Lesson 12

Digitization and Digitalization in the Supply Chain

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Digitization vs. Digitalization

Digitization

Converting analogue into digital data for further processing by electronic means.

- Cargo control systems
- Paperless trade environments
- eCustoms systems
- ePayment systems
- eB/L, eAWB, eCMR, …

The underlying condition for digitalization

Digitalization

Applications of digital technologies by organizations, industries or societies like

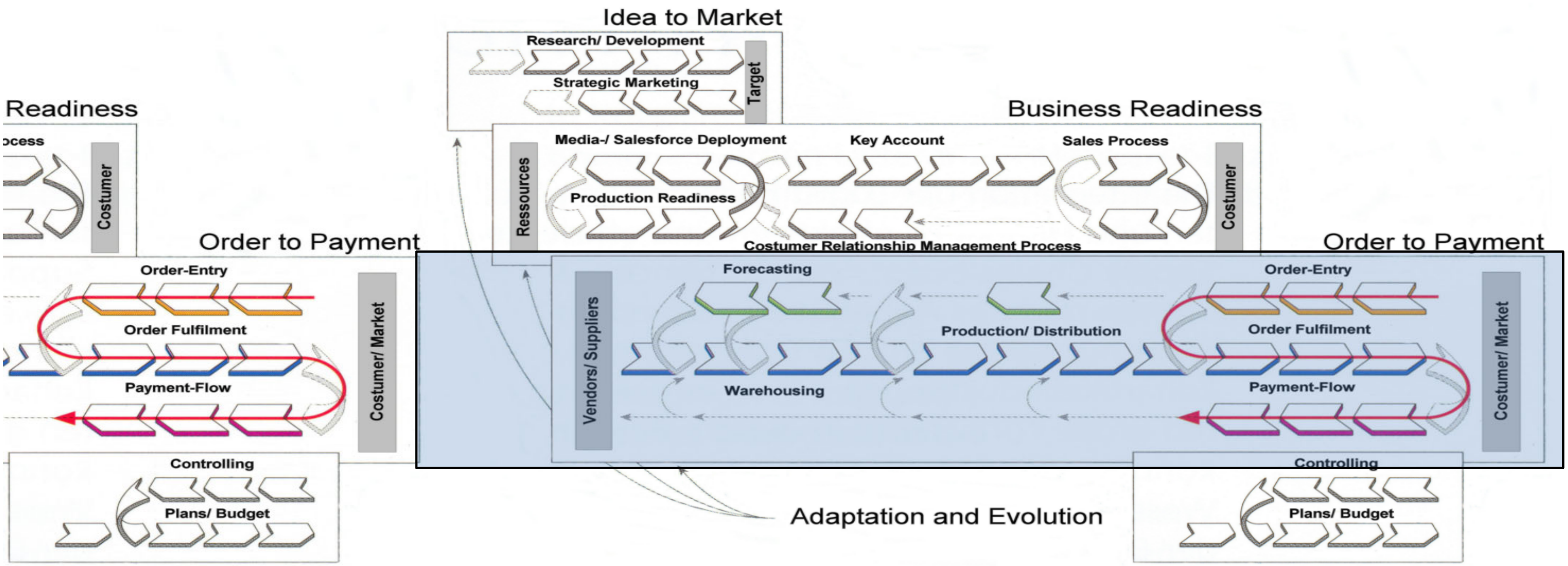
- Big Data
- Internet of Things
- Blockchains
- Uberization
- Digital transformation

Automation of operations or administrative processes, connecting different service, development of new business models - Up to the disruptive transformation of supply chains

Today's Topics

- Some initial thoughts concerning planning/control and IT support
- The Hierarchy of planning and control - MRP, ERP, APS, CPFR and beyond
- Visibility and Transparency – Challenges of SC execution – illustrated on a transportation chain
- "new disruptors" IoT, Big Data and digital transformation

SCM –Four generic processes as basic view on enterprises – related IT support



Interrelation of Planning, Control, Scheduling –> „Philosophies“

	Planning	Dispatching Scheduling	Control	Phys. Flow
Time frame				
Hierarchical Position				
Critical Element				
Solution By				
Types of Info., Data needed and applied				

Supply Chain Configuration	Supply Chain Planning	Supply Chain Execution

Interrelation of Planning, Control, Scheduling –> „Philosophies“

	Planning	Dispatching Scheduling	Control	Phys. Flow
Time frame	„anticipating“ “long run“			
Hierarchical Position	“high – top down“			
Critical Element	“Handle Uncertainty“			
Solution By	“Collecting Info“, Setting premises, Building scenarios“			
Types of Info., Data needed and applied	Historical data, patterns Forecasts, parameters Context Information			

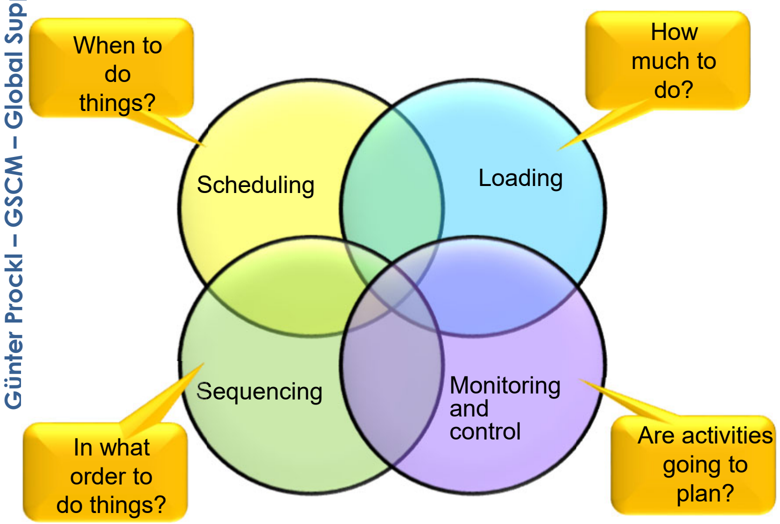
Supply Chain Configuration	Supply Chain Planning	Supply Chain Execution

Interrelation of Planning, Control, Scheduling –> „Philosophies“

	Planning	Dispatching Scheduling	Control	Phys. Flow
Time frame	„anticipating“ “long run“	“short run“		
Hierarchical Position	“high – top down“	“middle“		
Critical Element	“Handle Uncertainty“	“Select from Alternatives“		
Solution By	“Collecting Info“, Setting premises, Building scenarios“	“calculating Optima“		
Types of Info., Data needed and applied	Historical data, patterns Forecasts, parameters Context Information	“Situative“ data Capacities, lead-times		

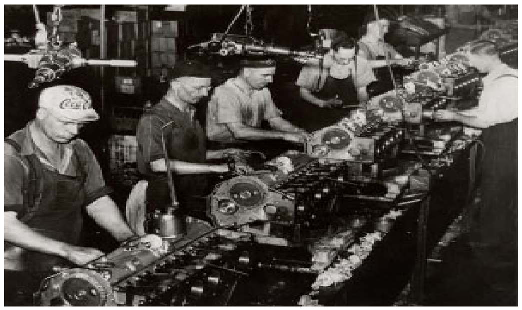
Supply Chain Configuration	Supply Chain Planning	Supply Chain Execution

Standard questions of production - Planning and Control



- What is to be produced for whom and by when?
  - Forecasting, operations planning
  - Determination of delivery date, sales management, lead time…
- What is needed for this production?
  - Demand assessment, procurement, accounts
  - Inventory management, stock reservation
  - Supplier selection, purchase orders ...
- When is it needed; when to generate parts needed?
  - Time scheduling, capacity requirement assessment
    Capacity load, order release ...
- Who does specifically what, when, how?
  - Sequence planning, work allocation, progress control

Physically fixed – e.g. Assembly line: contains the plan in a fixed structure



- Control by tight coupling by tight chaining : “Programming the hardware”
- Control is substituted by detailed beforehand planning
  - Control information is embedded in the structure/”hardware”
  - Hardly any scope left in the processes
  - But also complete fixedness- Quantities, timing!

- Do we still have this?

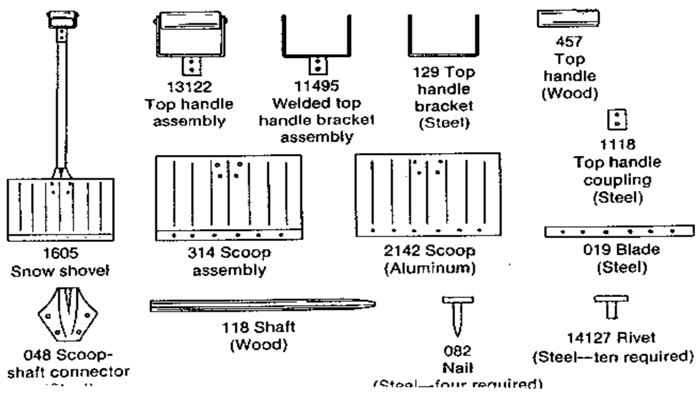
De-coupling Hardware and the Plan ("Software")
The "programme" as a hierarchy of plans

Production planning	**Master Production Schedule**	Forecasting Rough cut plannig Delivery date planning	Order processing
	Material requirement planning	Assessment of demand Order calculation Inventory accounting Reservations	Supplier Selection Purchasing orders writing Order processing control
		Shop order	Supplier Order
	Scheduling and capacity planning	Lead time scheduling Capacity requirement planning	
Production control	**Order release**	Sequencing Documents Job scheduling	Order Release
	Job control	Expediting, Order progress control Quantities and deadlines control Quality control	Incoming goods Quantities and deadlines Quality control

Material Requirement Planning – Explosion of the Bill of Material

Technical drawing

FIGURE 2.3 The 1605 snow shovel shown with component parts and assemblies



Working plan

2080 081	105	01	Papierwerk AG	20. 02. . .	Gebhard 2867
Auftrag-Nr.	-Nr.	U.– Gr.	Stichwort	Datum	Bearbeiter Tel.

