys/catalog/C14B, October 2014.

[2]The Open Group, "Open Data Format Technical Standard (O-DF), "https://www2.opengroup.org/ogsys/catalog/C14A, October 2014.

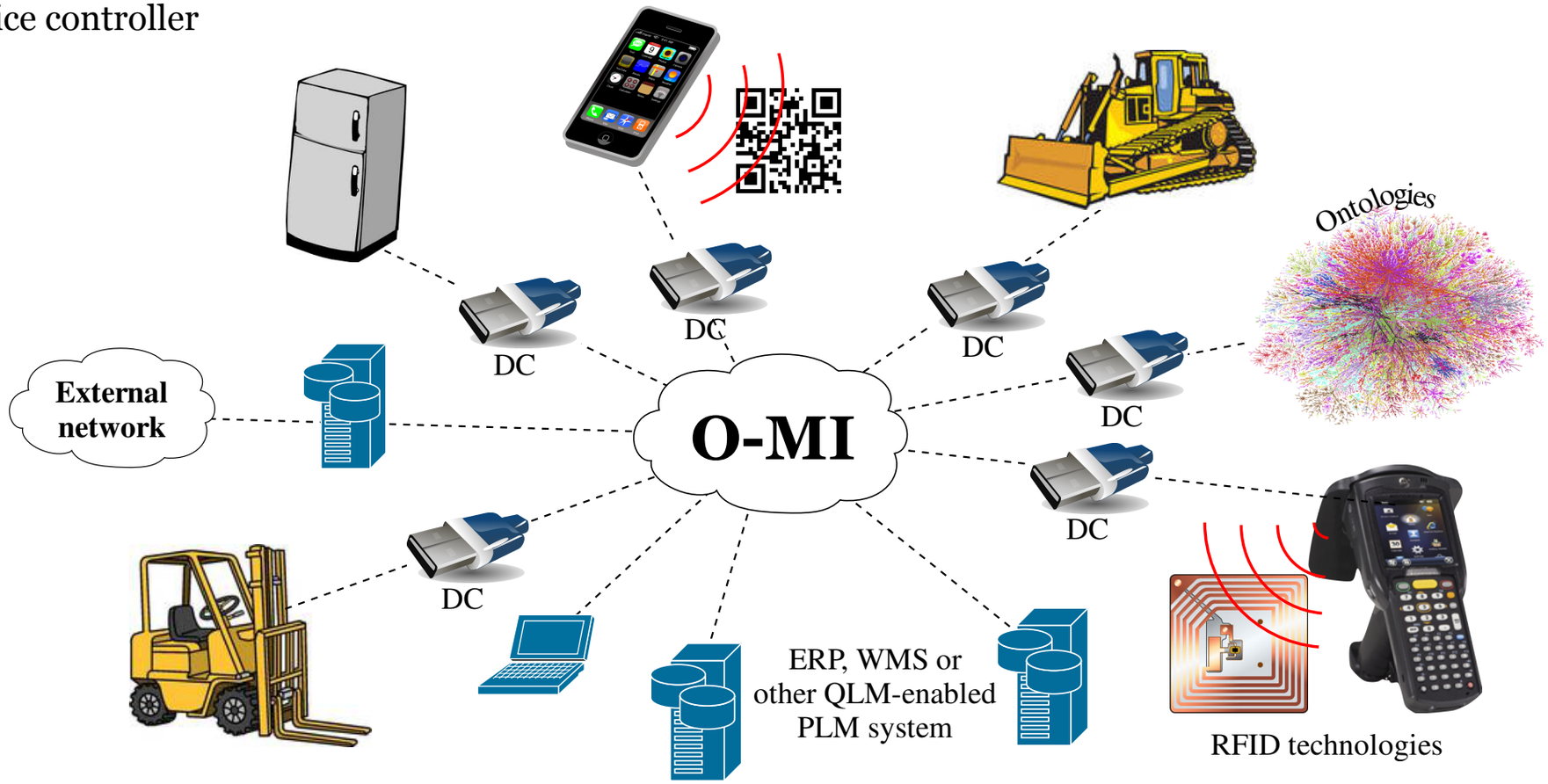
O-MI & O-DF standards as a foundation of Systems-of-Systems

O-MI/O-DF philosophy

It is based on the peer-to-peer philosophy where any "thing" can communicate with any other "thing". Two standards:

- Open Messaging Interface (O-MI)
- Open Data Format (O-DF)

DC : Device controller



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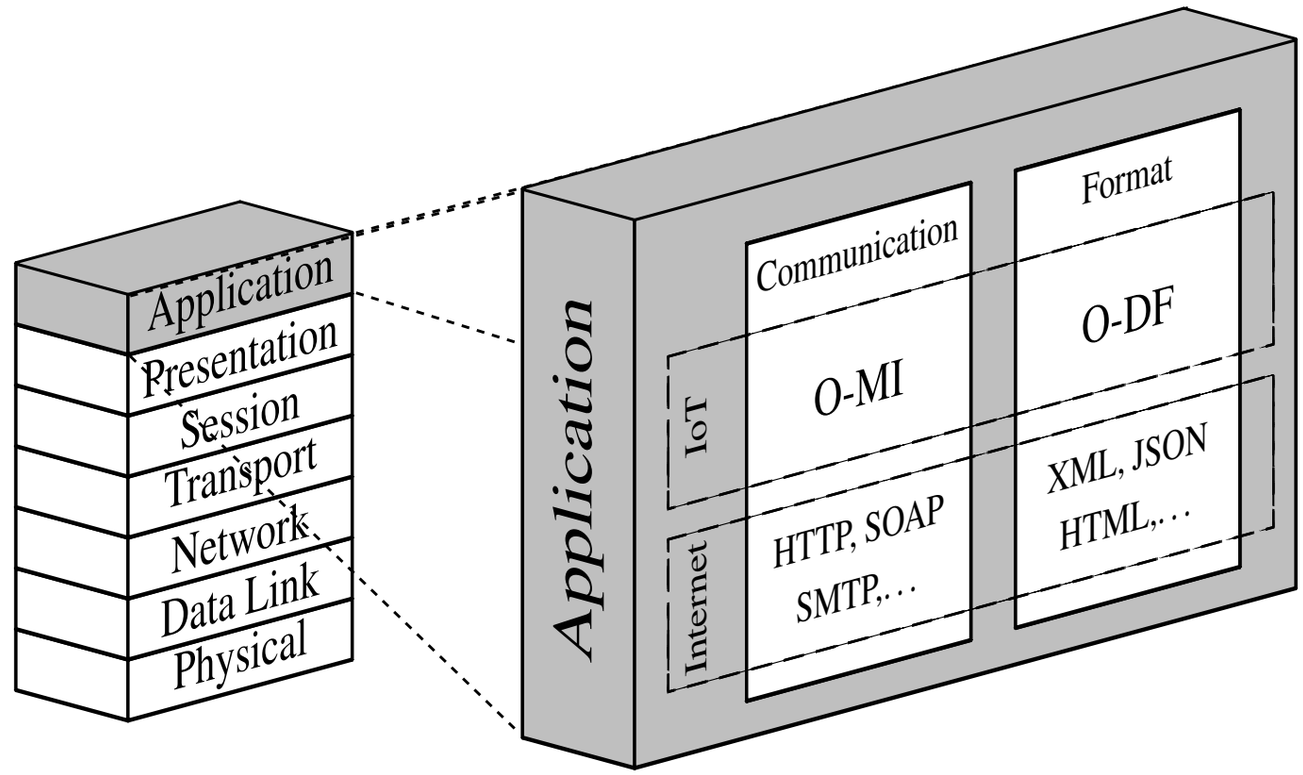

