



## Capability-driven requirements engineering



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Loucopoulos, P., Kavakli, E. and Chechina, N., 2019, June. **Requirements Engineering for Cyber Physical Production Systems**. In *International Conference on Advanced Information Systems Engineering* (pp. 276-291). Springer, Cham.

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## REQUIREMENTS ENGINEERING

*If you don't do a good job of capturing the requirements, the requirements are still there – you just don't know about them. So you are likely to produce a product that the customer doesn't want.*

[Whitehead 2001]

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## Overview

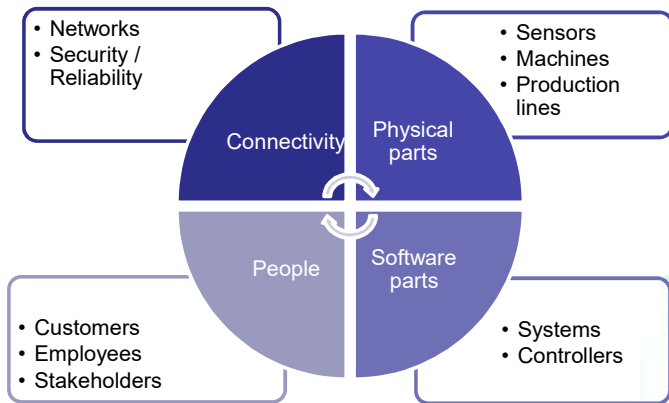
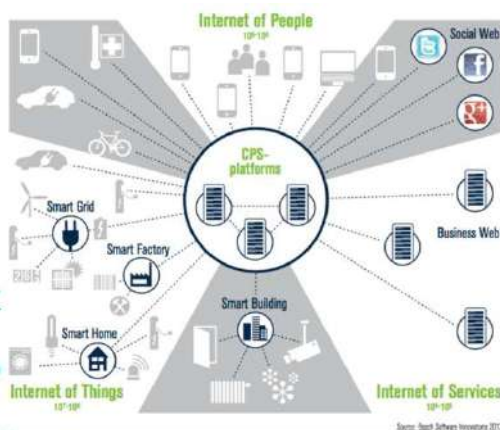
1. Challenges
2. e-CORE approach
3. e-CORE application
4. Discussion

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## Industry 4.0

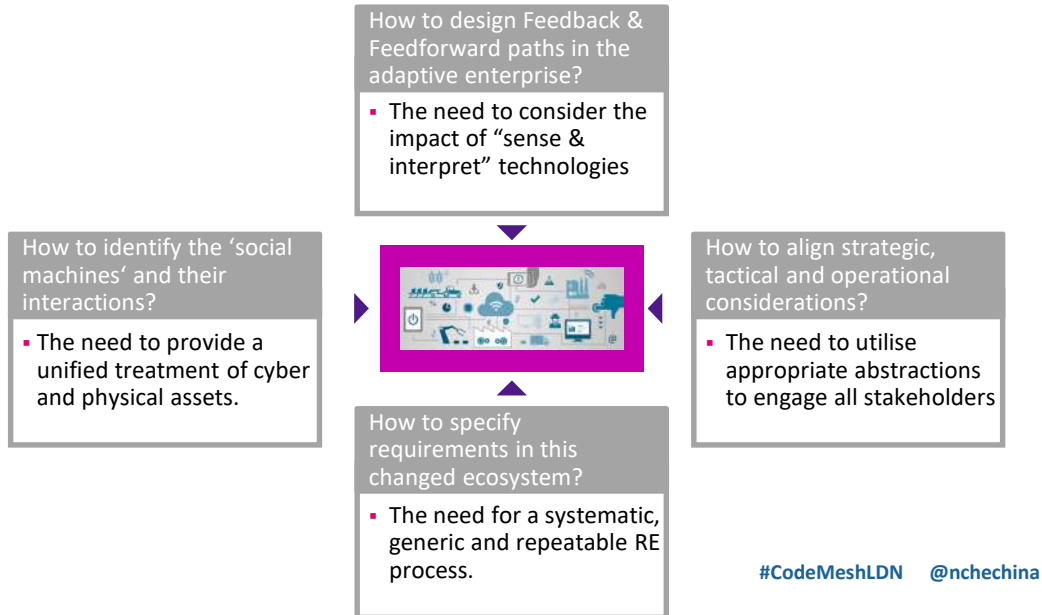
- "... the boundaries between the real world and the virtual world become increasingly blurred"
- "... systems are regarded as online networks of 'social machines' that are organised in a similar way to social networks"



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## Enterprise Challenges in the Age of Industry 4.0



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## Requirement Engineering Approaches

- Capability-oriented requirement engineering
- Goal-oriented requirements engineering
- Actor and intension-based approach
- Scenario-based requirements engineering
- Problem frame approach
- Environment modelling-based requirements engineering
- ...