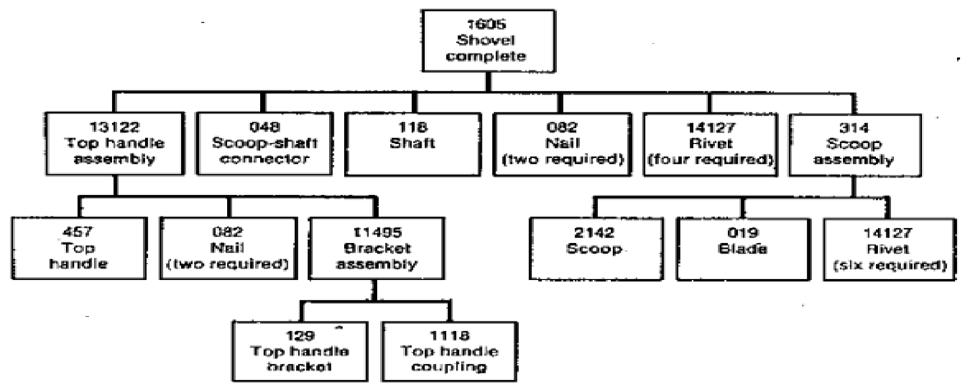
Lfd.-Nr	Stück	Benennung	Zeichnungs-Nr. Teile-Nr.	Pos.	Werkstoff	Modell – Lager-Nr.
142	10	Stopfbuchsen – Brille 2-teilig, 160 ø x 45	8429605 Teil 1 / 2	79 80	GG 18	R3 Kb 363

von MG-Nr.	Rohmaterial	Stück	Breite bzw. ø (mm)	Höhe (mm)	Länge (mm)	Zugabe (mm)
0420	Gußteil	2				

AG-Nr.	MG-Nr.	Arbeitsvorgang	t_r	t_e	Lohn-Gr.	n	s	Bemerkungen
01	5500	Anreißen Teilflächen			5			
02	3521	Fräsen Teilflächen und 2 Flächen, Maß 170	10	20	5			
03	5500	Anreißen Schraubenlöcher			5			
04	3403	Zusammen bohren und Gewindeschneiden 2 x M 8	7	13	4			
05	5004	Zusammenschrauben	10	10	4			
06	3107	Drehen komplett	25	60	6			
07	5500	Anreißen Schlitze 13 breit und Bohrung 10 ø			5			
08	3527	Fräsen 2 Schlitze, 13 breit	10	15	5			
09	3403	Bohren 1 x 10 ø	5	2	4			
10								

FIGURE 2.4 Parts for snow shovel

Product structure diagram



Indented bill of materials (BOM)

1605 Snow Shovel

- 13122 Top Handle Assembly (1 required)
  - 457 Top Handle (1 required)
  - 082 Nail (2 required)
  - 11495 Bracket Assembly (1 required)
    - 129 Top Handle Bracket (1 required)
    - 1118 Top Handle Coupling (1 required)
- 048 Scoop-Shaft Connector (1 required)
- 118 Shaft (1 required)
- 082 Nail (2 required)
- 14127 Rivet (4 required)
- 314 Scoop Assembly
  - 2142 Scoop (1 required)
  - 019 Blade (1 required)
  - 14127 Rivet (6 required)

Planning the quantities - Requirement planning: Primary/Secondary - Gross/net requirements

Indented bill of materials (BOM)

1605 Snow Shovel

13122 Top Handle Assembly (1 required)
457 Top Handle (1 required)
082 Nail (2 required)
11495 Bracket Assembly (1 required)
129 Top Handle Bracket (1 required)
1118 Top Handle Coupling (1 required)

048 Scoop-Shaft Connector (1 required)
118 Shaft (1 required)
082 Nail (2 required)
14127 Rivet (4 required)
314 Scoop Assembly
2142 Scoop (1 required)
019 Blade (1 required)
14127 Rivet (6 required)

FIGURE 2.5 Gross and net requirement calculations for the snow shovel

Part description	*Part number*	*Inventory*	*Scheduled receipts*	*Gross requirements*	*Net requirements*
Top handle assembly	13122	25	—	100	75
Top handle	457	[illegible]	[illegible]	[illegible]	[illegible]
Nail (2 required)	082	4	50	150	96
Bracket assembly	11495	27	—	75	[illegible]
Top handle bracket	129	15	—	[illegible]	33
Top handle coupling	1118	39	15	48	—

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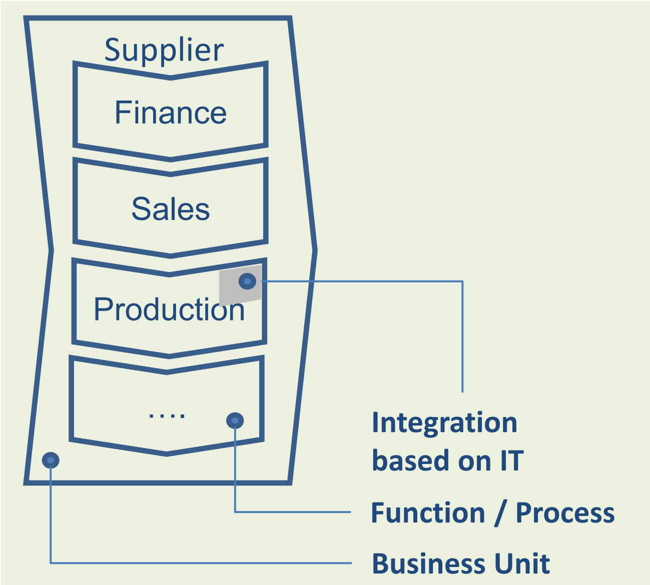
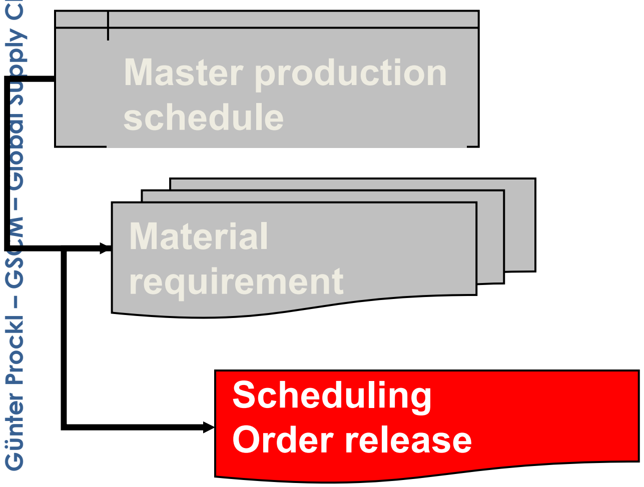
Phase 1: IT Support for basic Functions



Source: Fleisch, E., Österle, H.; 2000; A Process-oriented Approach to Business Networking; Electronic Journal of organizational Virtualness 2(2), 1-21

- Goal: Automation of information processes for basic functions like "**MRP**" or "billing" in finance
- Benefits: Higher efficiency for isolated processes
- Results: Isolated IT solutions
- BUT: Existing processes remain unchanged, potential of information technologies only partially exploited

Next: Scheduling and order release



Item	Row		1	2	3	4	5	6	7	8	9	10
13122 Top handle assembly, Lead time = 2	Gross requirements			20		10		20	5		35	10
	Scheduled receipts											
	Projected available balance	25	25	5	5	0	0	0	0	0	0	0
	Planned order releases			5		20	5		35	10		
457 Top handle, Lead time = 2	Gross requirements			5		20	5		35	10		
	Scheduled receipts				25							
	Projected available balance	22	22	17	42	22	17	7	0	0	0	0
	Planned order releases						18	10				
082 Nail (2 required), Lead time = 1, Lot size = 50	Gross requirements			10		40	10		70	20		
	Scheduled receipts		50									
	Projected available balance	4	54	44	44	4	44	44	24	4	4	4
	Planned order releases					50		50				
11495 Bracket assembly, Lead time 2	Gross requirements			5		20	5		35	10		
	Scheduled receipts											
	Projected available balance	27	27	22	22	2	0	0	0	0	0	0
	Planned order releases				3		35	10				
129 Top handle bracket, Lead time = 1	Gross requirements				3		35	10				
	Scheduled receipts											
	Projected available balance	15	15	15	12	12	0	0	0	0	0	0
	Planned order releases					23	10					
1118 Top handle coupling, Lead time = 3, Safety stock = 20	Gross requirements				3		35	10				
	Scheduled receipts			15								
	Projected available balance	39	39	54	51	51	20	20	20	20	20	20
	Planned order releases			4	10							

Leadtime = 2

Leadtime = 1

Scheduling „backwards“ and „forwards“

FIGURE 2.6 Gantt chart for cutting approach to snow shovel problem (front or earliest start schedule)

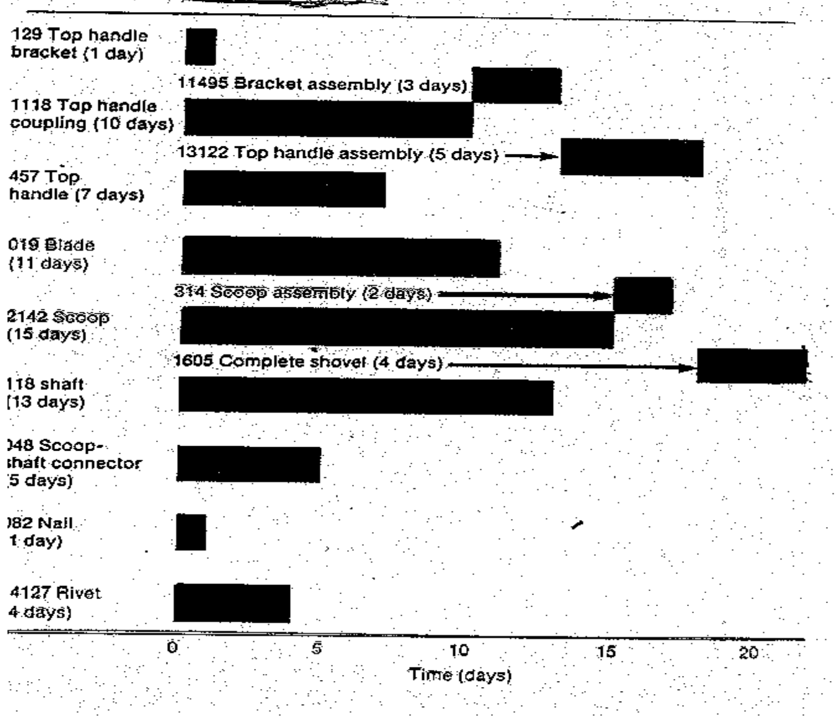
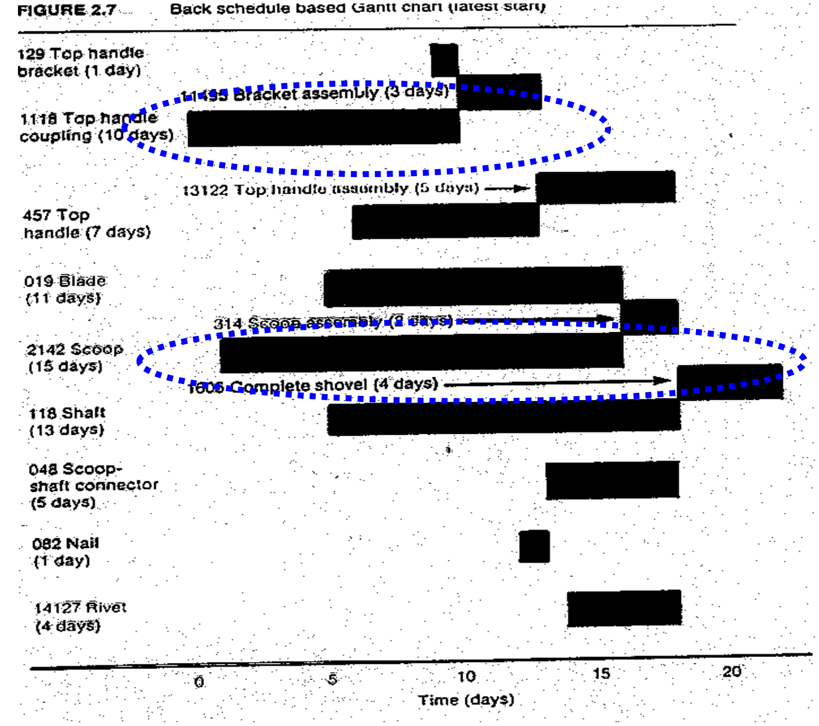
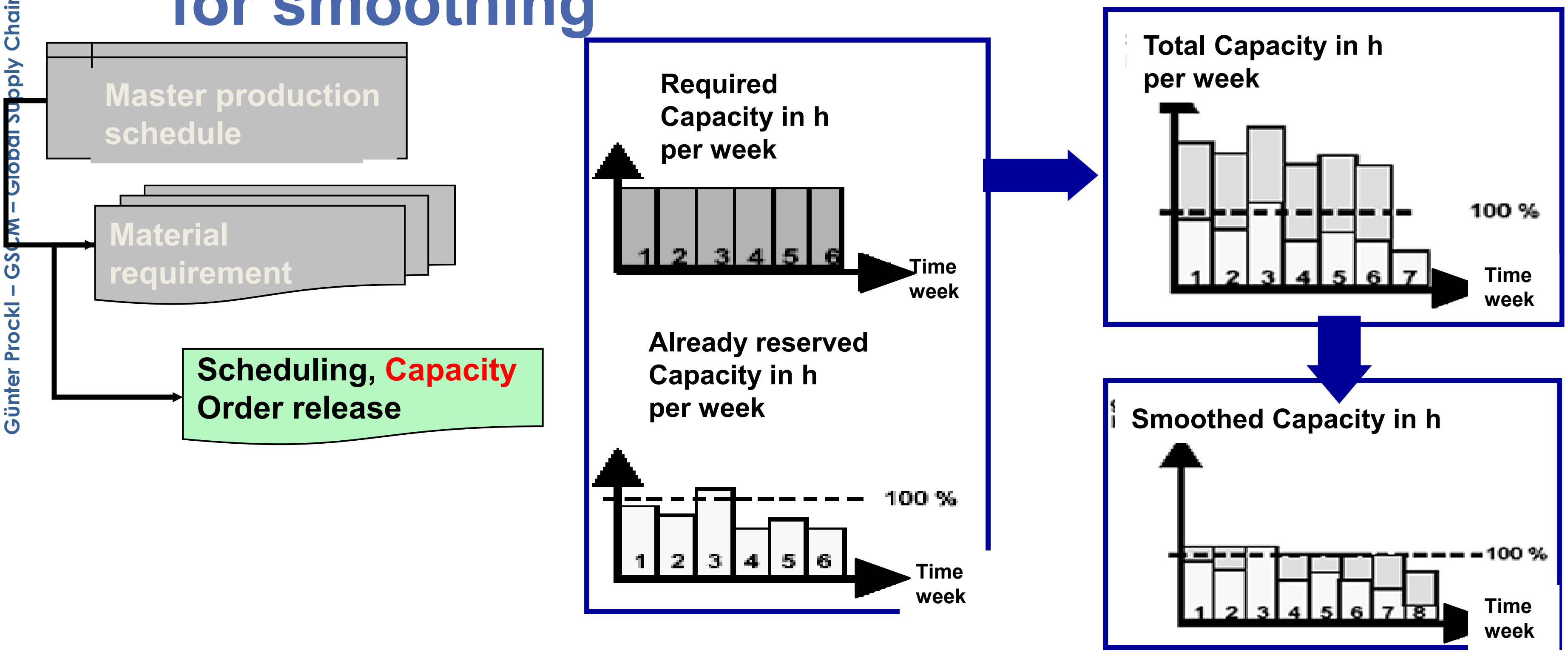