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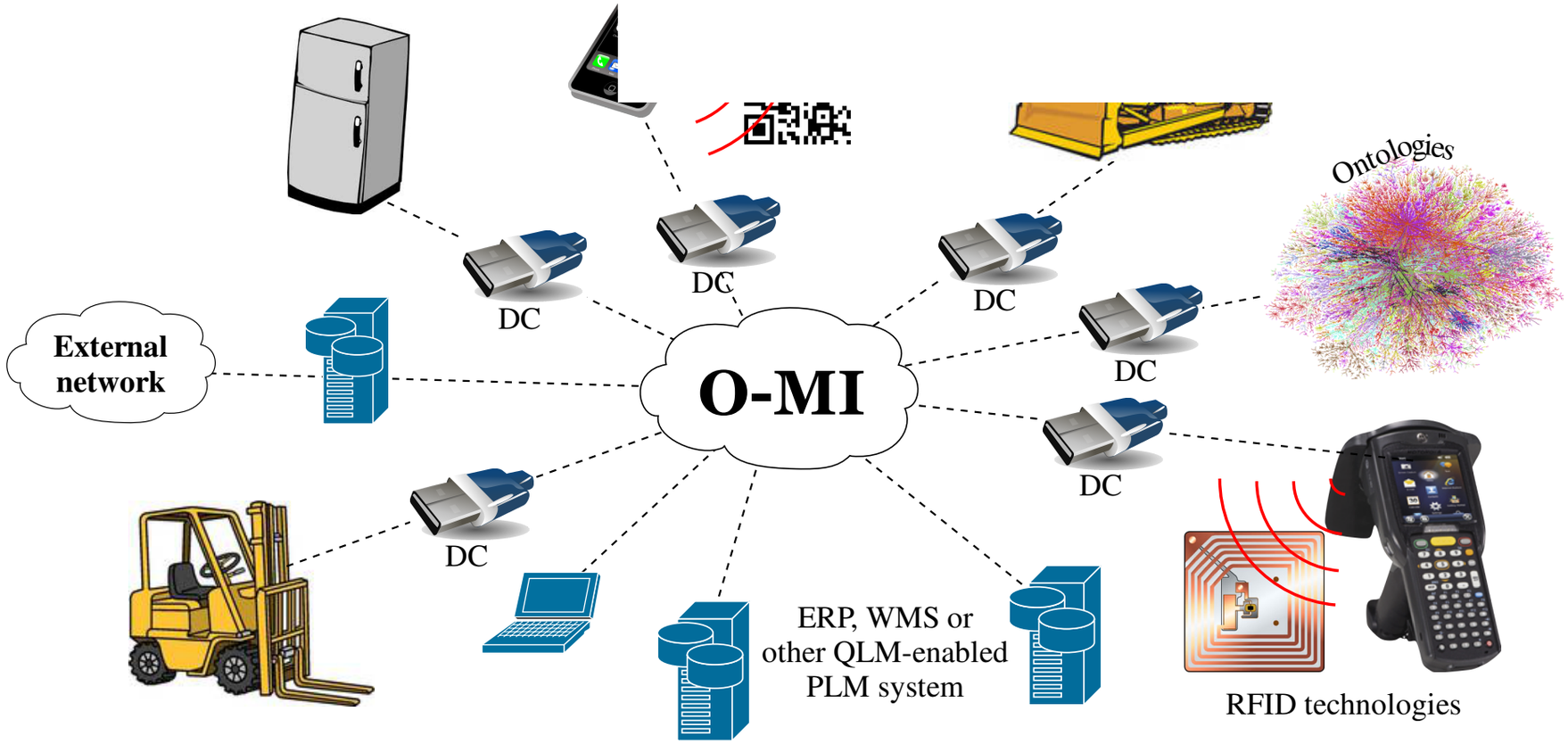

Architectural Issues & Structural Considerations in the IoT

n°	Property		Description
1	**Protocol agnostic**		O-MI/O-DF supports multiple underlying protocols, making it possible to transport the message using most "lower-level" protocols such as HTTP, SOAP, SMTP, FTP or similar protocols. It might also be possible to transport this message using files on USB sticks or other memory devices
2	**Three operations:**		
	Write		Used for sending information updates to O-MI nodes. This involves a O-MI/O-DF response to inform the message originator about the success or failure of the operation
	Read	*Immediate retrieval*	Information is retrieved immediately. This involves a O-MI/O-DF response from the targeted O-MI node, which returns the required information
		Deferred retrieval	Information is retrieved in a deferred way by placing subscriptions on a O-MI node. This is done with a O-MI/O-DF read query if the *interval* parameter has been set: • if a *callback address* is provided, then the data is sent using a O-MI/O-DF response at the requested interval; • if *no callback address* is provided, then the data can be retrieved (i.e., polled) by issuing a new O-MI/O-DF read query and by indicating the ID of the subscription
	Cancel		Used for canceling subscriptions before they expire. This involves a O-MI/O-DF response to inform the message originator about the success or failure of the operation
3	**Time-to-live (TTL)**		If the message has not been delivered to the "next" node before TTL expires, then the message should be removed and an error message returned to the message originator (if possible)
4	**Self-contained message**		A O-MI/O-DF message contains all the necessary information to enable the recipient to appropriately handle the message. In a more concrete level, the message contains all the relevant information such as the actions to be performed (read, write, subscription...), the message validity period (TTL), the mode of communication (asynchronous or synchronous), the callback address, *etc.*
5	**Multiple payload formats**		Any O-MI/O-DF message can transport actual information using any text-based format that can be embedded into an XML message. A response may include return elements that correspond to several O-MI/O-DF requests. In that case, it is even possible to use different payload formats in different return elements. However, the return payload would normally be in the same format as the original request payload
6	**Real-time communication**		O-MI/O-DF allows piggy backing a new request with a response. This is a crucial property both for real-time communications and to enable two-way communications with nodes located behind firewalls
7	**Publication and discovery**		Publication of new data sources, services and meta-data can be done with O-MI/O-DF write operation. "RESTful" URL-based queries allow the discovery of them, including discovery by search engines
8	**Target O-MI nodes**		The receiving node(s) are then responsible of re-routing the query to the targeted O-MI nodes, or sending back an error message to the requesting O-MI node in case of failure