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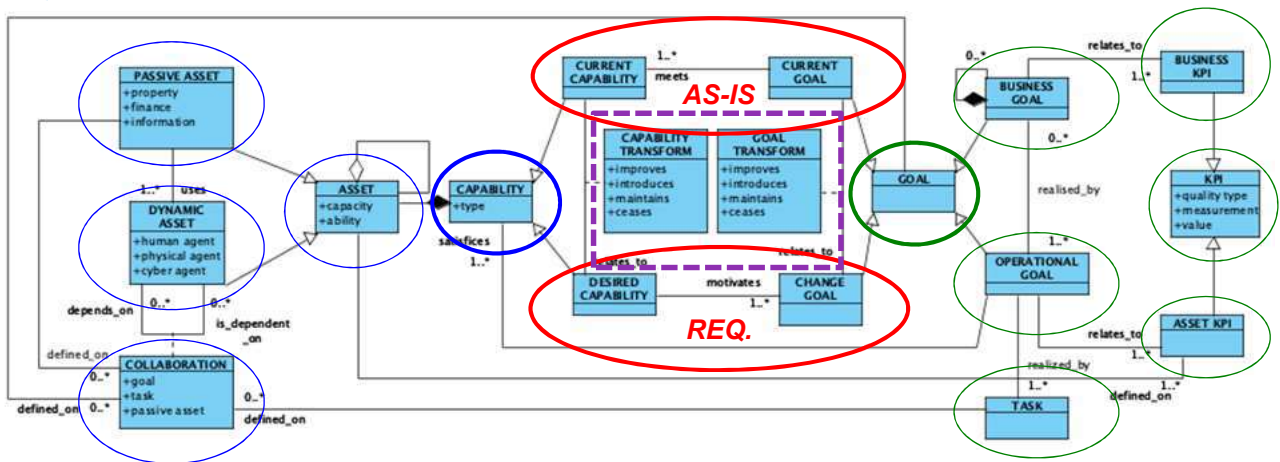
## Capability-oriented approach

- Focusing on
  - Reflection against existing and new enterprise goals
  - Alignment with existing technological infrastructure
  - Collaboration of human, physical, and IT systems
  - Collaboration with cyber-physical networks
  - Integration into organisational structure

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## The e-CORE Metamodel



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## History of, and experiences with, e-CORE

- Capability as a service<sup>1</sup>
- The Smart Cities Operation case<sup>2</sup>
- The Smart Parking case<sup>3</sup>
- The Autonomous Vehicle Management application<sup>4</sup>
- The Production Planning and Rescheduling application<sup>5</sup>



i-Doha



[1] Sandkuhl, K. and J. Stirna, Eds. (2018). *Capability Management in Digital Enterprises*, Springer.

[2] P. Loucopoulos, E. Kavakli, D. Anagnostopoulos, and G. Dimitrakopoulos. 2018. *Capability-oriented Analysis and Design for Collaborative Systems: An example from the Doha 2022 World Cup Games*. In Proceedings of the 2018 10th International Conference on Computer and Automation Engineering (ICCAE 2018). ACM, New York, NY, USA, 185-189.

[3] M. Salah Hamdi, A. Ghannem, P. Loucopoulos, E. Kavakli, H. Ammar. 2019. *STAD: Intelligent Parking Management by Means of Capability Oriented Requirements Engineering*, 32nd International Conference on Industrial, Engineering & Other Applications of Applied Intelligent Systems Graz University of Technology (IEA/AIE-2019). Graz, Austria, July 9-11, 2019 (to appear)

[4] G. Dimitrakopoulos, E. Kavakli, P. Loucopoulos, D. Anagnostopoulos, T. Zographos. 2019. *A capability-oriented modelling and simulation approach for autonomous vehicle management*, Simulation Modelling Practice and Theory, Volume 91, 2019, pp. 28-47.

[5] Loucopoulos, P. and E. Kavakli. 2017. *Analysis of Requirements for a Cyber Physical Production System in the Automotive Industry*. in *AMCIS 2017*. 2017. Boston, USA.

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## Industrial example of e-CORE use