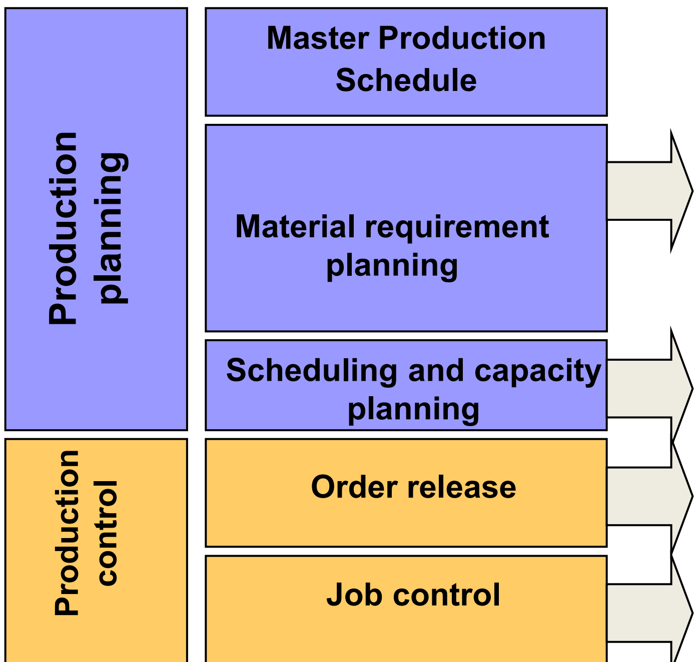
FIGURE 2.7 Back schedule based Gantt chart (latest start)

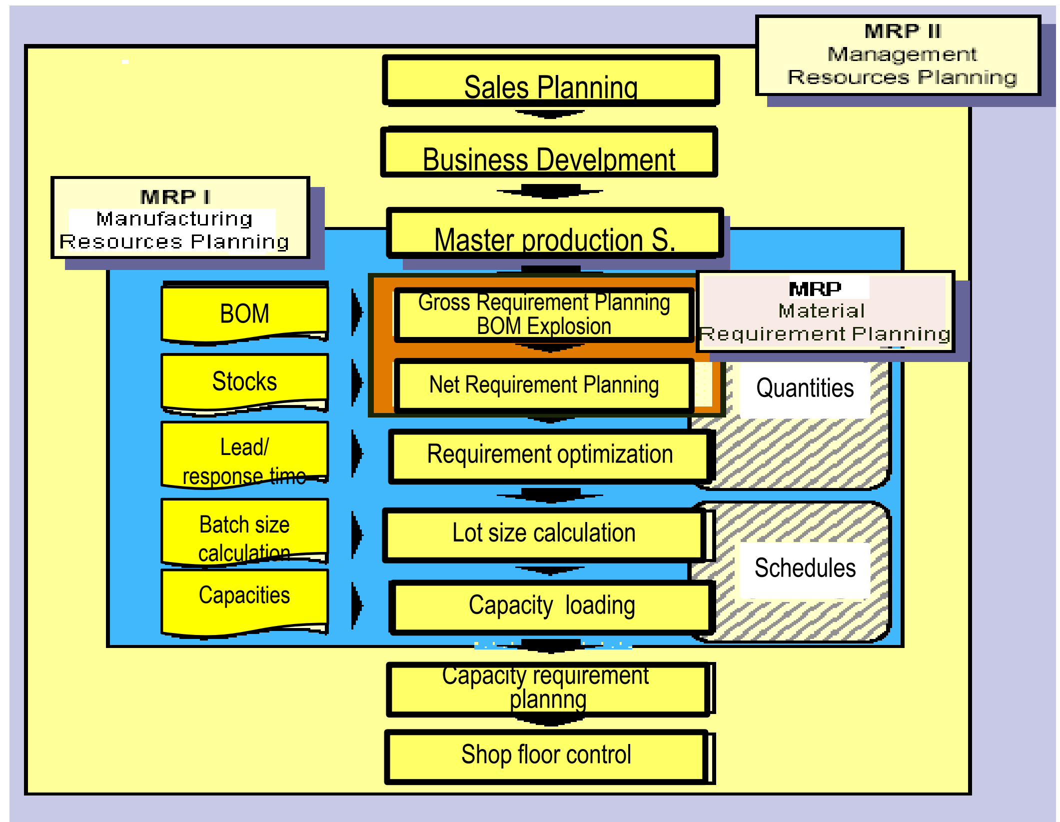


Capacity requirement planning and – Need for smoothing

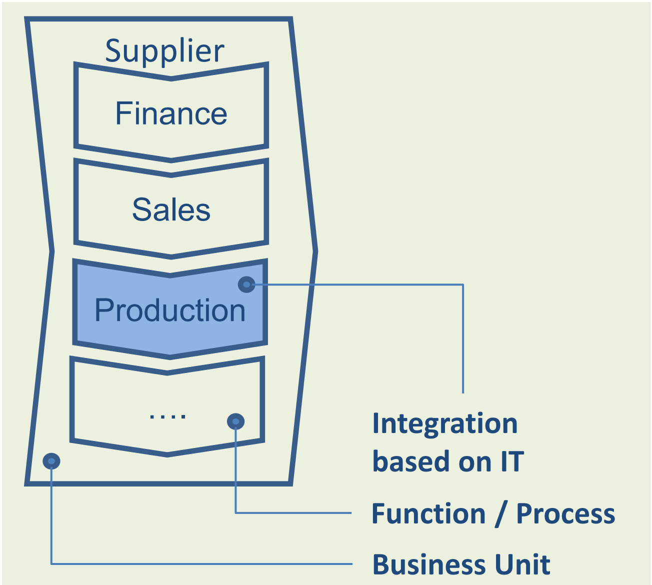


MRP 50-60ies - MRP I, 60ies- 80ies MRP II, from the 80ies





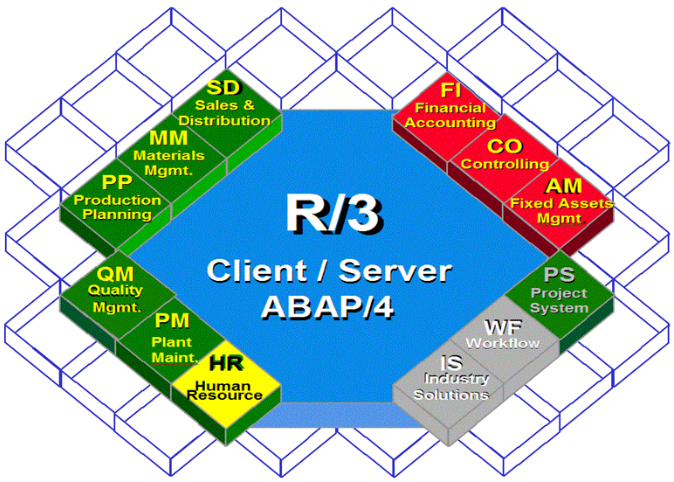
Phase 2: IT Support for functional Blocks



Source: Fleisch, E., Österle, H.; 2000; A Process-oriented Approach to Business Networking; Electronic Journal of organizational Virtualness 2(2), 1-21

- Goal: Process optimization within functional blocks like "finance" or "sales" or "production"
- Benefits: Higher efficiency of function specific processes
- Results: New methods like production planning
- BUT: Barriers between functional blocks stay intact

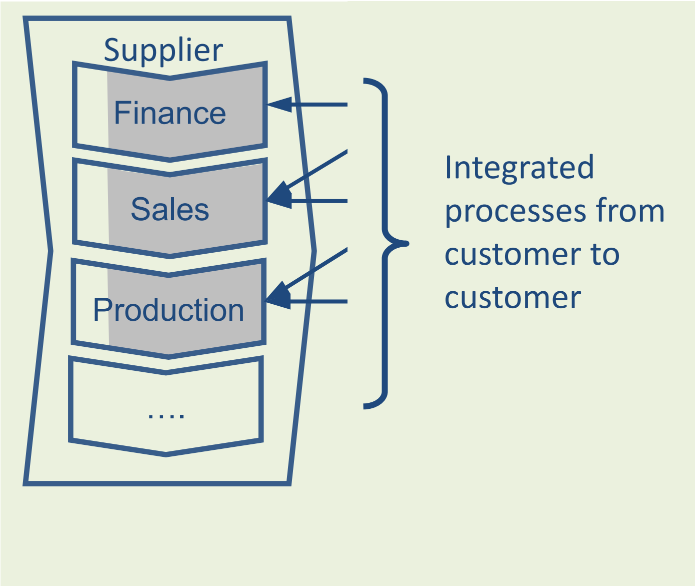
„The xRP-Logic“ …



- **Automation** of the hierarchical process – **Top Down**
  - work through hierarchical and step-by-step
    - Material Requirement Planning MRP
    - Manufacturing Resource Planning MRP I (MRP II)*
    - Management Resource Planning MRP II (MRP III) *
    - Enterprise Resource Planning ERP
  - Control hierarchy – centralized - loop system
    - analytically derived plan targets
    - planning results of one stage are inputs of the following stage
    - Feedback and control of deviations
    - Countervailing measures, searching for trade-offs