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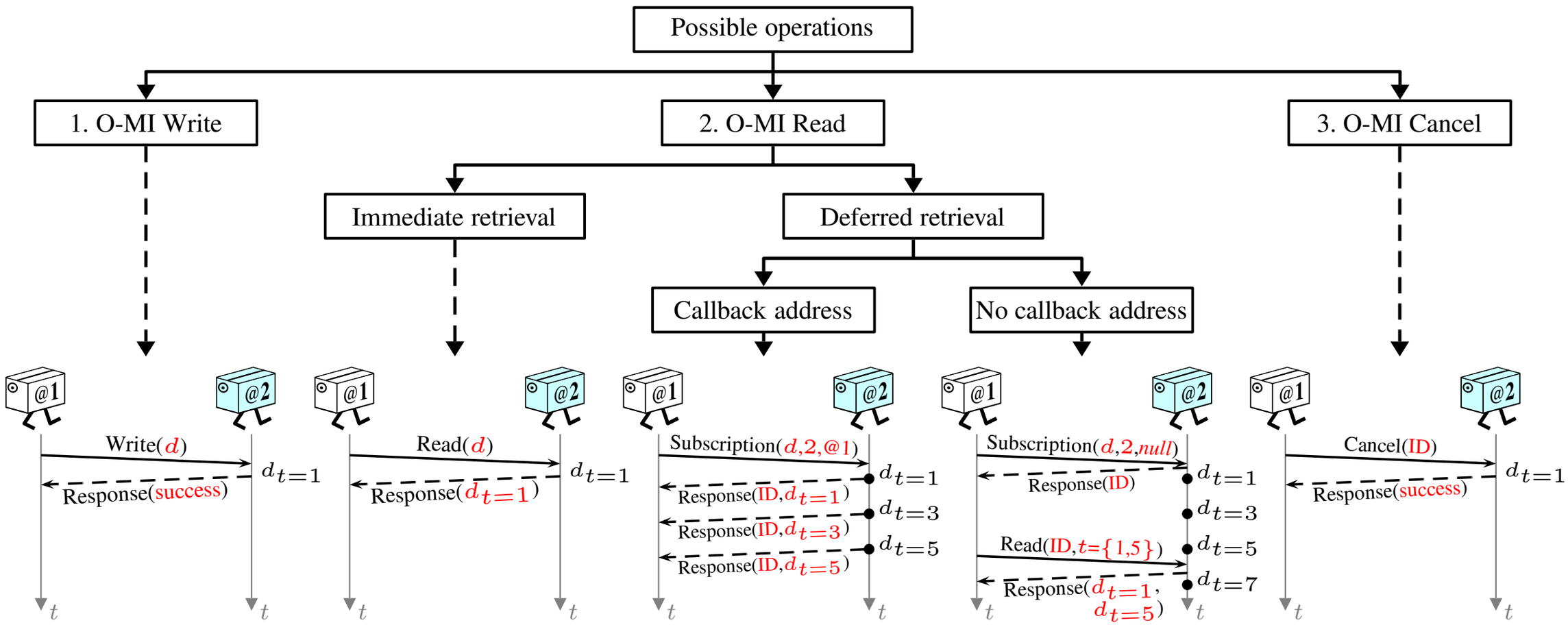
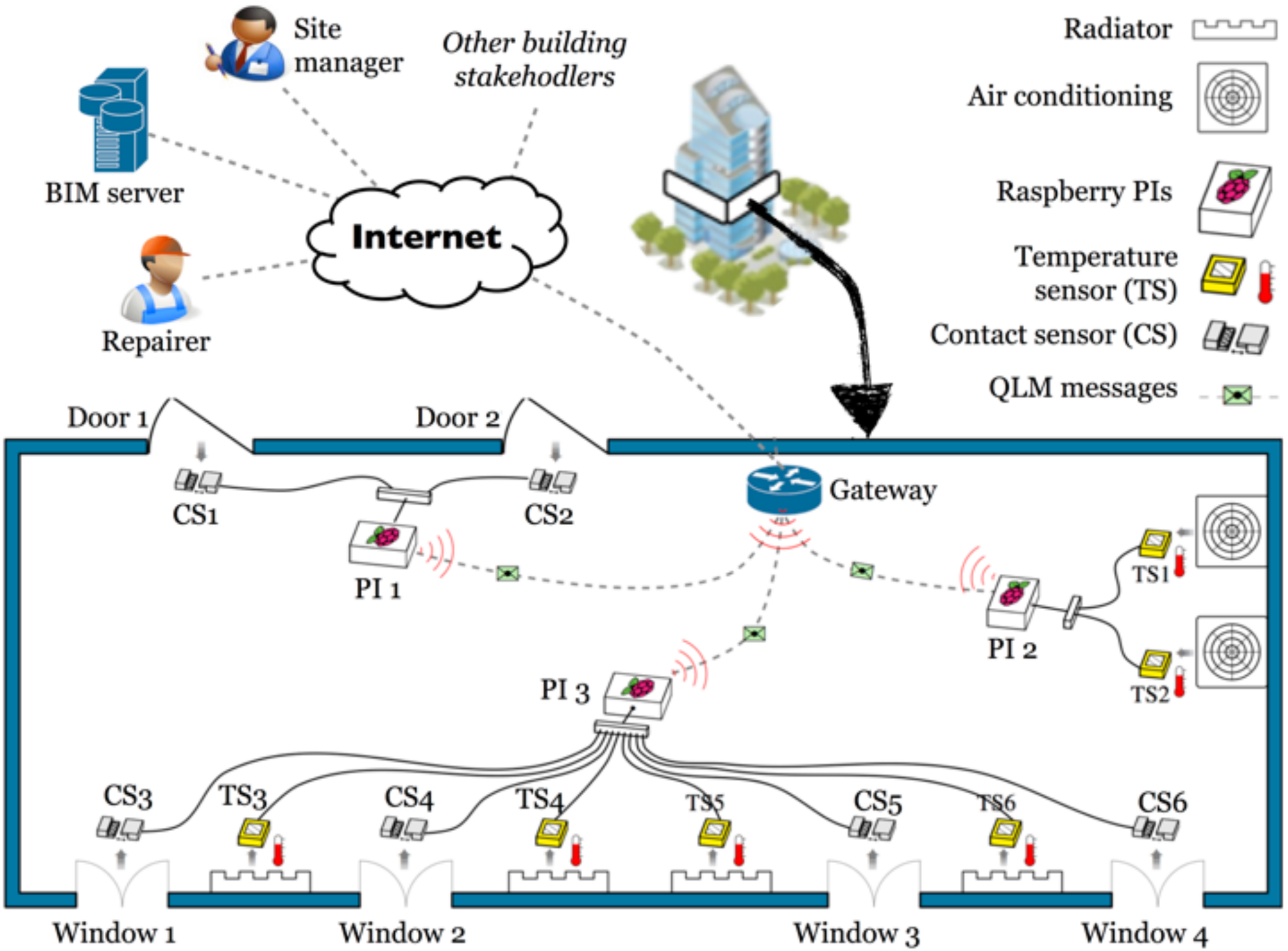
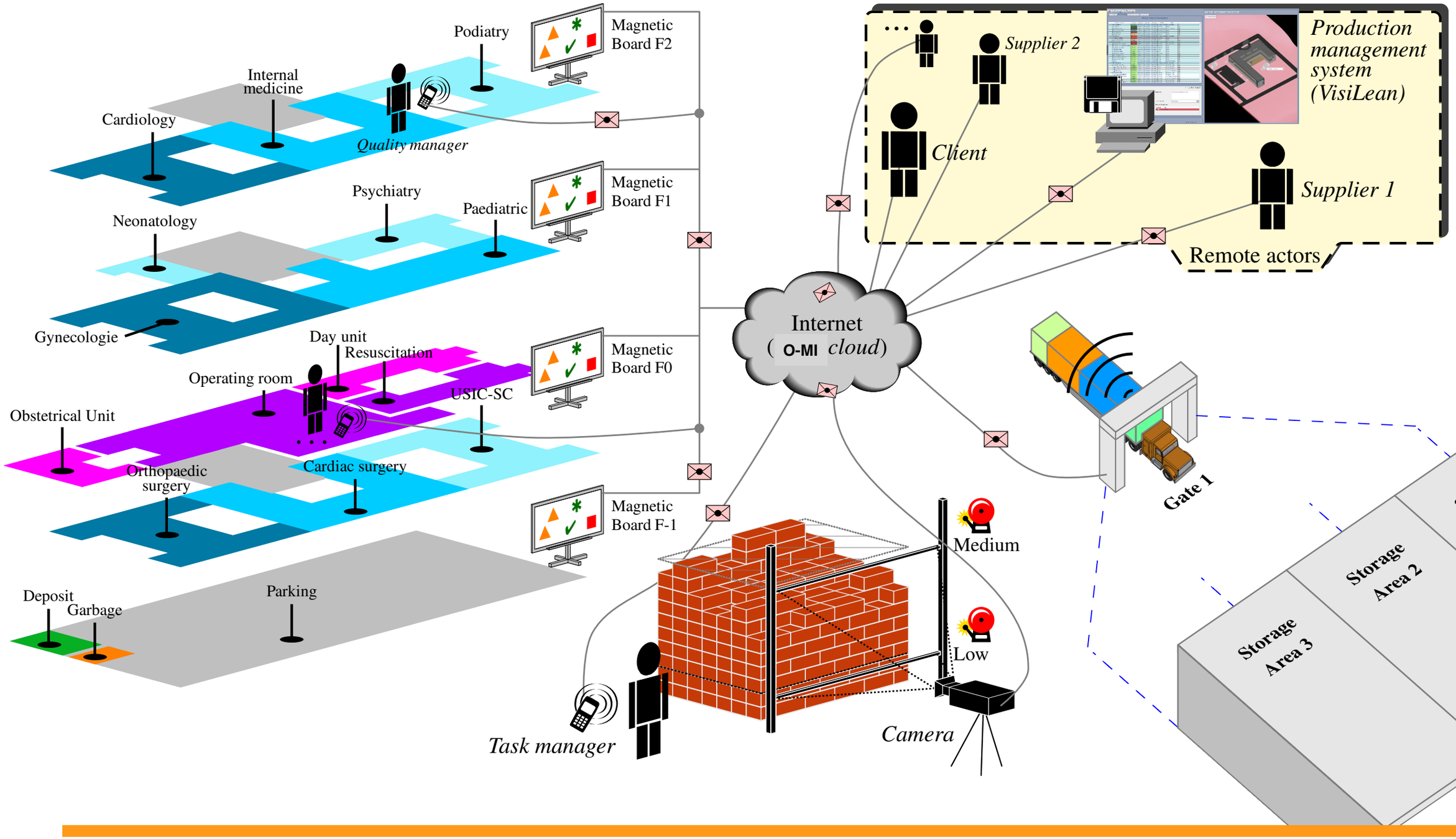