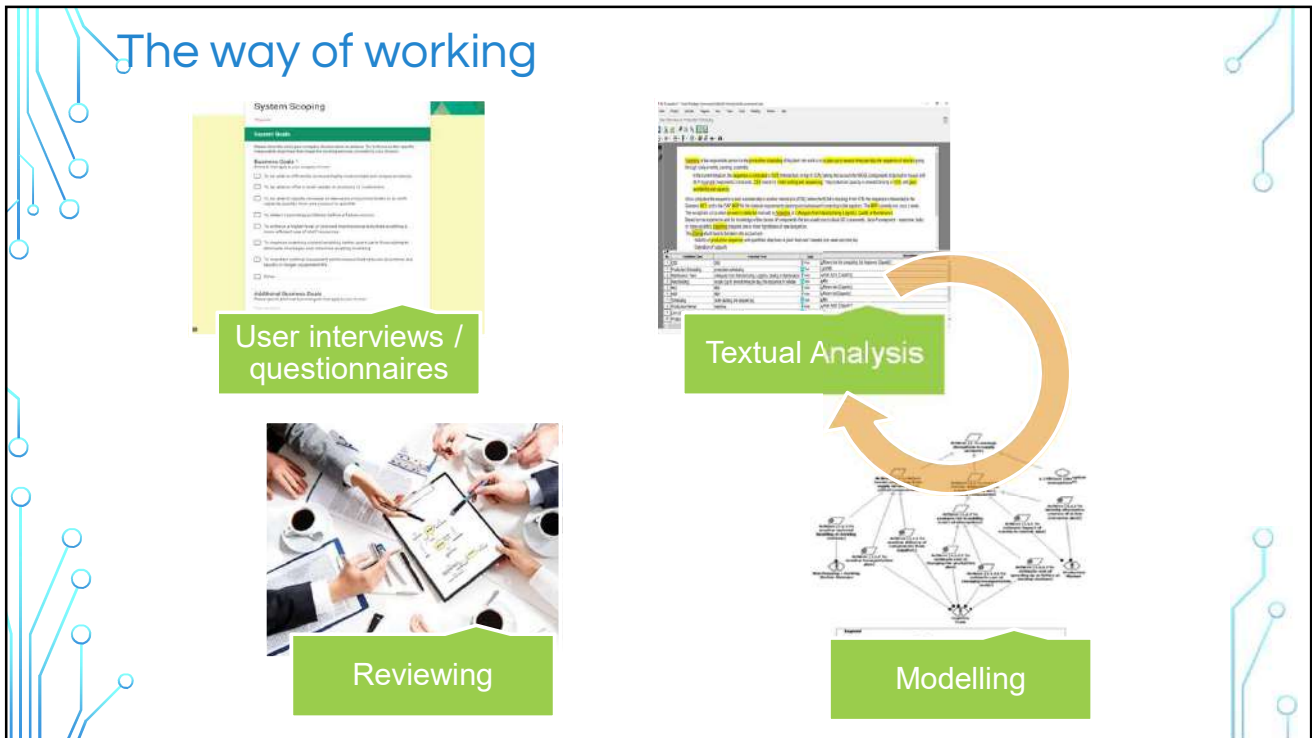


### Transformational requirements

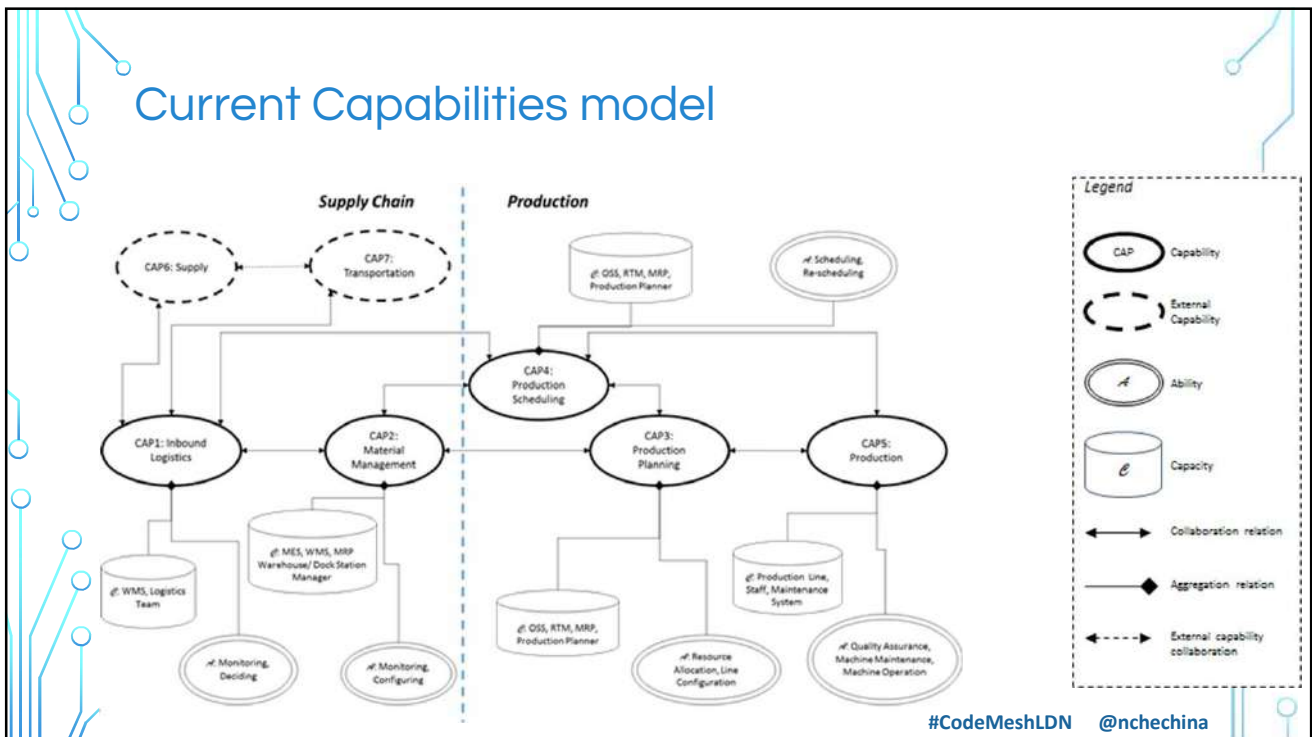
- Managing disruptions in ***'inbound logistics'***
- Managing disruptions in ***'production'***