* Unclear usage of terms

Phase 3: Development of internally integrated Processes



Source: Fleisch, E., Österle, H.; 2000; A Process-oriented Approach to Business Networking; Electronic Journal of organizational Virtualness 2(2), 1-21

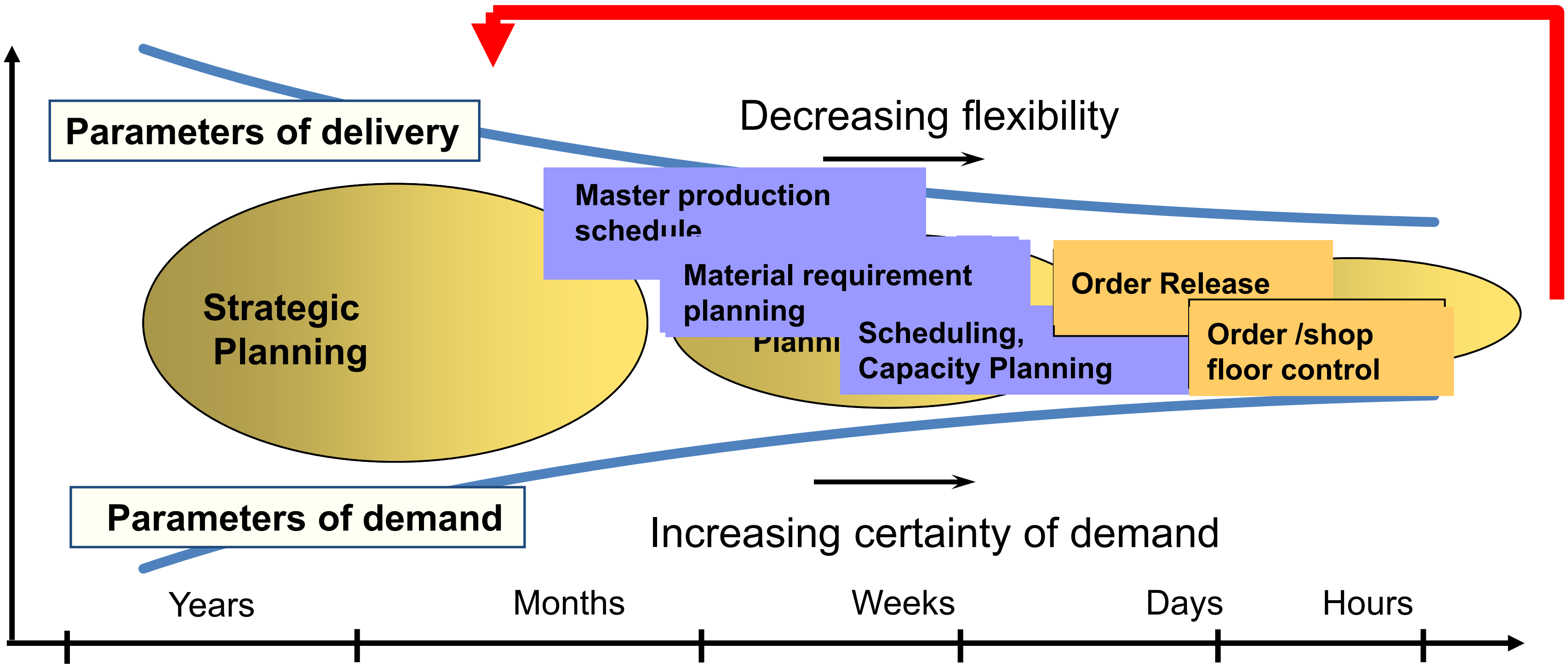
- Goal: Process optimization between order entry and payment after product delivery
- Benefits: Higher process speed, efficiency, customer satisfaction
- Results: ERP become backbone of industrial organizations
- BUT: No automation of processes between different business units

Interrelation of Planning, Control, Scheduling –> „Philosophies“

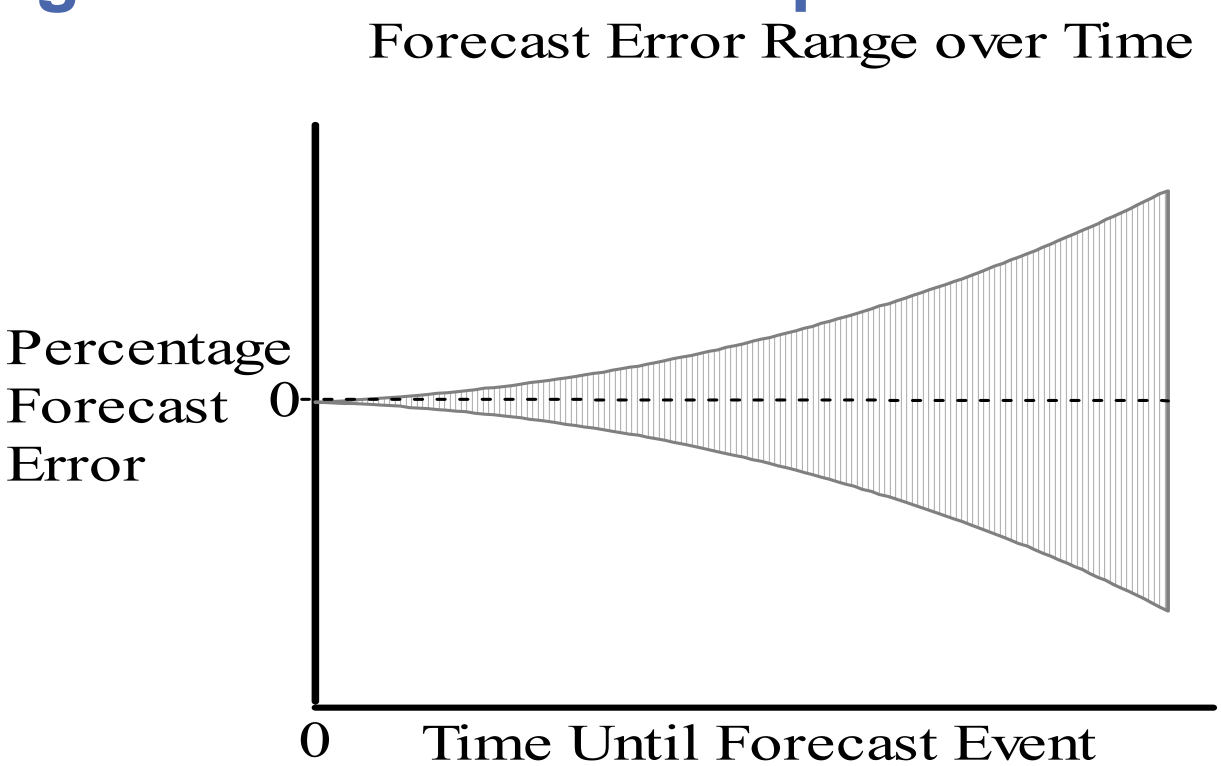
	Planning	Dispatching Scheduling	Control	Phys. Flow
Time frame	„anticipating“ “long run“	“short run“	“simultaneous“	
Hierarchical Position	“high – top down“	“middle“		“shop floor“
Critical Element	“Handle Uncertainty“	“Select from Alternatives“	“phys./technological determined“	
Solution By	“Collecting Info“, Setting premises, Building scenarios“	“calculating Optima“	“Applying rules“	
Types of Info., Data needed and applied	Historical data, patterns Forecasts, parameters Context Information	“Situative“ data Capacities, lead-times	Real-time data, Events, disturbances, “Triggers“	
	Supply Chain Configuration	Supply Chain Planning	Supply Chain Execution	

Some Complications & Challenges in more modern business environments

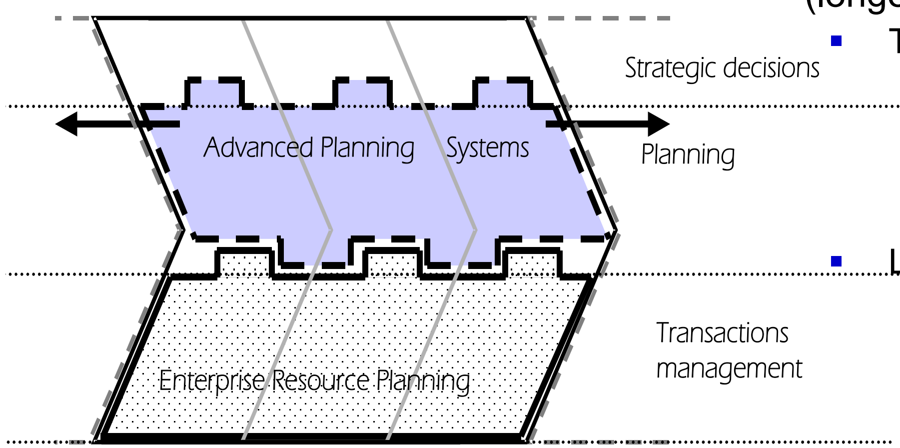
Complication 1: … The “time funnel” …



… together with “the trumpet of doom”

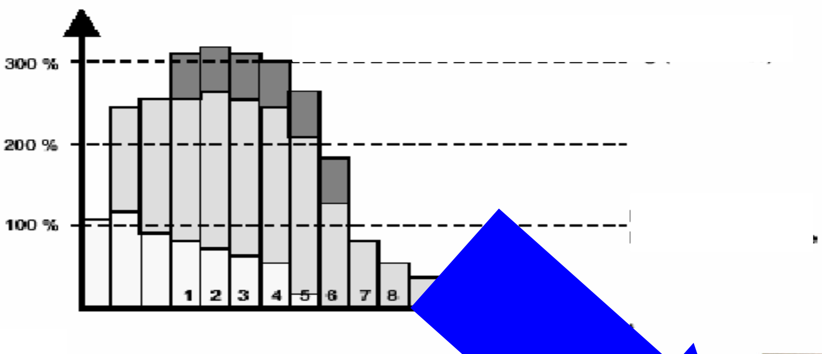


From ERP to Advanced Planning Systems



- Why are Enterprise Resource Planning (ERP) often not (longer) sufficient
  - Top-Down, sequential design logic
    - No consideration of interactions
    - Priority usually set on production; based on forecasts that are not re-questioned
    - no trade-offs between sub-functions
  - Little flexibility, time-consuming, complete planning runs
    - Planners used plans de facto only as a first orientation and make use of notes or a spreadsheet
    - Precise data on the system, but the scheduling logic to simplify the constraints,
      - Assumption of unlimited capacity
      - Based on average processing time and standard waiting time

e.g. ATP, CTP instead of capacity "piles"



- Special ATP-Functionalities
  - Online-availability check by managers using different databases
  - Linked to modules in partner companies
  - Simulation (what-if, how-to-achieve) to search for alternative solutions

