The Digital Twin –

a new concept for managing production and logistics in the context of Industry 4.0

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Institute of Logistics and Material Handling Systems

Workshop Desription

The Digital Twin is meanwhile a recognized concept of Industry 4.0, used primarily in the engineering domain for products and their production. So far, however, there are only a few approaches to using this new conceptual approach for logistical purposes as well, especially for the order-oriented control of products and their components, from procurement and transport to storage and staging for production, through to finishing and finally distribution of the goods. Based on the customer order, such an order-oriented digital control twin should, if possible, map and support the entire process chain. The concept should take advantage of the technical and informational capabilities created by Industry 4.0, such as RFID, GPS, Internet platforms, and cyber-physical objects. Likewise, new software tools and algorithms such as Machine Learning, Big Data, Artificial and Business Intelligence should be integrated into the concept.

In this workshop, the existing approaches, and concepts of a digital control twin in the field of logistics and production will be presented and discussed. The basic data structures, functions and algorithms are to be identified. At the same time, the interface and communication paths between the technical and the logistical digital twins will be pointed out shown. Finally, existing deficits in the previous concepts will be identified in order to derive research priorities for further research and development.

Intended target group: Mainly conference attendees, but open to all researchers and teachers at university institutes of information systems, logistics and production management, and staff at research institutes and developers of ERP software.

Structure of the Presentation

0. A Vision of a Digital Control Twin in Logistics

Lack in Research of Digital Twin for Value-Chain Networks !

stalten. Dazu zählt der Ansatz eines digitalen Zwillings, der als digitale Abbildung von Maschinen anlagenbezogene Daten in nutzbarer Form sammelt, aufbereitet und präsentiert. Aktuelle Lösungen zielen jedoch vor allem auf die Betriebsphase einer Anlage. Die vorgelagerten Phasen und die Integration des Wertschöpfungsnetzwerkes inklusive der Kunden wurden bisher kaum berücksichtigt.

Statement: A lack in research and design of Digital Twins for Value-Chain Networks which are not technical but customer order-oriented !

Quelle: „Industrie 4.0 Innovationen im Zeitalter der Digitalisierung“, S. 16, BMBF (Hrsg.), 2020

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A Vision: „Digital Control Twin“ in Logistics

Structure of the Presentation

0. A Vision of a Digital Control Twin in Logistics

1. Introduction – The Challenge of Logistics in the era of Industry 4.0

2. The General Concept of Digital Control Twins in Production & Logistics

3. Data Grid of Production and Material Flow for Rulebased-Computation

4. Short Resumee and Discussion

Presentation

0. A Vision of a Digital Control Twin in Logistics

1. Introduction – The Challenge of Logistics in the era of Industry 4.0

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The challenge of Logistics in the era of Industry 4.0

- ***the Right Material Items***
- ***at the Right Time***
- ***at the Right Place***
- ***in the Right Quantity***

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→ *Real World of Material Flow Items*
→ *Virtual World of Material Flow Items*

Rough Calculation of Data Grid for an Automotive Factory (exemplary)

2.500 cars per day * 20 days in Master Production Schedule (MPS)

10.000 material items (raw parts, single parts, assembly groups, modules,

→ 500 Mio. material flow items in the scope

In combination with

→ thousands of Counting Points in Production & Transport (→ Data Grid) for planning, control & monotoring of all Material Flow Items and permanent data acquisition each … ‚second' ….

What we suppose:
There is a relationship between all Counting Points (CP) and between Product and Components which pass these CP's !

What we have to do:
We have to define this data grid and the relationship and to use this structure for control of production and material flow !