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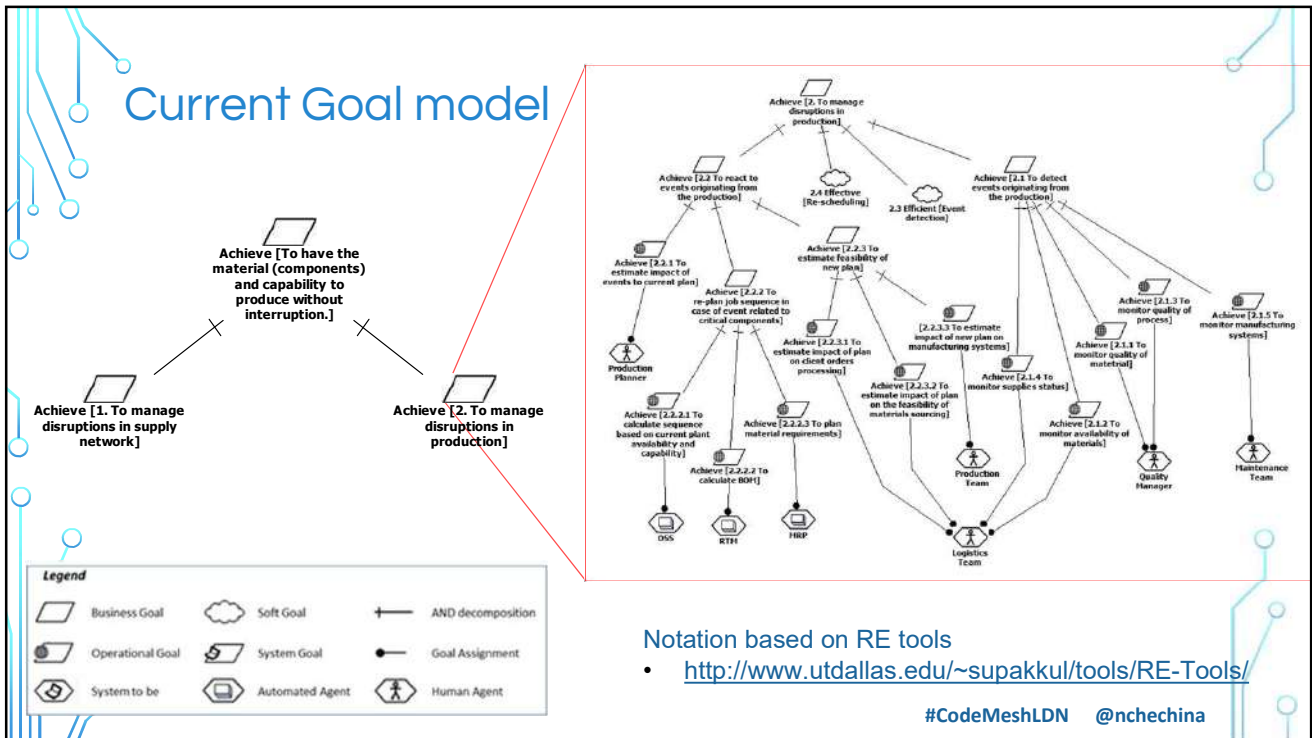
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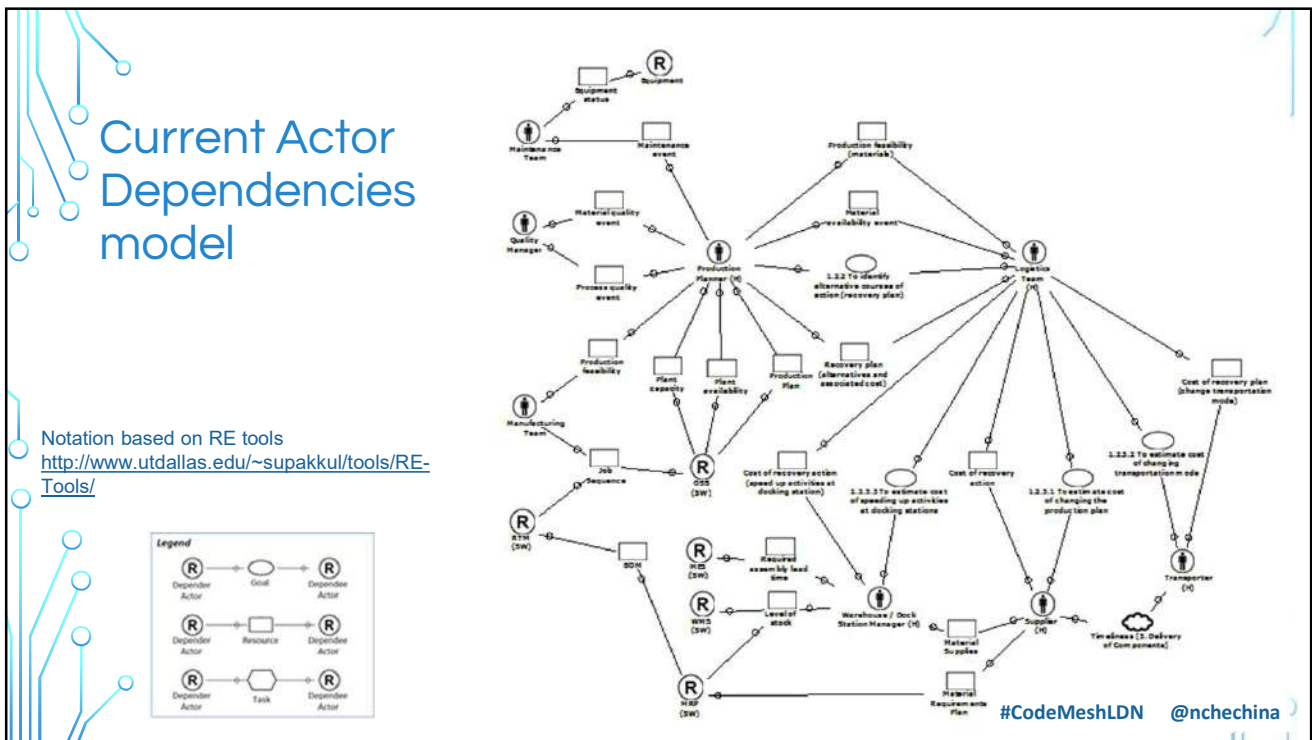