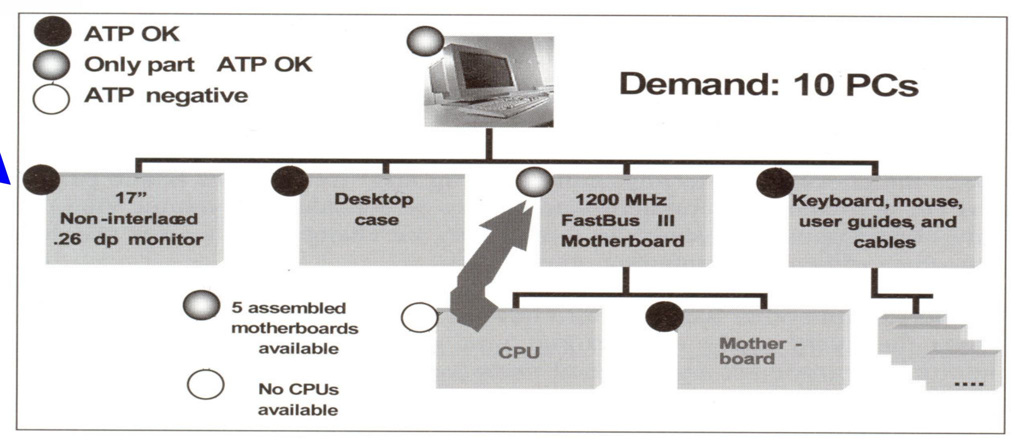
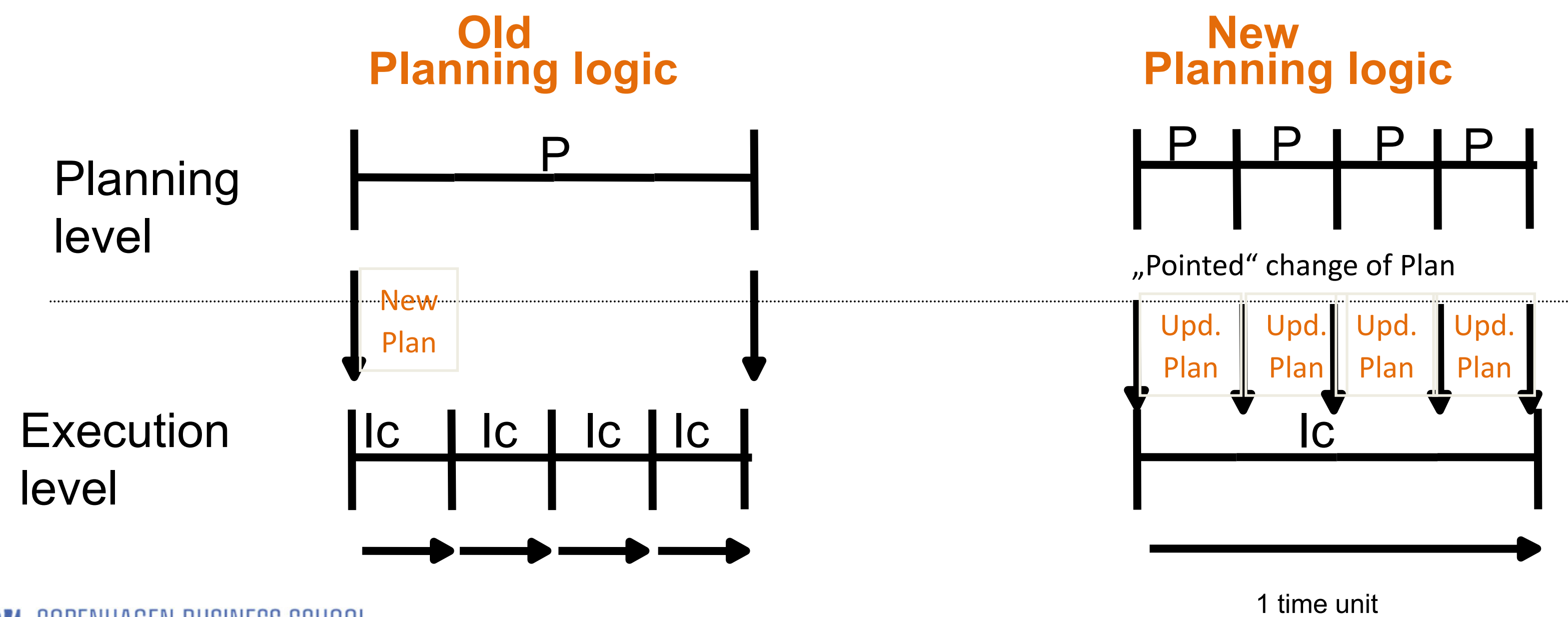


Figure 3.16: Example for an ATP check

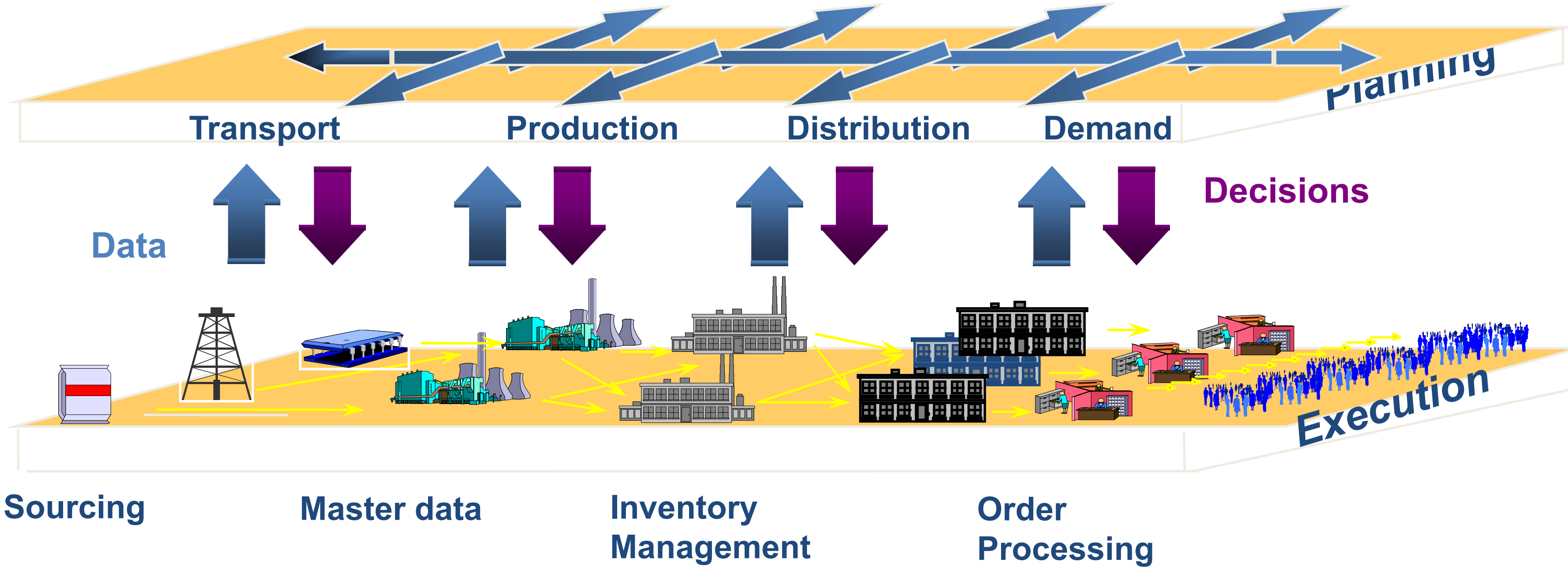
Source: Knollmayer

Overcoming the time funnel by a changed planning logic – Better „muddling through“ in a sequence of “not perfect” plans than a perfect but quickly obsolete plan



P = Planning cycle
IC = Intervention cycle

Thus closer timing/integration of the “worlds” of Execution and Planning



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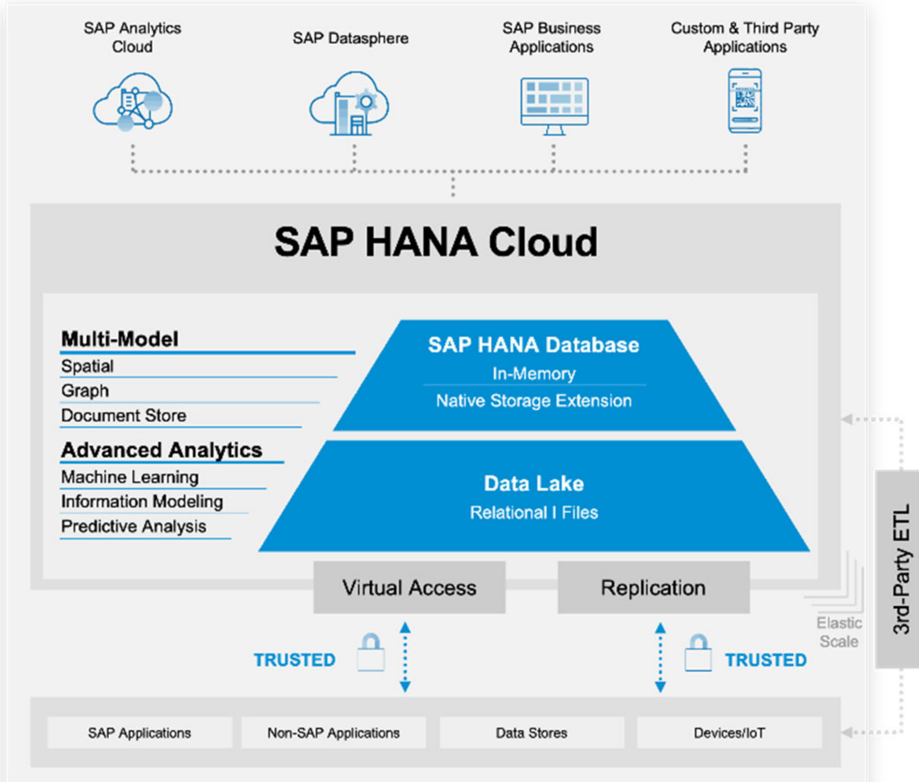
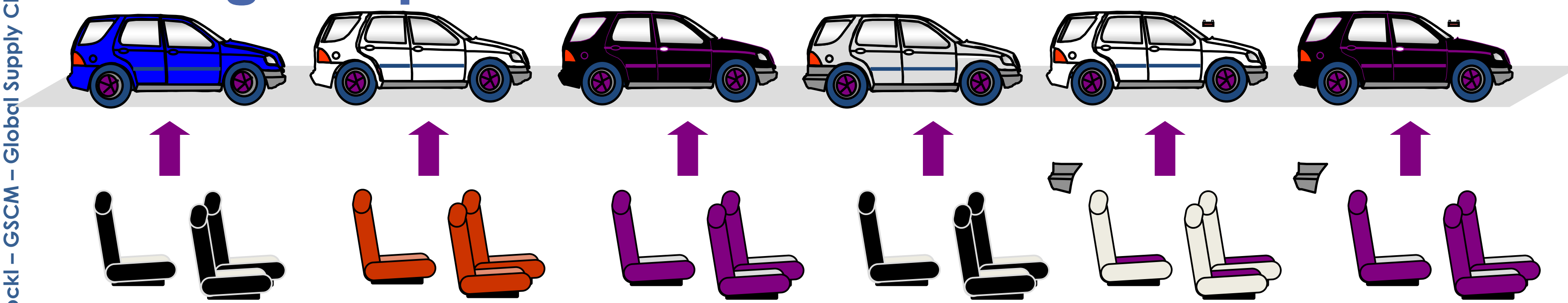
Current ERP seem to reflect such ideas better



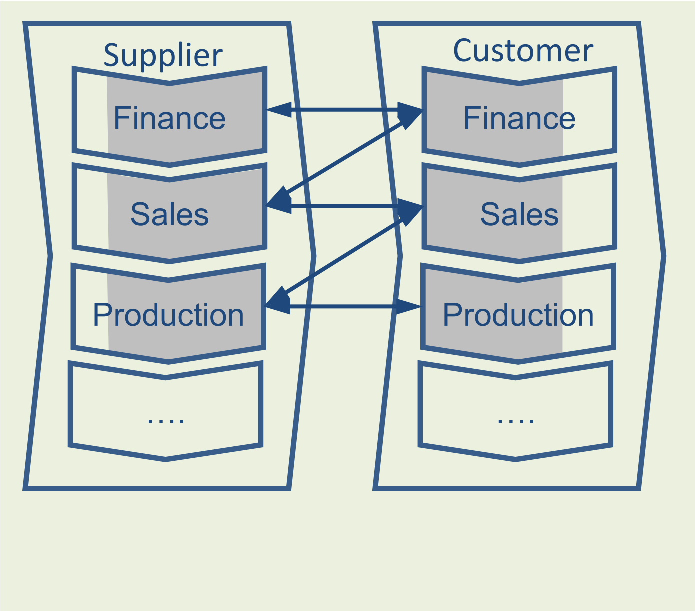
Complication 2: What about a Supply Chain – e.g. Sequenced JIT flow



- JIT sequenced delivery of parts to align with production sequence
- Product variation needs to match each vehicle
  - Color
  - Fabric
  - Style
  - Features (heating, airbags, etc.)