Building Energy & Information Management: University campus - France



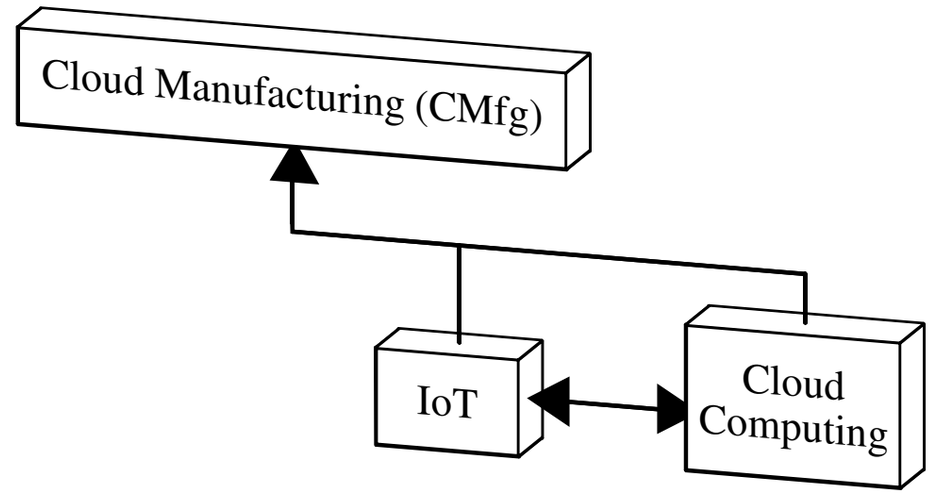
[4] Kubler, S., Madhikermi, M., Buda, A., Främling, K., Dergient, W., Thomas, A. (2014) Towards data exchange interoperability in building lifecycle management, 19th IEEE International Conference on Emerging Technologies and Factory Automation, Barcelona.

Enhanced lean construction management using IoT standards

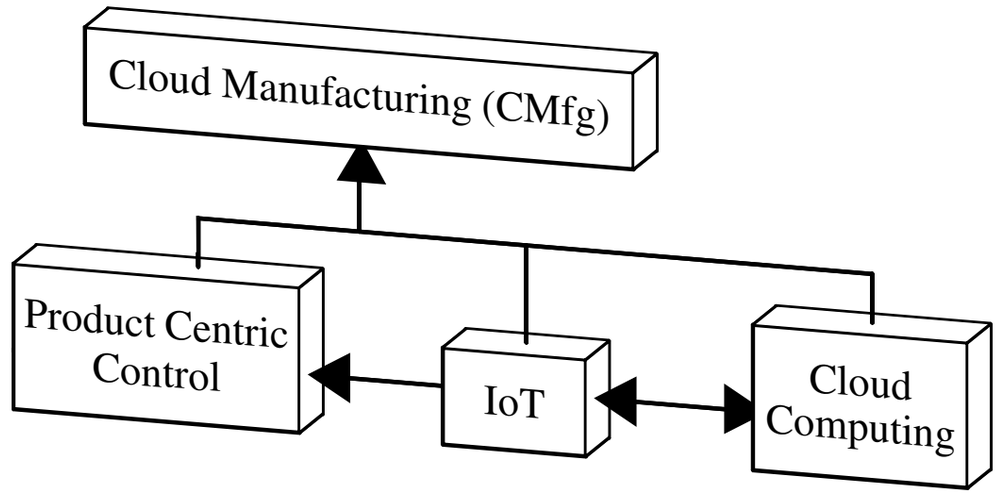


[4] Bhargav, D., Kubler, S., Främling, K., Koskela, L (2014) Opportunities for enhanced lean construction management using Internet of Things standards, Automation in Construction, *accepted for publication*.