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At first some Terms of ‘Digital Twin’

- *Digital Twin*
- *Digital Twin Concept*
- *Digital Control Twin Concept*

→ *Engineering-oriented Digital Control Twin Concept*

→ *order-oriented Digital Control Twin Concept*

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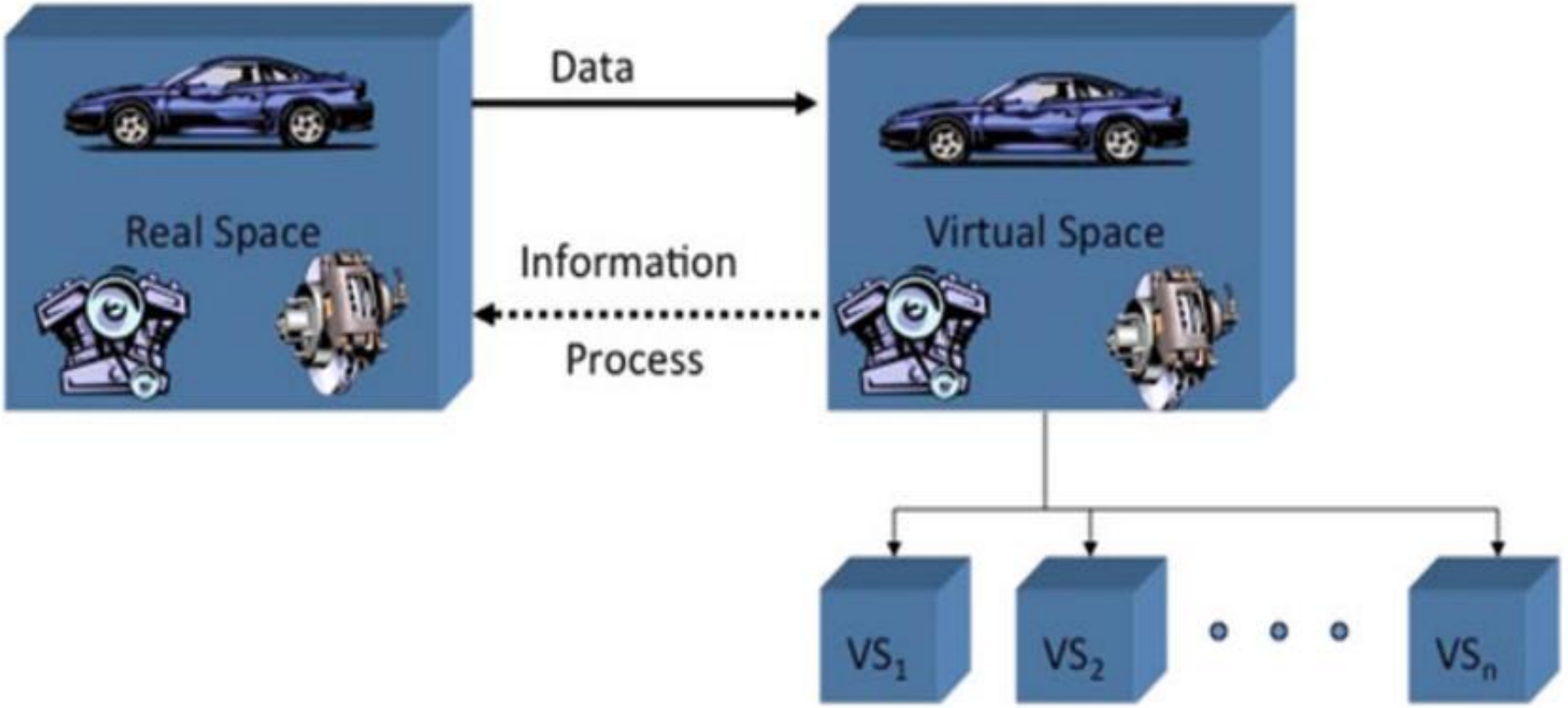
‘Digital Twin Concept’ of M Grieves an J. Vickers



Digital Twin Concept : bi-directional relation between the real and virtual world

→ *the DT Concept is more than a DT which is only a representation of an object*

→ *the DT Concept tightens the real world and the virtual world in a ‘certain’ way whereby the virtual word contains the target for the real world and is ‘leading’ the real world …*

The Five Elements of the Digital Control Twin Concept

The Digital Control Twin concept is an adaption of the DT concept which specifies the real world, the virtual world and the connection between them in order to regulate the processes of the real world thru the virtual world in a certain way.