- A supplier may ship one or more different kinds of products to a vehicle
  - Seatings
  - Instrument panels
  - Door panels
- Shipments may be made to one or more receiving assembly lines

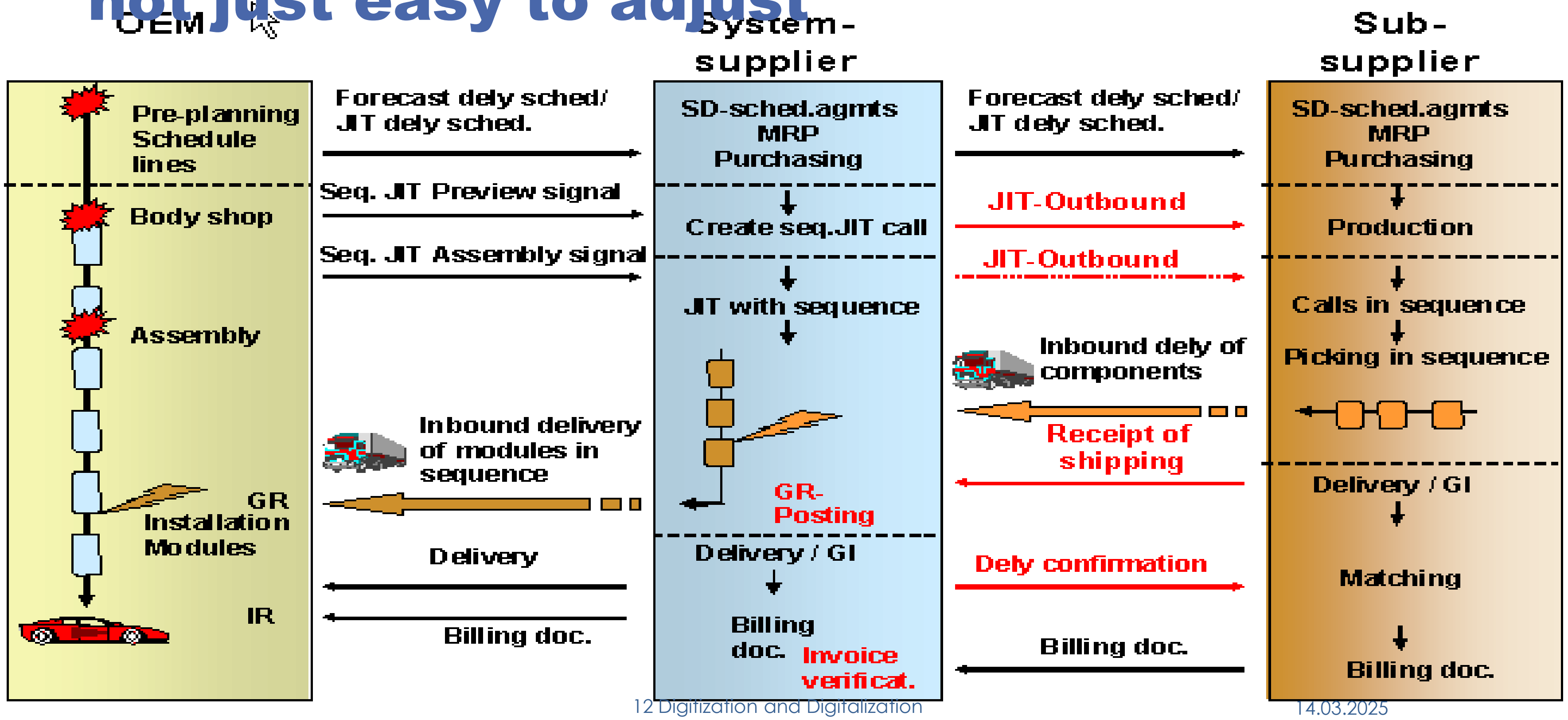
Phase 4: Process Integration at Interfaces between Companies



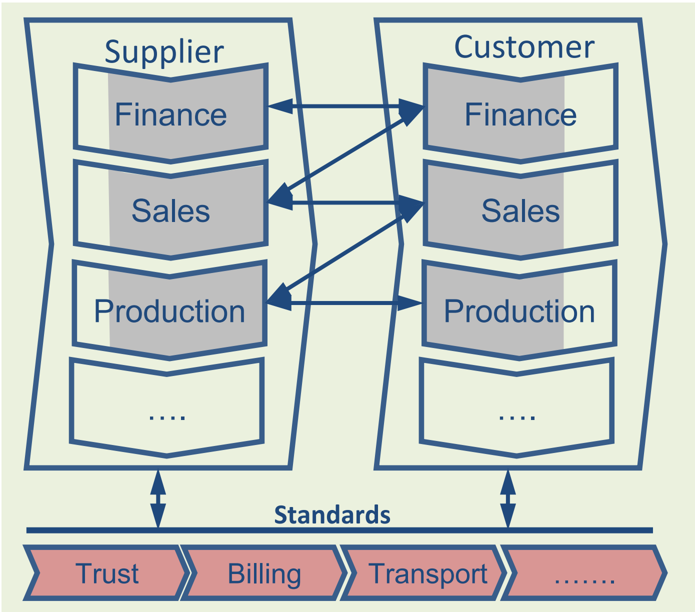
Source: Fleisch, E., Österle, H.; 2000; A Process-oriented Approach to Business Networking; Electronic Journal of organizational Virtualness 2(2), 1-21

- Goal: Automated information processes at the interface between supplier and customer
- Benefits: Higher efficiency and quality at the interface
- Results: EDI connections; 1:1 and 1:n relationships
- BUT: No wide spread use of EDI due to costly and complex implementation processes

Planning and Managing of integrated flows across boundaries - Certainly not trivial and not just easy to adjust



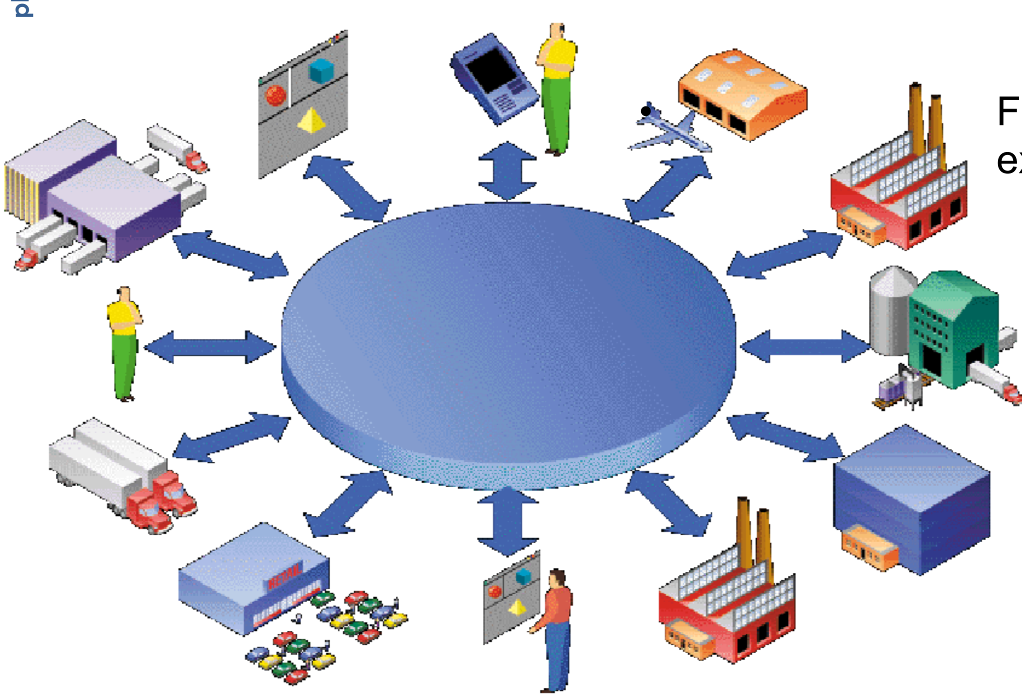
Phase 5: m:n Coordination of Companies



Source: Fleisch, E., Österle, H.; 2000; A Process-oriented Approach to Business Networking; Electronic Journal of organizational Virtualness 2(2), 1-21

- Goal: Cost reduction for networking between firms
- Benefits: Optimized information processes within the borderless enterprise
- Results: Web service based information infrastructure, m:n networking of business units
- BUT: Missing link between material and information flow

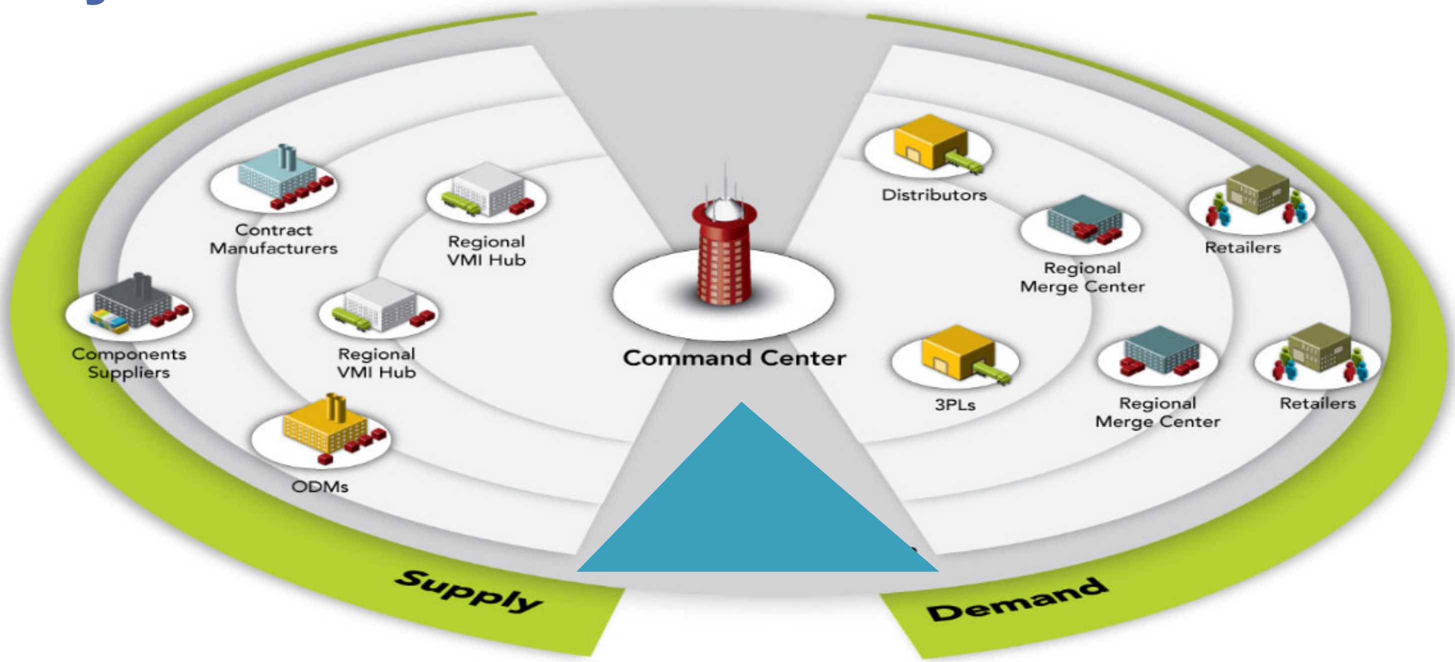
More top-down: Collaborative approaches in the extended companies context –