Cloud Manufacturing (CMfg) Taxonomy



Cloud Manufacturing (CMfg) Taxonomy



Cloud Manufacturing (CMfg) Taxonomy

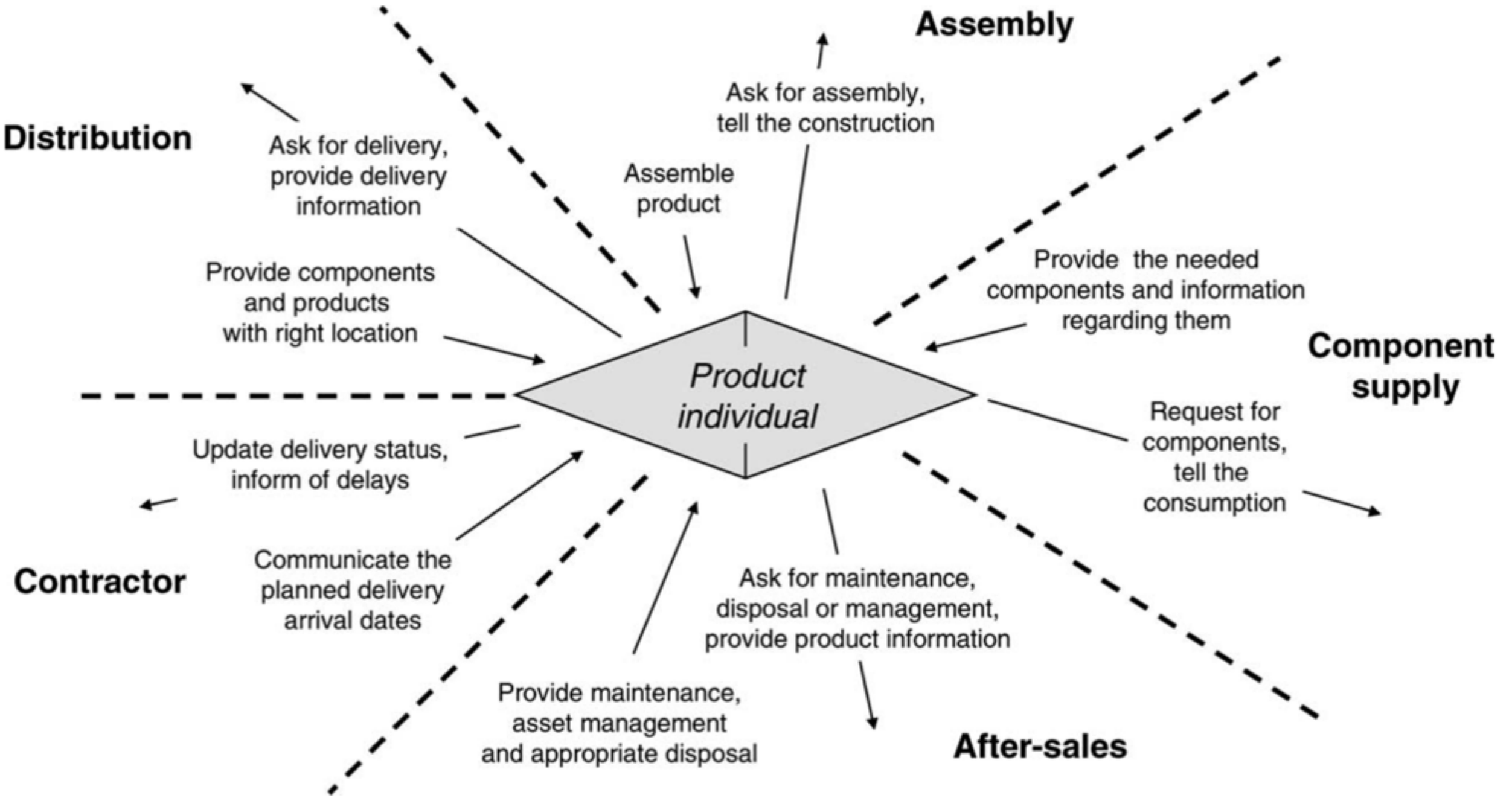
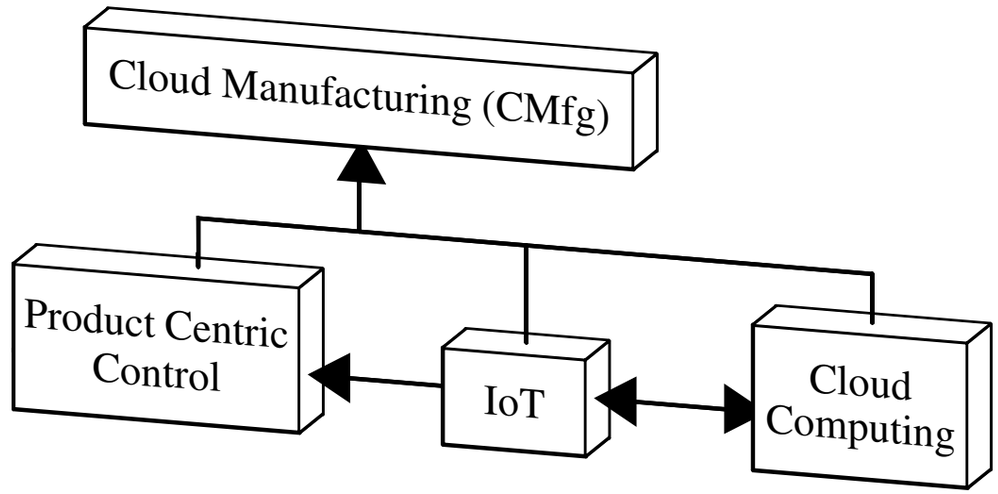
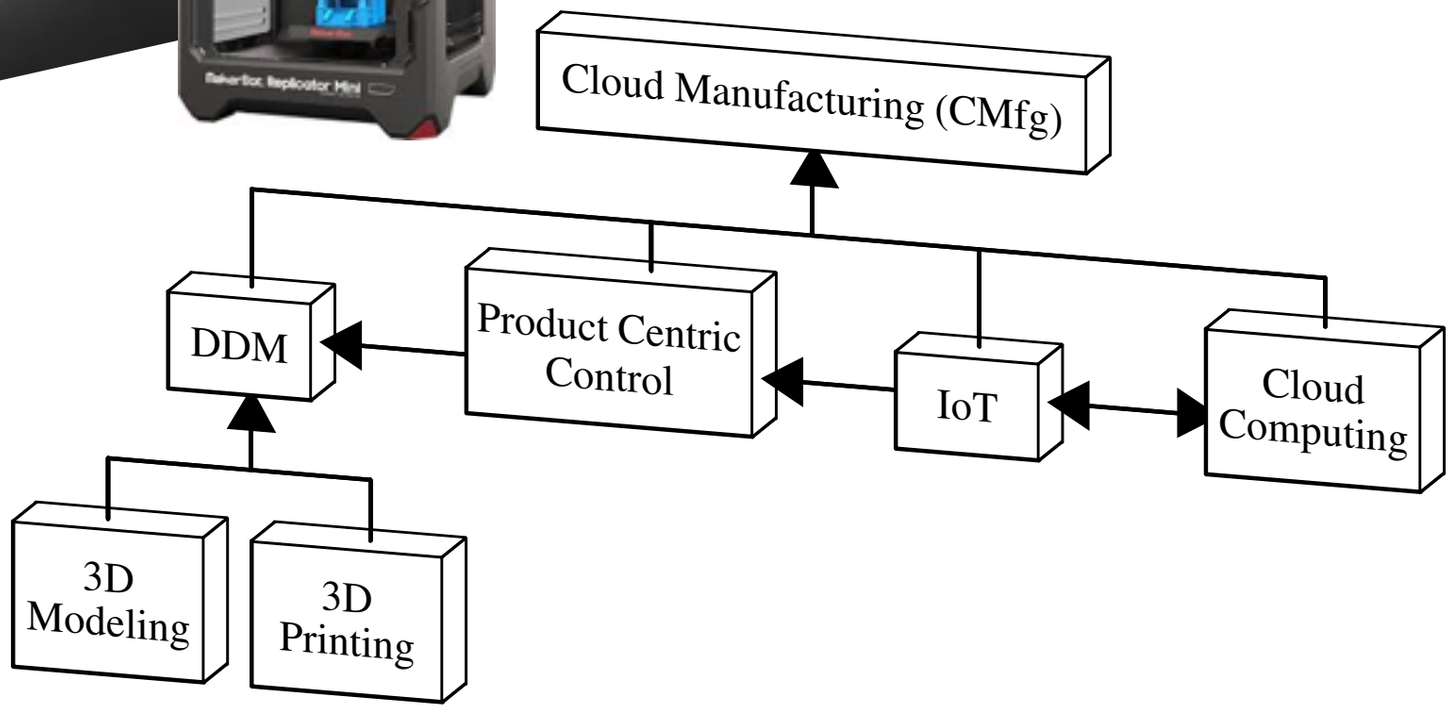


Fig. 3. Inside-out control of project deliveries.

Cloud Manufacturing (CMfg) Taxonomy



Cloud Manufacturing (CMfg) Taxonomy



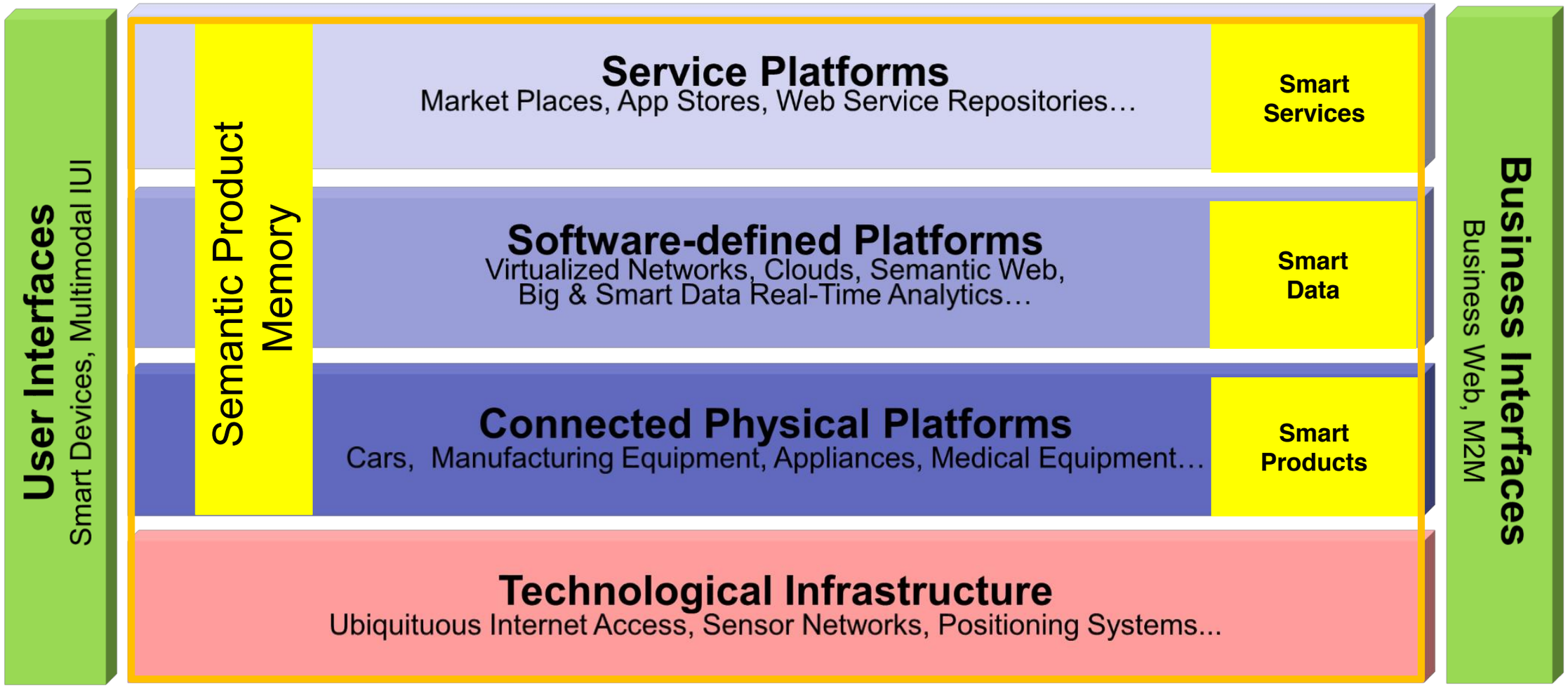
"a tractor (or backend system) detects – based on sensor data fusion – that the pump is defective. The after-sales service system is immediately notified and turns to the services of the CMfg community to i) access product-related data and models (e.g., CAD models) and then ii) identify an optimal manufacturer for the broken pump parts. The digital model is sent to the community members who can produce the custom part via 3D printing. The closest (or cheapest) 3D printer service provider(s) can be discovered (e.g., via IoT discovery mechanisms), so that the pump part can be produced to order and shipped to the farmer."