The DCT concept is defined by some specific terms for the main elements

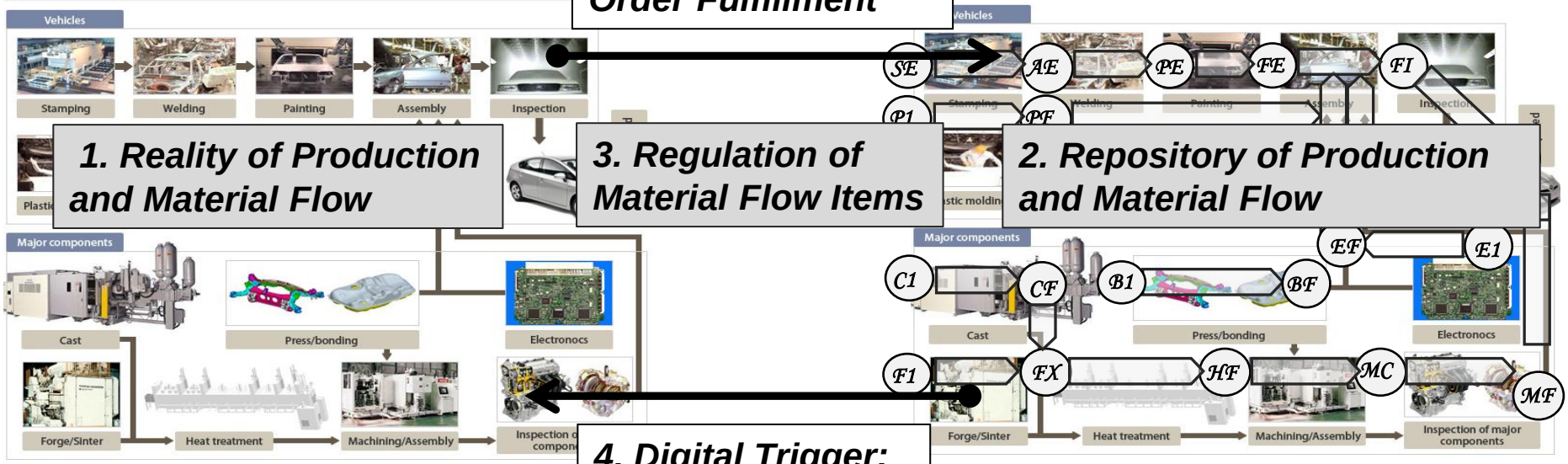
1. *Reality: the real world of physical material objects (items) in a real environment*
2. *Repository: the virtual world is mapped by data that is stored in different databases, which are connected to each other*
3. *Regulation: are all methods to control the real world thru the virtual world*
4. *Digital Trigger: are a 'push' for physical material items in a process in a certain environment at a certain time and place (target data for process control)*
5. *Digital Shadow: 'snapshot' of physical material items in a process in a certain environment, at a certain time and place (actual data for process control)*

Digital Control Twin Model for order-oriented Processes

Real World of Production and Logistics

Virtual World of Production and Logistics

5. Digital Shadow: Acquired Data of Order Fulfillment



1. Reality of Production and Material Flow

3. Regulation of Material Flow Items

2. Repository of Production and Material Flow

4. Digital Trigger: Digital Order and Schedules

 # Products & Components *… Counting Points* *Material Flow Intervals*

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Big Picture : SCP/ERPS System

2. Repository (Virtual World of Logistics)

A) Customer Orders & Forecast of Products & Components

B) Schedules & Order of Products & Material Items

C) Product Structure / Bill-of-Material

D) Production & Material Flow Network (‚Count.-Points')