From the limited world of the single company to the exchange of planning data „up“

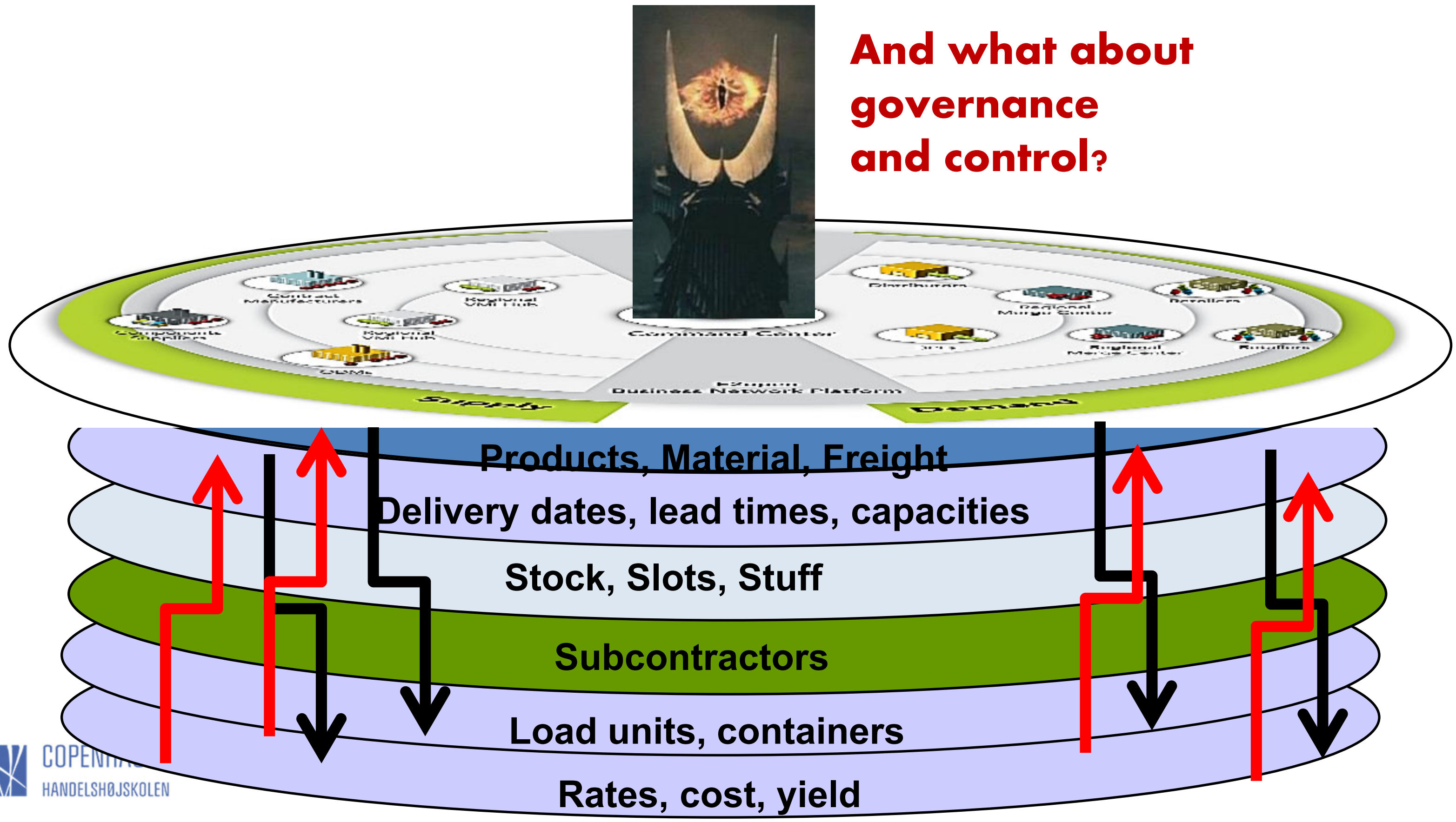
- One common forecast instead a sequence of Forecasts
- Communicated along the chain
- Improved by the experience of all the players in the chain
- Taking restrictions of – in ideal – all players into account
- On an aggregated level, usually „Views“ of the single actor on its part of the forecast

Potential approaches for solutions across Boundaries - Supply Chain Towers for more visibility?



What about the basement of the tower?

And what about governance and control?



Global Supply Chain Management

More Bottom-Up – From "conducted Orchestra" more towards the "Jazz-Combo"

- Jamming: work within a structure and live by its own dynamics
  - Agree on the general theme and focus
  - Agree on certain rhythm
  - Roughly agree on who plays when

Thus providing a stabilizing framework

- Interaction with self-control and interpretation
- Unscripted instead of Pre-planned
- "Real time" with current restrictions
- More alignment than transfer and processing of Plans
- "**Muddling through**": the best plan is always the current one

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e.g. Control by visualization and Transparency

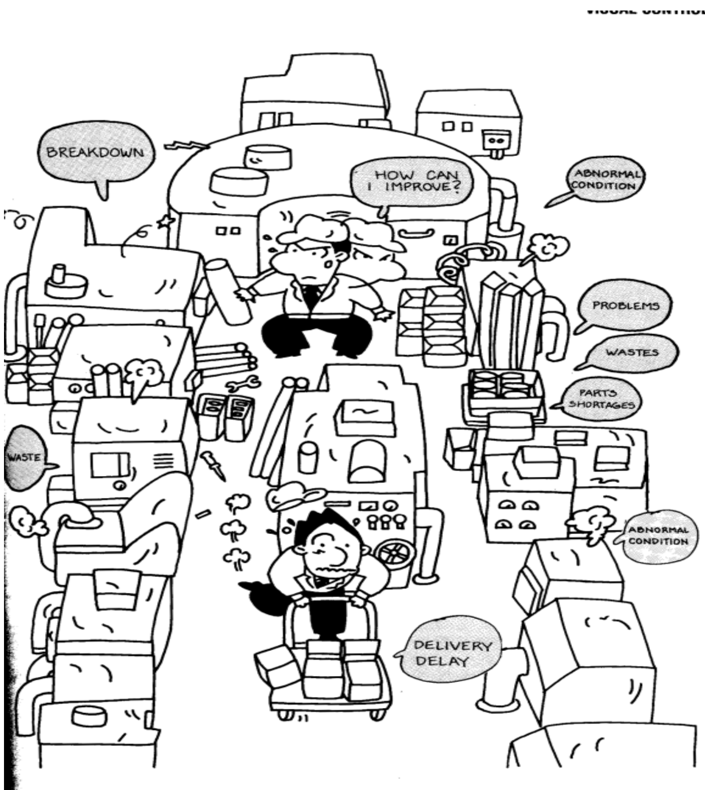


Figure 14. The Easy-to-Observe Workplace

Potential approaches for solutions
The jazz metaphor: „Muddling through“

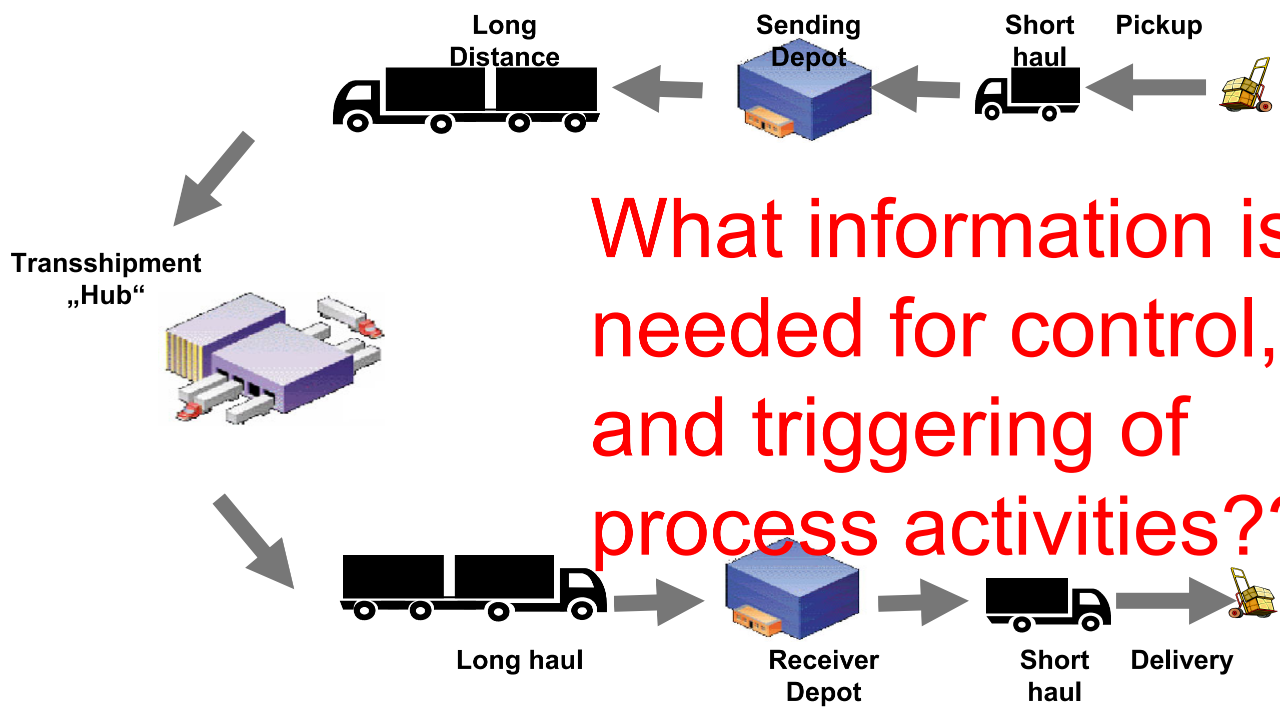
That might become a cacophony without sound structures and underlying processes

In the company extending context- Supply Chain Event Management –

„Align
instead of
central control“

- **Monitoring**
  - Getting real-time status data across companies along the supply chain (eg, status of stocks, orders, shipments, production)
  - Comparing it with projected standard processes (business rules) => Events (deviations, planned, unplanned events)
- **Notification** component (Notification) is escalating events, ideally, in each case those responsible
- Solution component (simulation) supports search for problem-solving alternatives
- Control component (control), effects of the desired action on the remaining supply chain process
- Identification, documentation, key performance indicators (KPIs) of the extended supply chain (Measurement)