SUMMARY

- Manufacturing Paradigms Through The Ages
- CMfg Taxonomy: Underlying Concepts & Technologies
- FI-WARE & Open Platform 3.0
- Conclusion

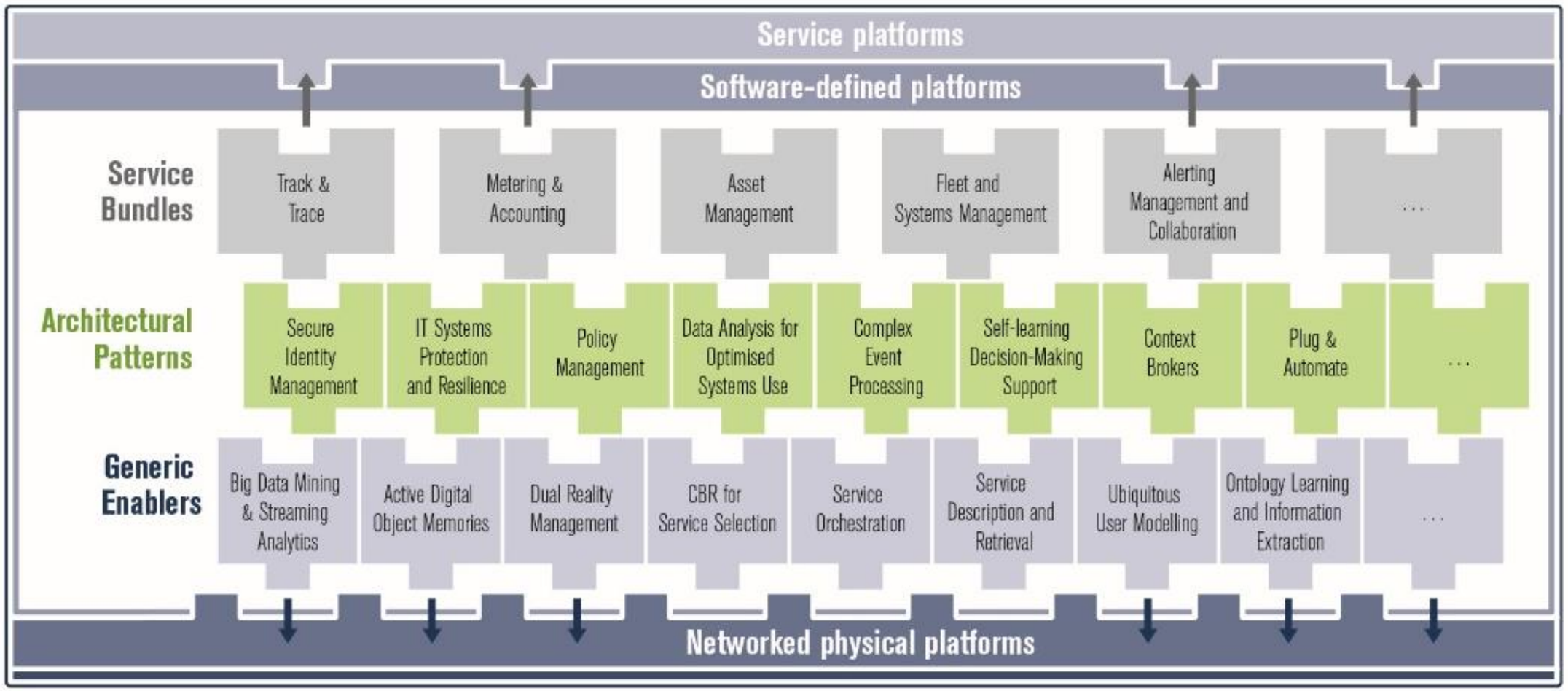
FI-WARE — Cloud-based platform pushed by EU

Layer Cake for the Smart Service World



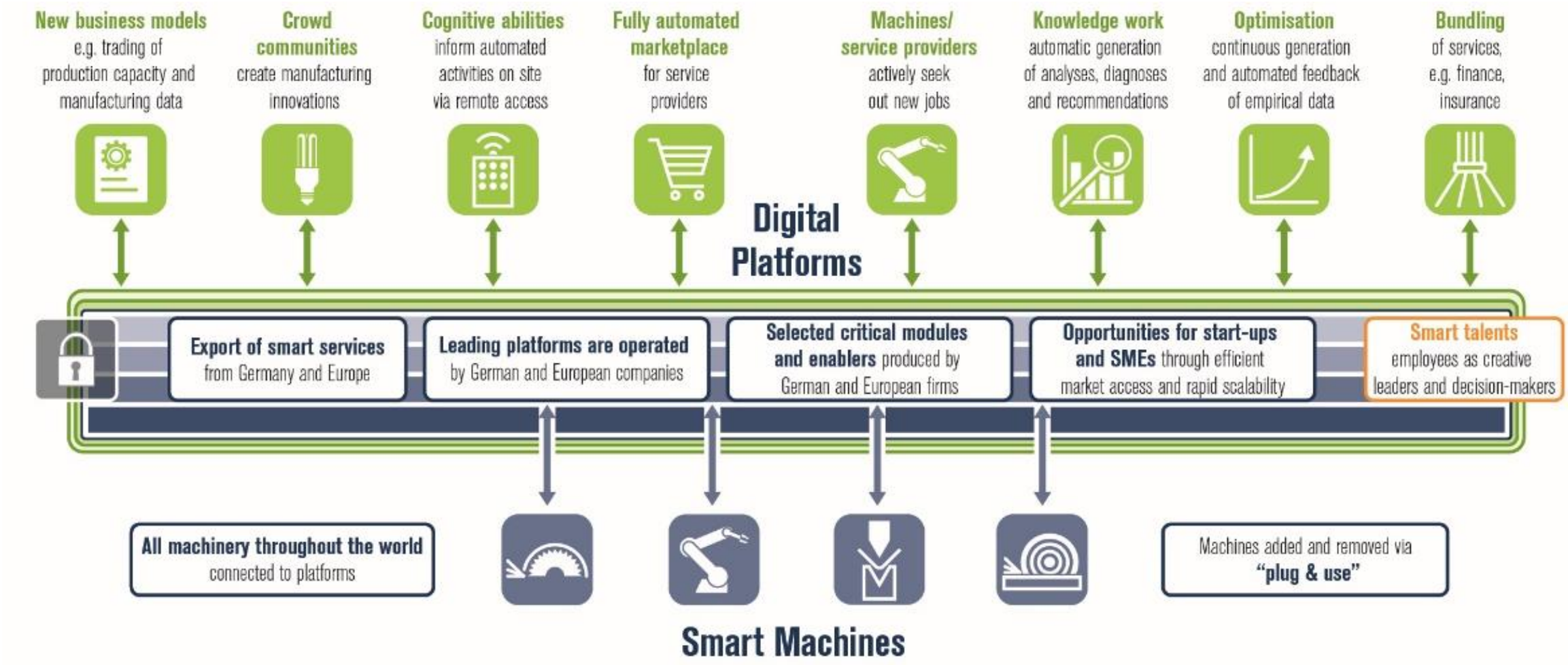
FI-WARE — Cloud-based platform pushed by EU