E) Transport, Storing & Handling Structure

F) Capacities, Constraints, & Process-Calendars

G) Control-Data of Objects & Processes

*BI

7. Data Gravity Centre

*DA

Hints & Alerts

6. Process Control Cockpit

3. Regulation of Production & Material Flow

8. Application Controller

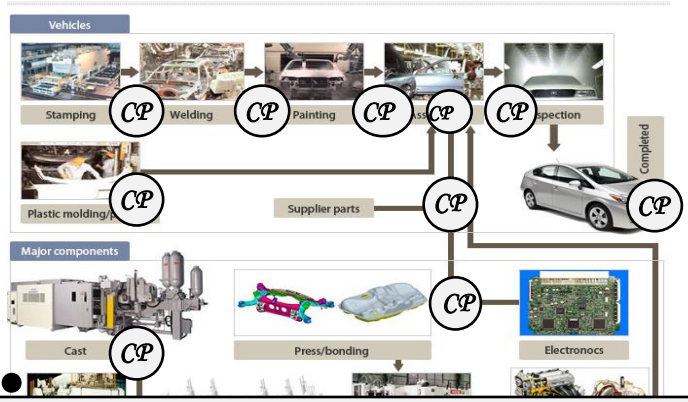
Process Dominance

Sets of Regulation-Tools & Rules

Update- / Process- / Response-Cycle Times

4. Digital Trigger

Issuing of planned Orders & Schedules (Target Data)



5. Digital Shadow

Receiving of fulfilled Orders & Schedules (Actual Data)