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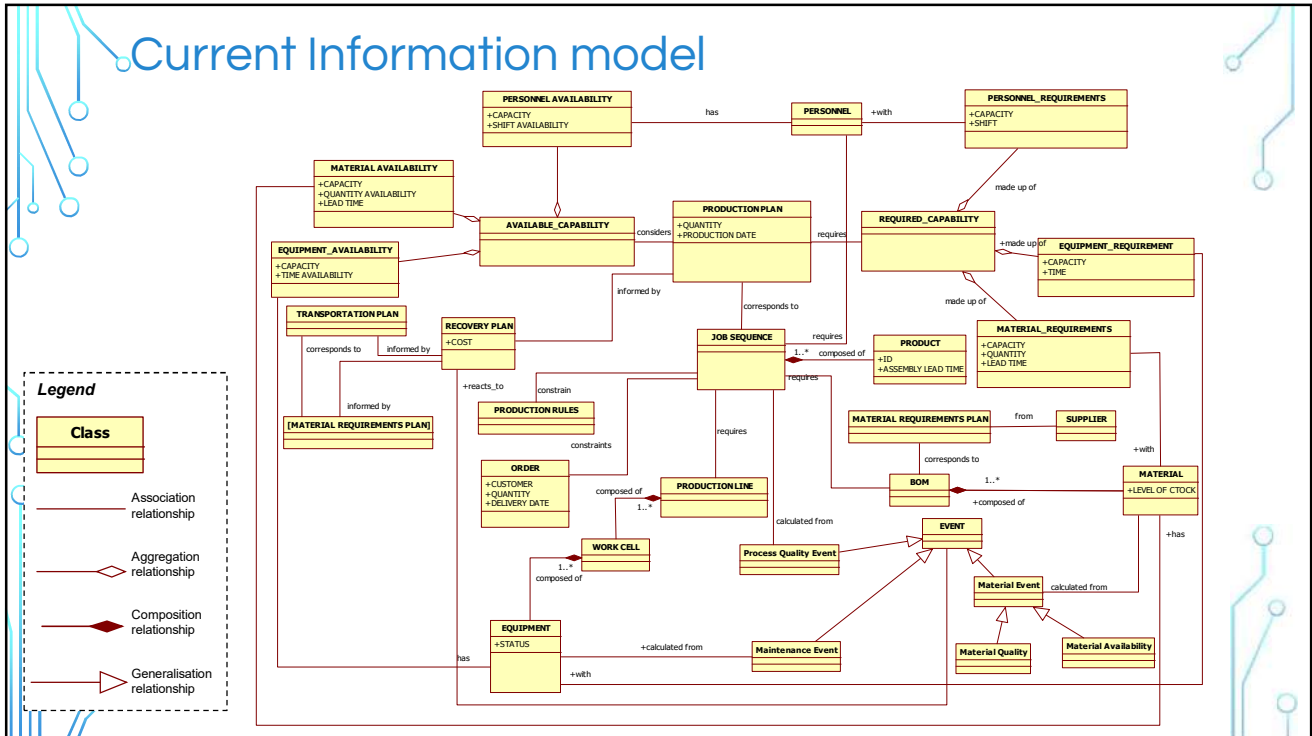
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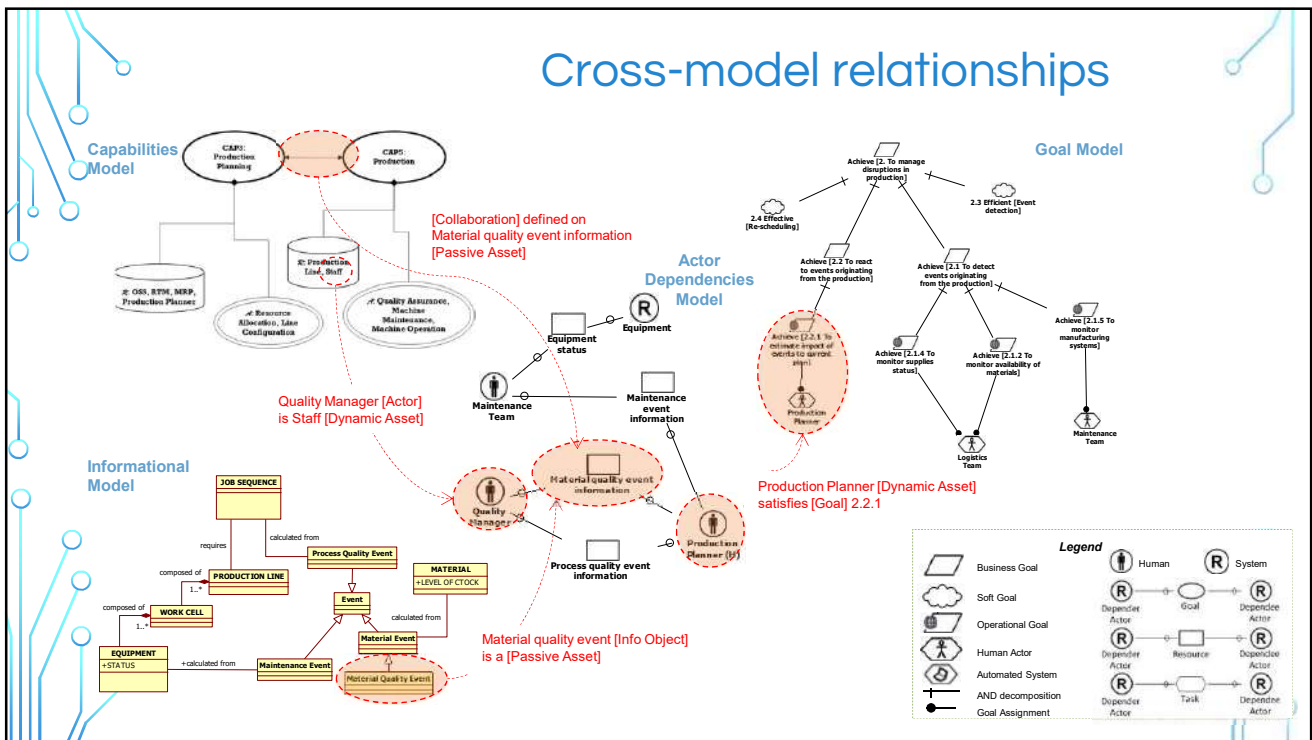