Generic Enablers, Architectural Patterns and Service Bundles in Software-Defined Platforms



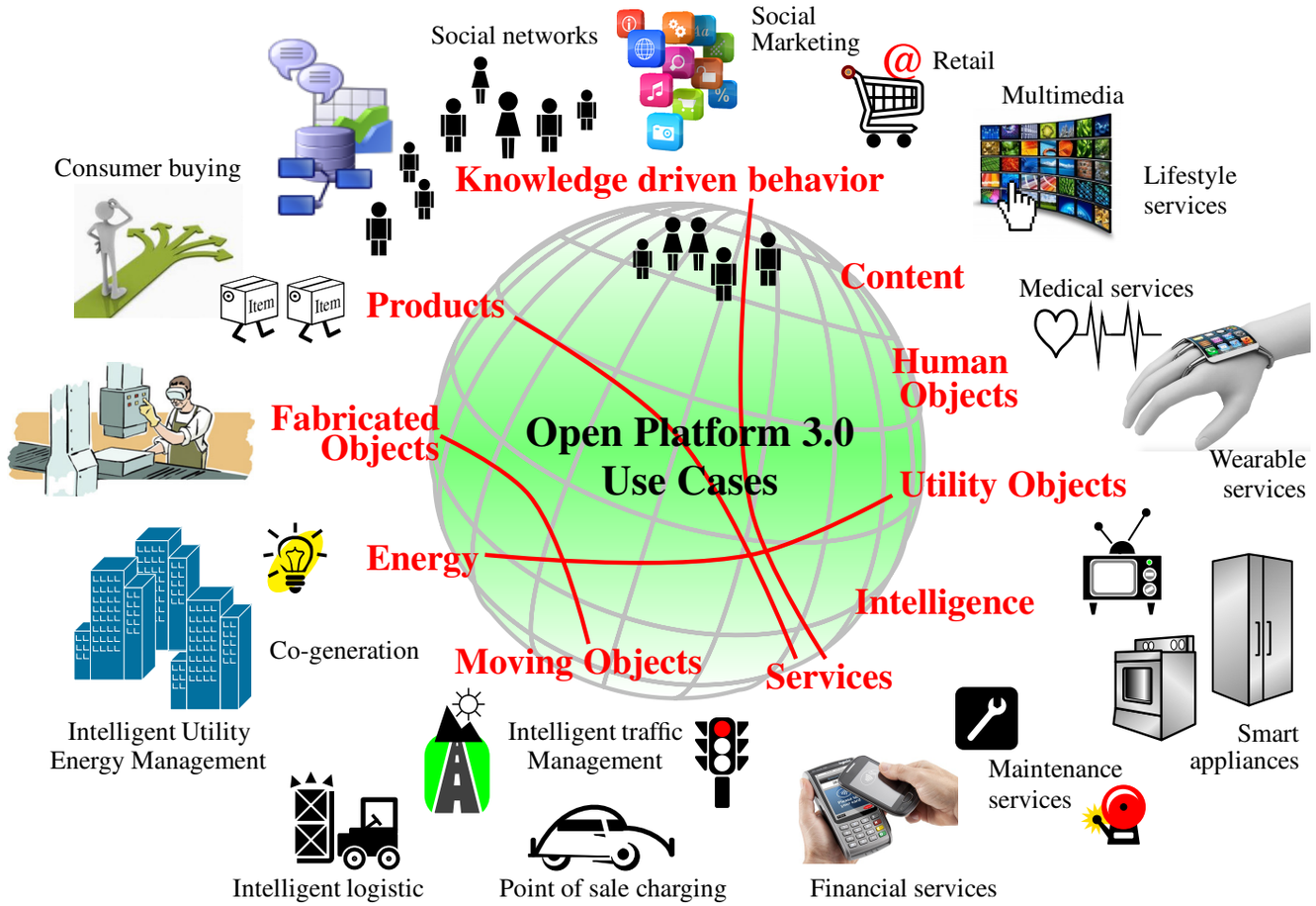
FI-WARE — Cloud-based platform pushed by EU

Smart Manufacturing Services 2015



The Open Platform 3.0™

22 Use Cases defined in the White Paper (Nexus in Force)



THE Open GROUP

The Nexus of Forces in Action

Business Use-Cases of Open Platform 3.0™

A White Paper by:

Members of the Open Platform 3.0™ Forum, a Forum of The Open Group
Led by Mark Skilton, Synthetic Spheres Ltd.

March 2014

SUMMARY

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Conclusion

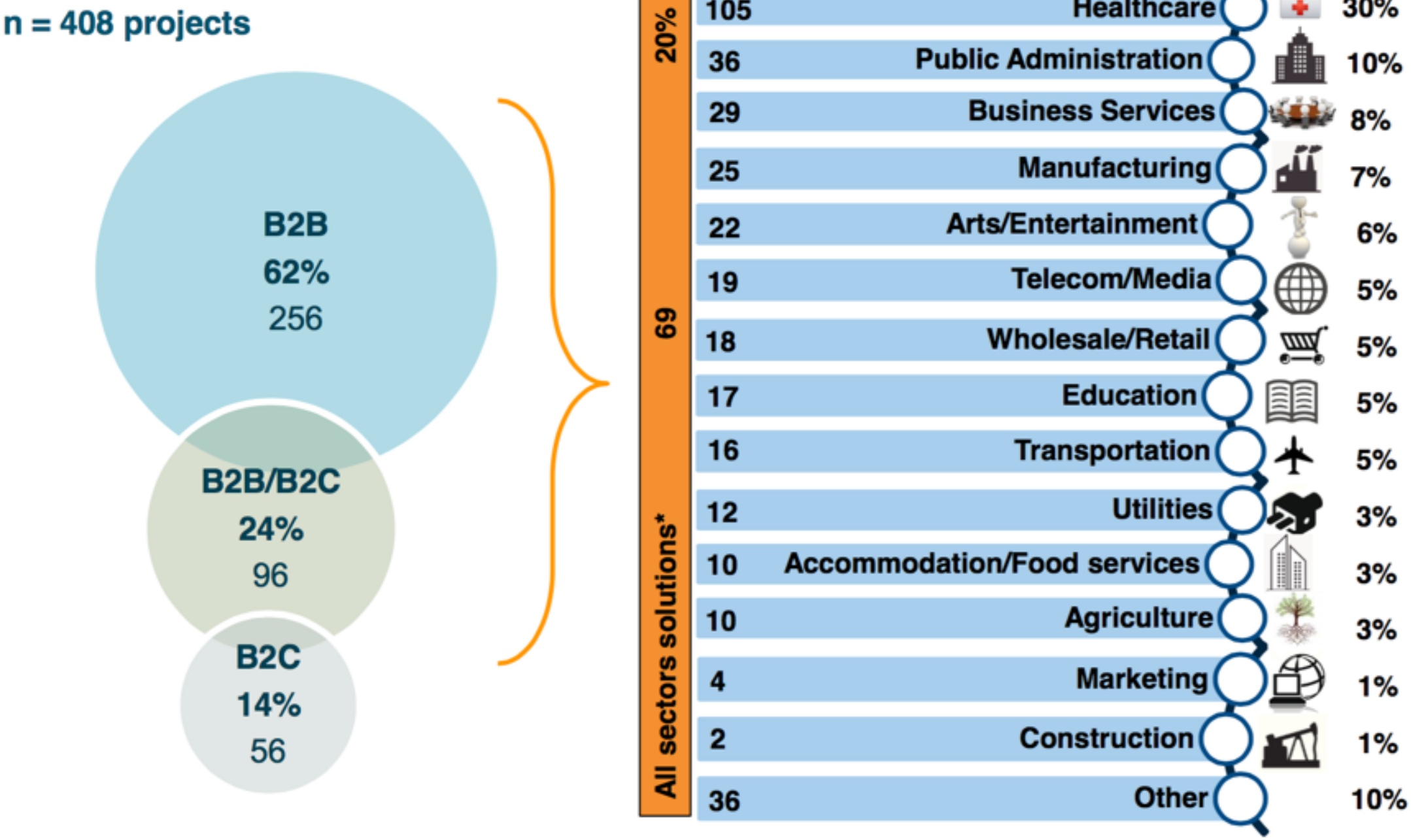
- Need to address — in the future — the Vertical Silos' that shape today's IoT and Cloud-based IoT solutions.