*CP

1. Reality (manufacturing, transporting, storing, handling ...)

*CP

Process Output

*DA Digital Analytics

*BI Business Intelligence

*CP Counting Points

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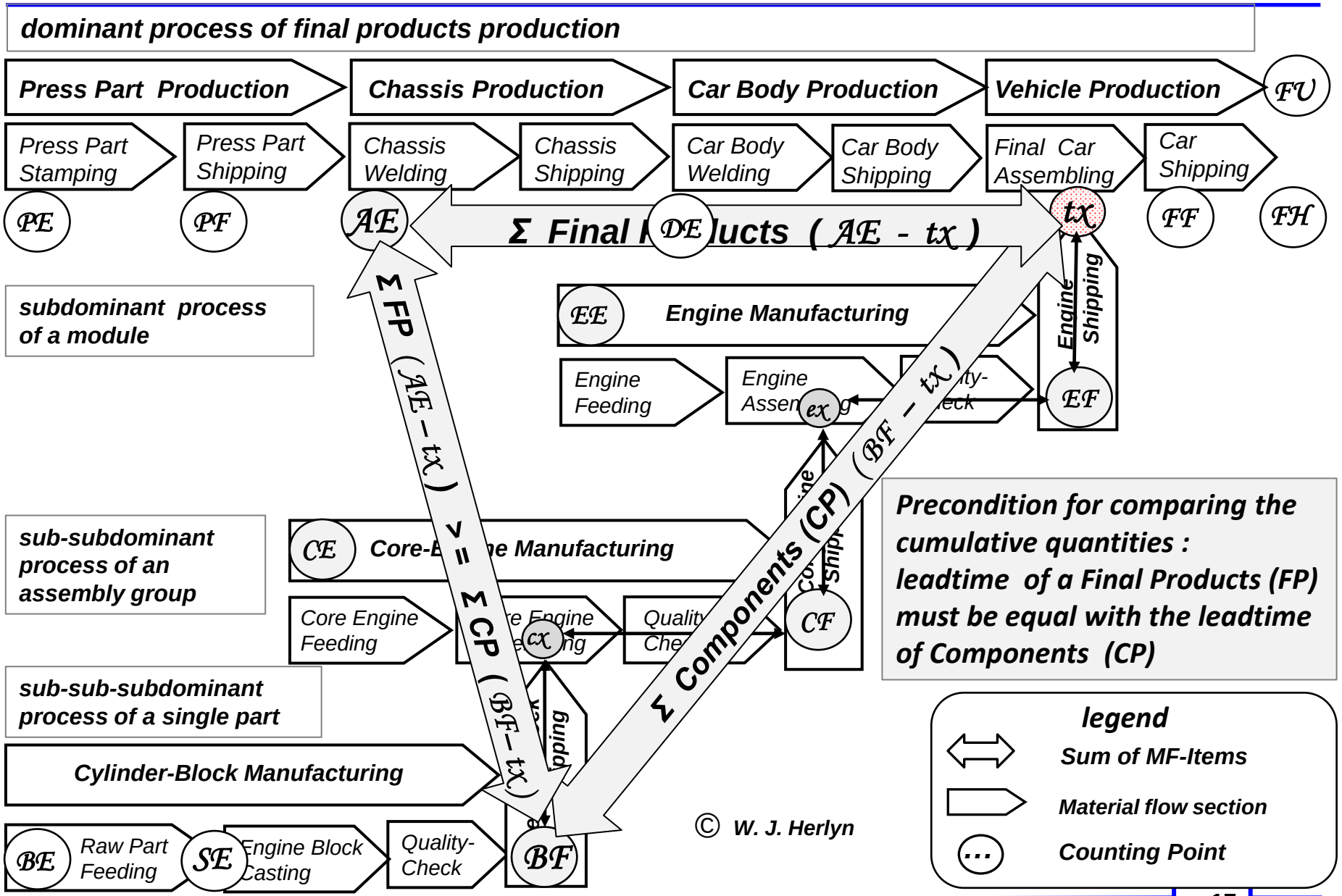
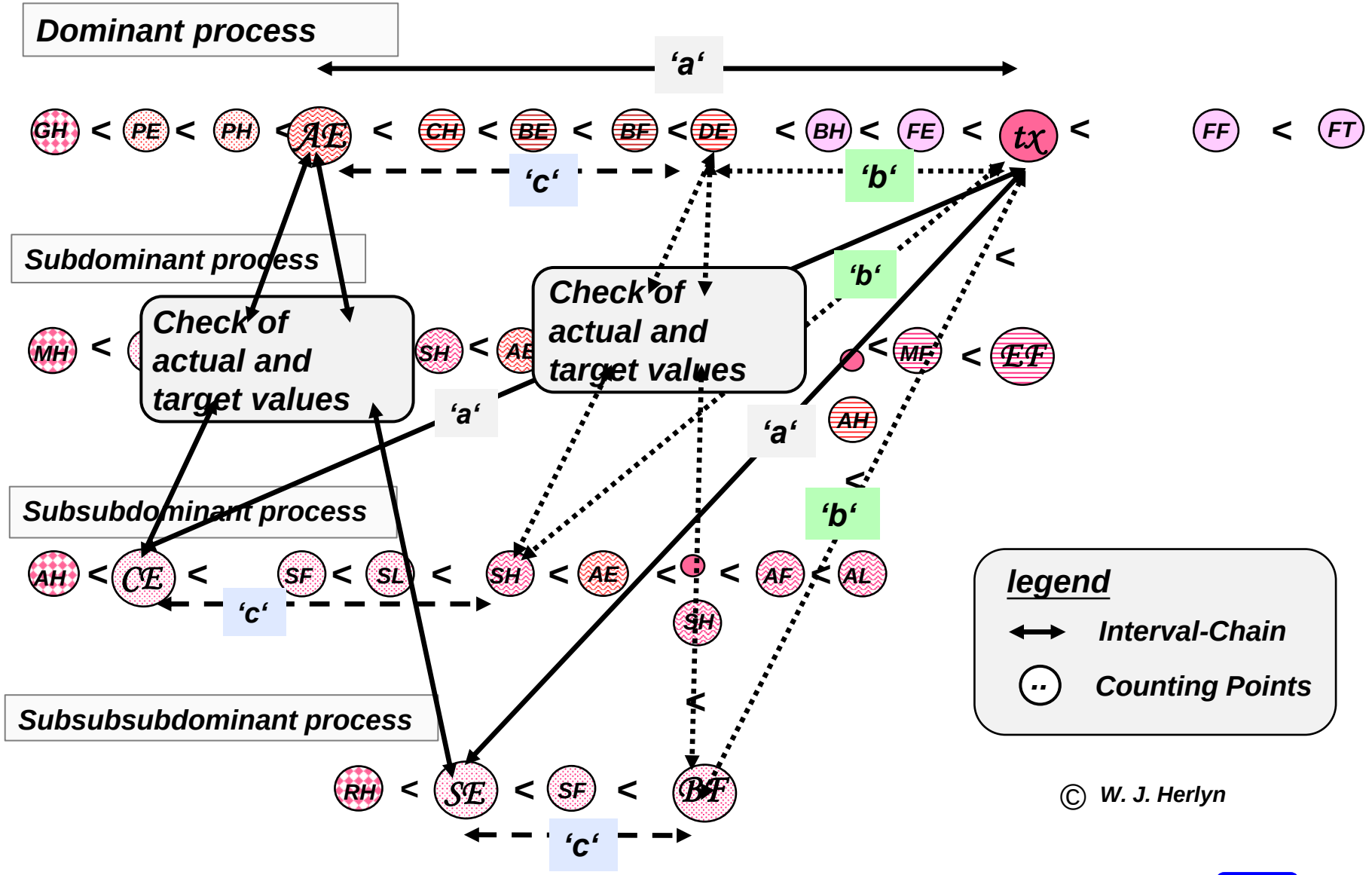
Hierarchical Data Grid and Relation of Material Flow