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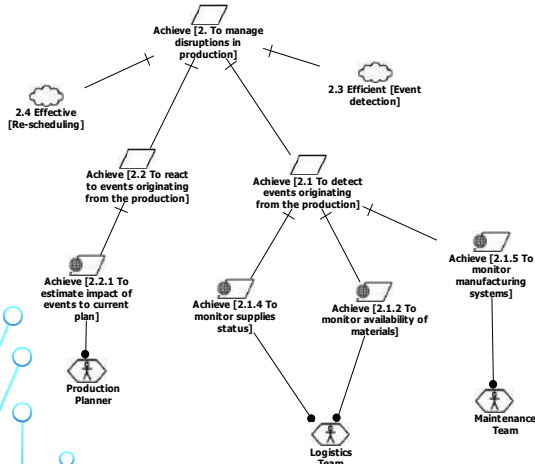
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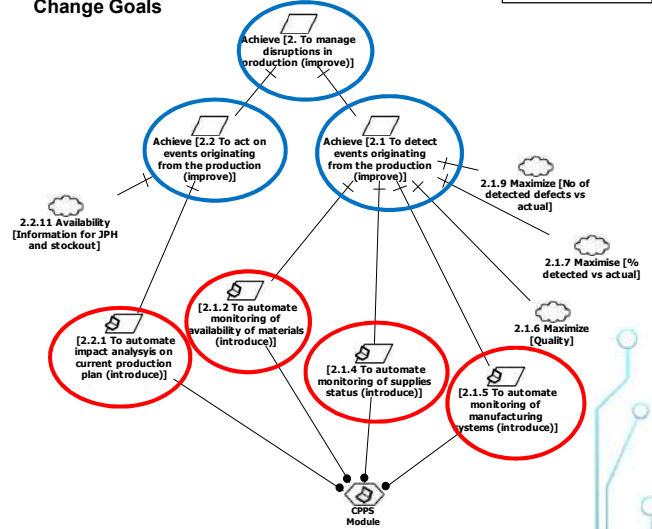
# From As-IS to Change Goals