- Need for more advanced:
  - IoT ecosystems for Systems-of-Systems (based upon Open IoT standards)
  - Data discovery mechanisms (e.g., geo-location, semantic-based discovery) to enable to integrate any domain- or application-specific platform
  - Cloud Computing is on the hype curve: but what about "Fog Computing"?

- Europe is "intensively" pushing (e.g., for H2020 calls on IoT, CPS…) the FI-WARE cloud solution in all sectors, including manufacturing.

* Roy Schulte (2015) Gartner Business Intelligence, Analytics & Information Management Summit, Sydney, Australia

Conclusion



10 Accelerators (CREAtiFi, EuropeanPioneers, FI-Adopt, FICHe, FI-C3, Finish, FINODEX, IMpaCT, SOUL-FI, SpeedUp)

(*) The 'All sectors' segment includes solutions that are transversal to all markets and not industry-specific.

(**) Multiple answers were allowed. Percentages are calculated out of the total number of available B2B and B2B/B2C proposals (352)

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Technological Theory of Cloud Manufacturing

Sylvain Kubler, Luxembourg University, SnT - Interdisciplinary Centre for Security, Reliability & Trust
Jan Holmström, Aalto University, Department of Industrial Engineering and Management, Finland
Kary Främling, Aalto University, School of Science and Technology, Finland
Petra Turkama, Aalto University, Business School, Finland

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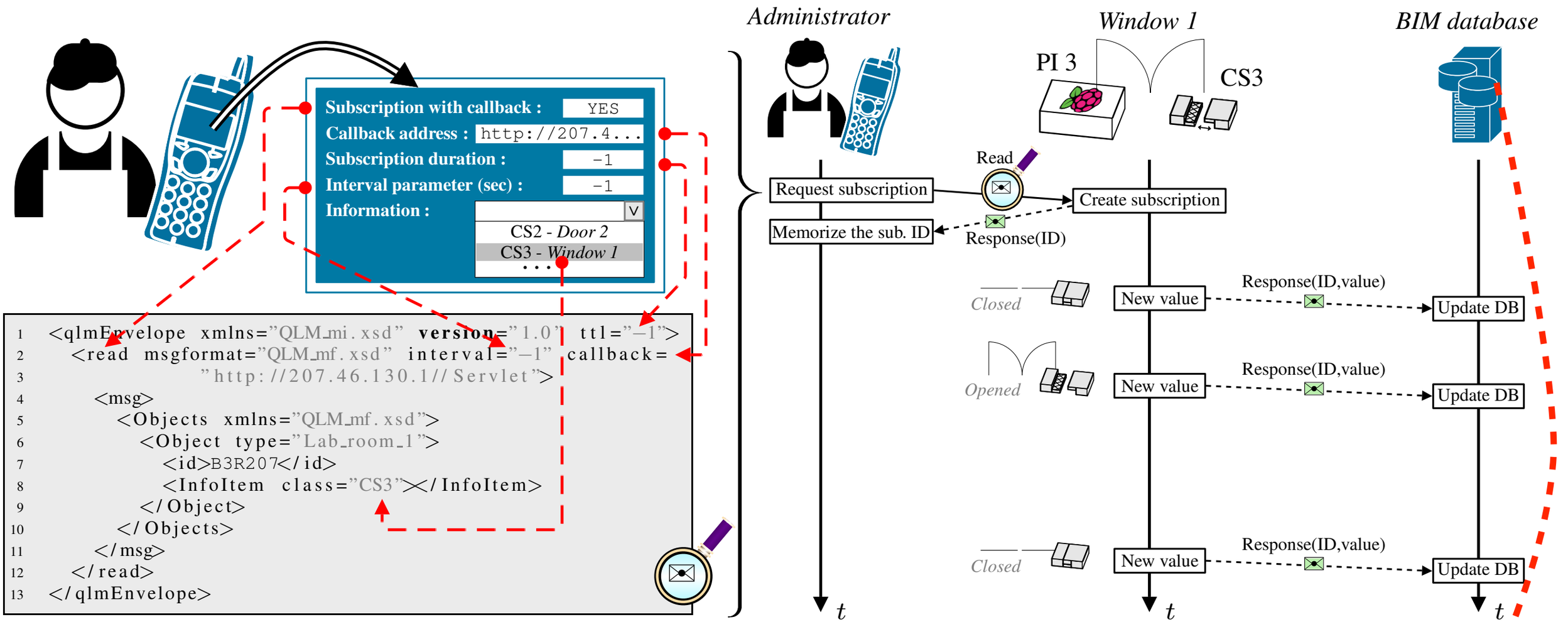
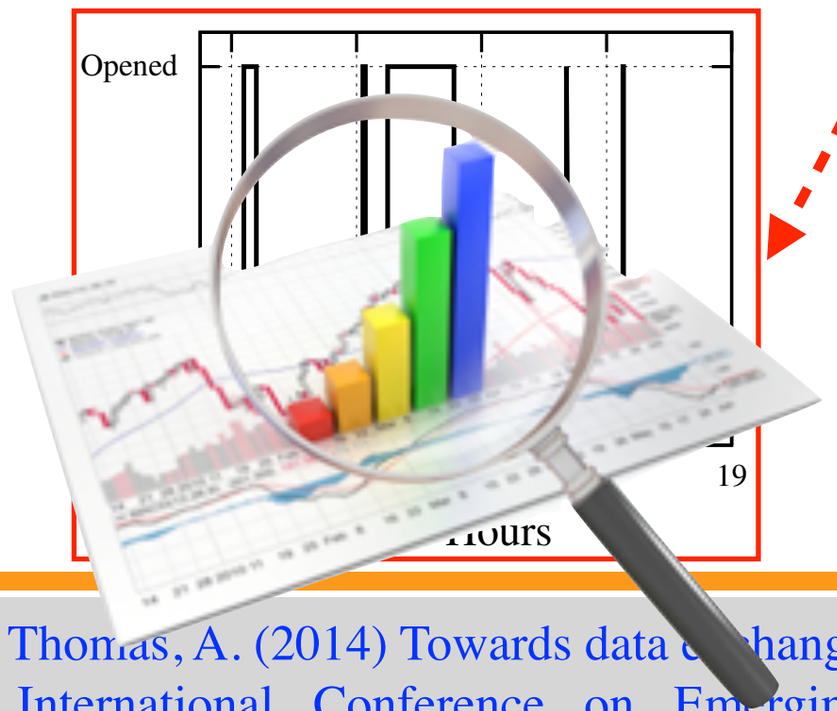


Energy efficiency

Cost optimization

Predictive maintenance

...



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