Rulebased Calculation in a Material Flow Network (exempl.)



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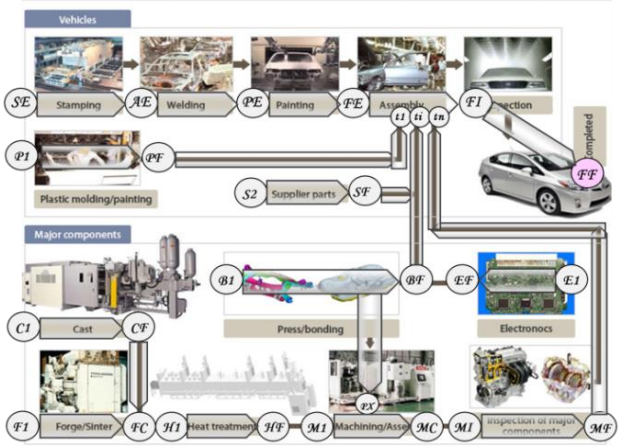
Tomorrow: Order-oriented Control Cockpit for Products and Components

Alerts

Digital Control Twin for a certain step

Digital Control Twin for several ‚steps' in a Chain of a Network

Digital Control Twin for the entire Network



Industry 4.0 : Order-oriented Control Board

A Central Control Board visualizes the actual technical status of about 240 'stations' in the plant vehicles flow thru, from the pressing shop to welding stations, from car body shop over car coating to the final assembly lines. The focus is on technical equipments of manufacturing process and their functionality.

Technical-oriented view of a Control Board:

- *Visualisation of vehicle flow for all factory sections - but no explicitly defined digital flow structure*
- *Actual flow-status in all factory sections of vehicles - but no information about material flow status*
- *Instant Alerts of technical problems - but no information about logistics problems*

For logistic purposes a 'Central Logistic Control Board' should visualize the actual status about vehicles in and between all 240 'stations' in the plant and in additional about the status of all material flow items in the shipping, storing and sorting stations that are required for feeding vehicle manufacturing.

Logistic oriented view of a Control Board :

- *actual status and targets (date, quantity, sequence,…) for vehicles flow*
- *'Alerts' for actual/target deviations of vehicles and material items*
- *automatical regulation of vehicle and material flow if deviations are 'accecptable' (in a certain range)*
- *simulation of vehicle and/or materail flow, if deviation is 'inacceptable' Toutside a certain range)*
- *data analytics and predictions*
- *….*

Thanx for your attention !

and time for Discussion

Research Project https://www.researchgate.net/project/Digital-Logistic-Twin-Concept

Universität Magdeburg https://www.ilm.ovgu.de/Herlyn-path-32,25,20,199.html

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