## AS-IS Goals

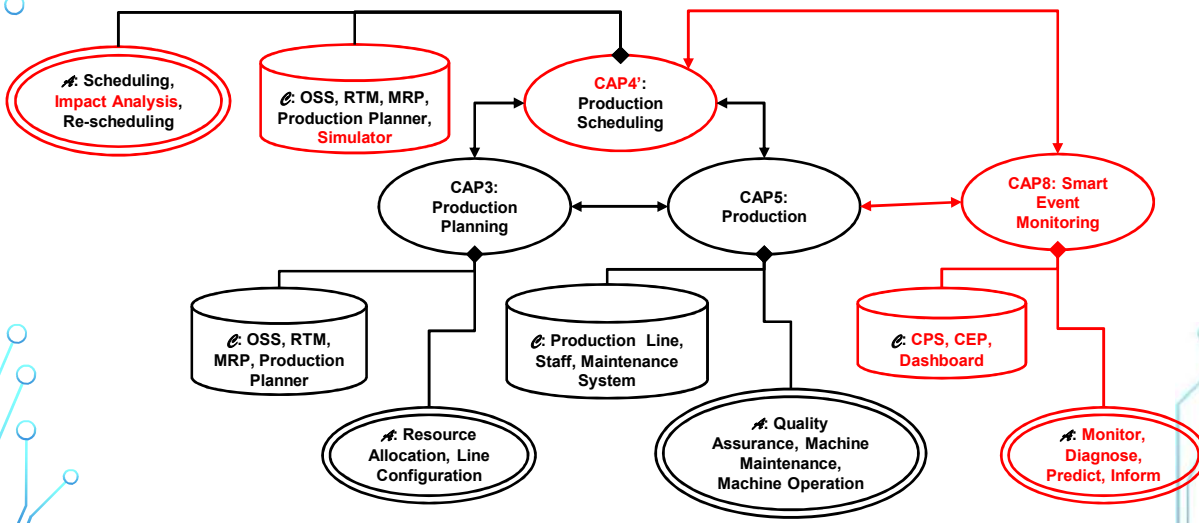


## Change Goals

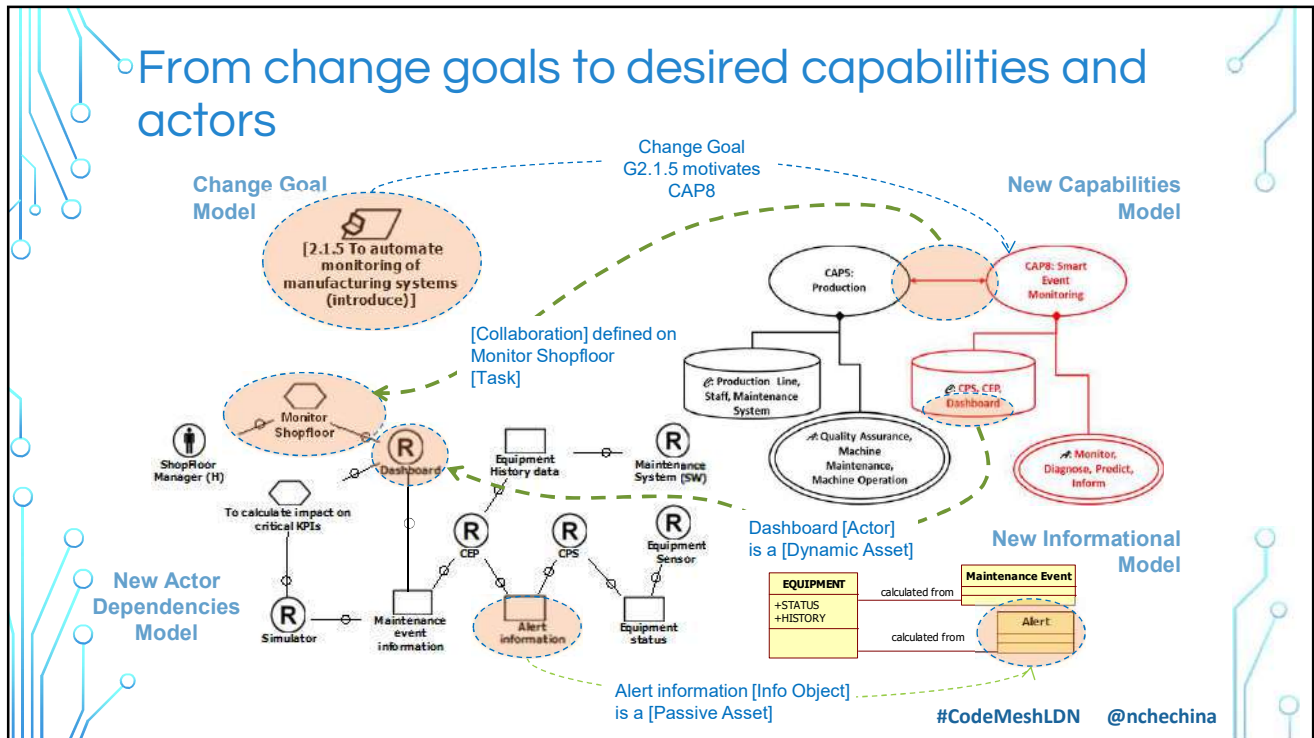


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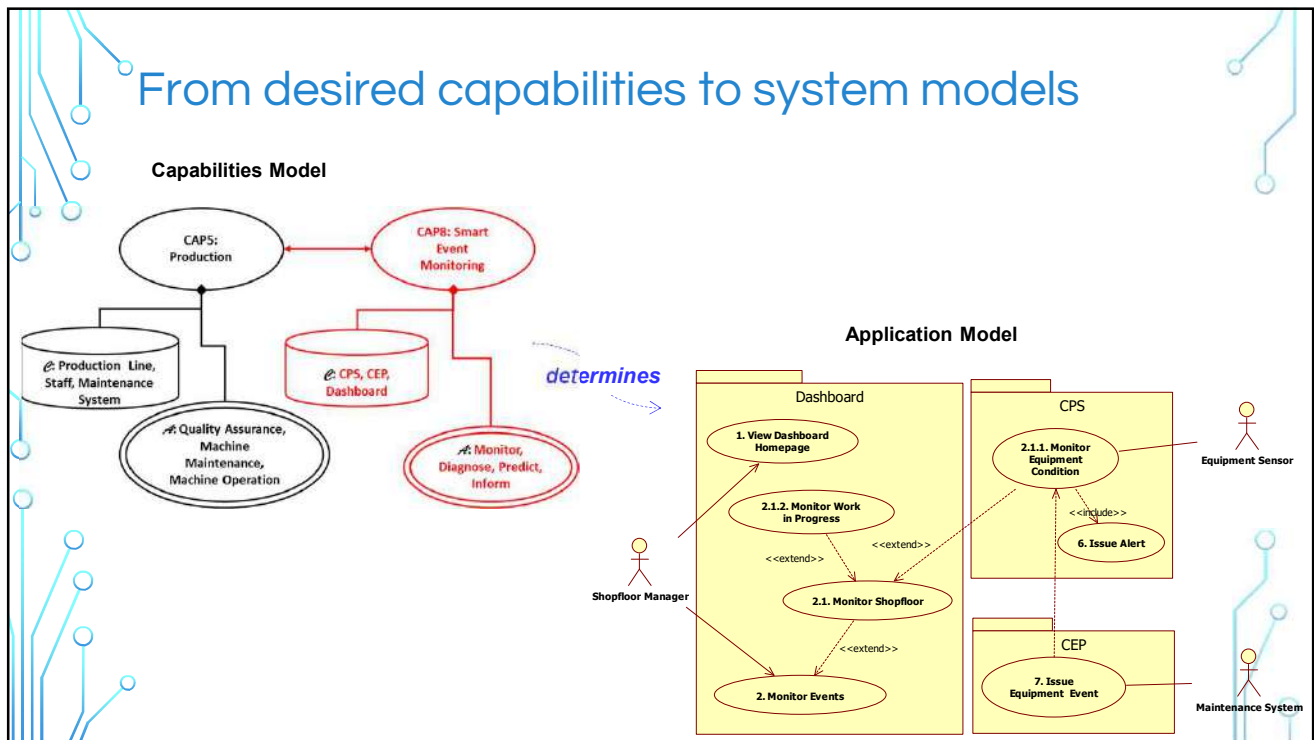
# Desired Capabilities model



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The **hardest** single part of building a software system is deciding precisely **what to build**.

*Frederick P. Brooks, Jr.*

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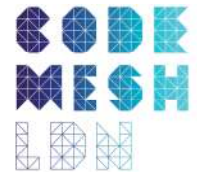
## Future challenges

- Design challenge
  - Emergent behaviour, dynamics
  - **Fixed goals** → **Emergent goals**
- Modelling challenge
  - Anticipation and representation
  - **Functional, non-functional, emergent requirements**
- Predictability challenge
  - Continuous dynamic composition
  - **System and its behaviour** ↔ **environment**



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