Eg. Chain of Events in Transportation

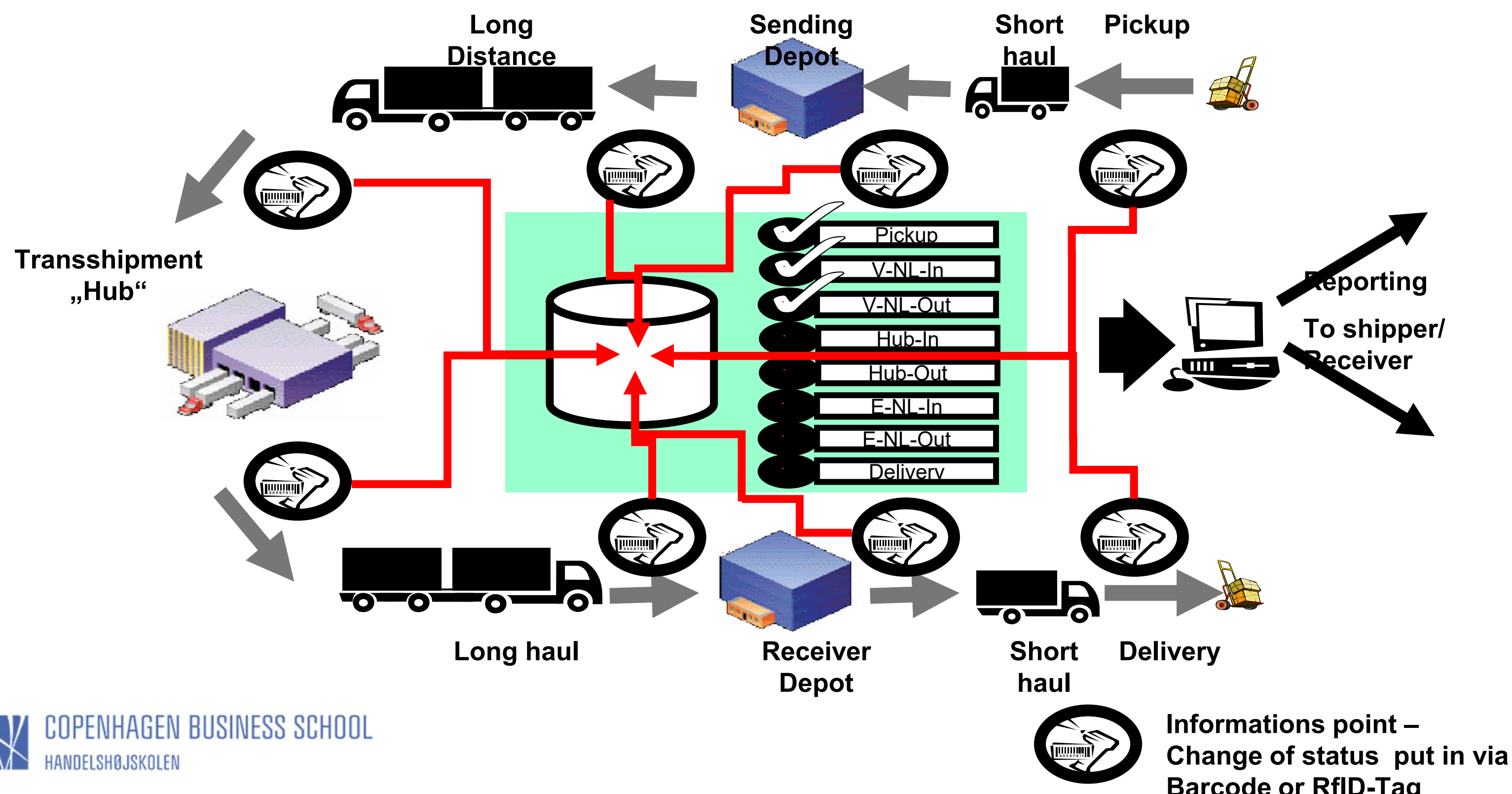


What information is needed for control, and triggering of process activities??

How to handle the necessary information technically?

How is the information coded?	Hand or machine written			
How is information read at I-Point?	By human eyes			
Where is the status information stored?	Maybe on label; More likely in central database			
Where/how is the required control activity triggered?				
Basic advantages	No additional costs			
Basic disadvantages /dangers	Reading errors, typos, lack of motiviations			

Eg. Chain of Events – Tracking in Transportation



Levels for Tracking – Interesting for whom

1 **Vessel level**
e.g. via AIS
VIN

2 **Container level**
(GPS, GSM, GPRS, SAT; meshed networks)
Container number

3 **Shipment level**
(Tracking single containers)
(GPS, GSM, GPRS, SAT; meshed networks)

Tracking what, for whom, for what purpose?

<table>
<tr><th colspan="6">Hierarchy and means in building logistical units</th><th colspan="2">Tracking and Tracing</th></tr>
<tr><th colspan="4">Unit – Stage</th><th>Means</th><th>e.g</th><th>Tracked unit e.g.</th><th>Identification standard e.g.</th></tr>
<tr><td rowspan="6">Transporation unit (TU)</td><td colspan="3" rowspan="2"></td><td>Means of transport (active TU)</td><td>Trucks, Ships, Planes, Trains</td><td>Truck in international tramp traffic</td><td>Vehicle Identification Number (VIN)</td></tr>
<tr><td>Supporting means of transport (passive TU)</td><td>Container, Waggon, Swap trailer, Trailer</td><td>Container</td><td>Alphanumerical ISO-Container-Number</td></tr>
<tr><td rowspan="4">Load Unit</td><td colspan="2"></td><td>Loading device</td><td>Behälter, Paletten, Unit Load Device</td><td>Reusable transport boxes</td><td>Global Returnable Asset Identifier, (GRAI)</td></tr>
<tr><td rowspan="3">Shipping Unit</td><td>Packing unit (bundle)</td><td rowspan="2">Packages</td><td>Parcel, Box, Palet, Display</td><td rowspan="3">Shipment e.g. Parcels</td><td rowspan="3">Serial Shipping Container Code (SSCC)</td></tr>
<tr><td>Sales unit (Article)</td><td>Package, Sack, Barrel, Bottle, Can, Tray,</td></tr>
<tr><td>Quantity unit (Ware)</td><td>Transport object</td><td>Bulk material, Solids, Gases, Liquids</td></tr>
</table>

Digitization vs. Digitalization

Digitization

Converting analogue into digital data for further processing by electronic means.

- Cargo control systems
- Paperless trade environments
- eCustoms systems
- ePayment systems
- eB/L, eAWB, eCMR, …

The underlying condition for digitalization

Digitalization

Applications of digital technologies by organizations, industries or societies like

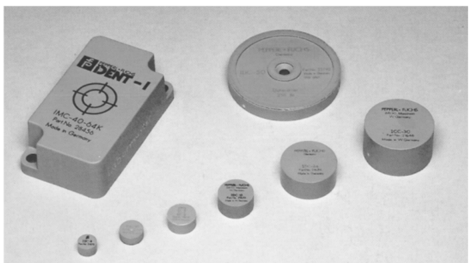
- Big Data
- Internet of Things
- Blockchains
- Uberization
- Digital transformation

Automation of operations or administrative processes, connecting different service, development of new business models - Up to the disruptive transformation of supply chains

Difference between Barcode & Smart Object Technologies - RfID

- ID-number is written into an electronic tag
- Reader uses magnetic field or electromagnetic waves in order to read the stored information
- Complex communication protocols are used for communication between reader and tags
- In principle (depending on type of tag):
  - No direct visibility is needed (but problems e.g. with metal barriers)
  - No alignment of reader and tag is needed
  - Several 100 tags can be read at the same time
  - Problems with fluids and metal objects inside the packaging

There exist a number of different RfID Tags – e.g. Electronic Tags for Automation Purposes



- Used since the 80s for production and material flow applications within industrial facilities
- Short reading and writing ranges (<< 1m)
- Relatively high costs per tag (between a few and 100 Euros depending on application area)
- Functions:
  - Identification of objects in order to control material flows inside the production line
  - Storage of some larger amounts of data (up to 32 kByte and more) as compared to tags
  - No bulk reading due to short reading and writing ranges

e.g. Smart Labels for Applications in Retail and Logistics

- Smart labels for open loop applications are on the market since the late 90s
- Reading ranges today up to 12 meters (depending a lot on transmission frequencies)
- Costs per tag less than a few €Cents
- Functions:
  - Identification of products, packaging and transportation means like skeleton boxes, pallets
  - Storage of additional data (ID plus 512 bit)
  - Bulk reading up to 500 tags in a few seconds
  - Locating possible with special infrastructure

How is the information coded?	Hand or machine written	Machine readable label with object id	One or two dimensional barcode label of object ID		
How is information read at I-Point?	By human eyes	Optical reading devices; charac-ter recognition (OCR)	Optical by mobile or stationary barcode scanner		
Where is the status information stored?	Maybe on label; More likely in central database	Data record on central server	Data record on central server		
Where/how is the required control activity triggered?		Centralized matching of „as is“ and „to be“; triggering	Centralized matching of „as is“ and „to be“; triggering		
Basic advantages	No additional costs	No or limited costs for the labels	Low costs for labels; automatization		
Basic disadvantages /dangers	Reading errors, typos, lack of motiviations	Reading errors more likely, dirty, hidden labels	Sinlge reading of barcode; dirty, hidden labels		

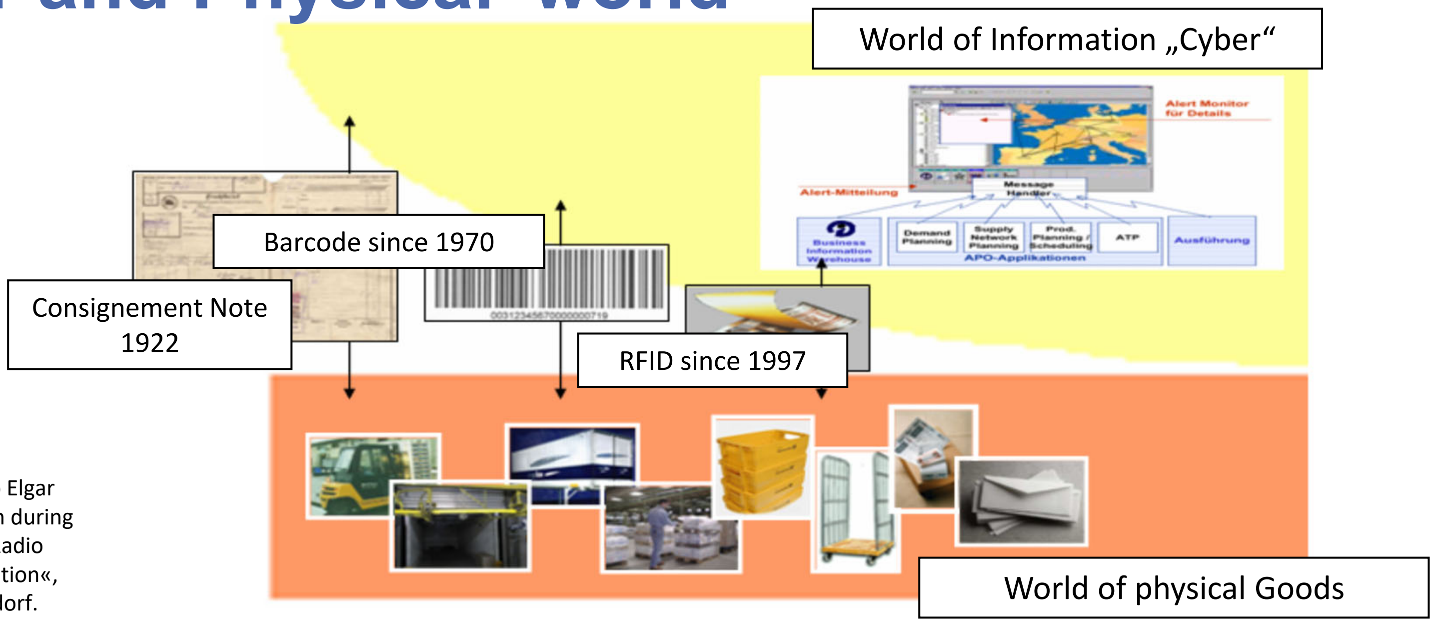
Semi-active electronic Tags with Sensing Functions

© SURU

- First products on the market quite a few years (classical form of a smart card)
- Used for monitoring temperature in logistical processes (pharmaceutical products, flowers, food)
- Very short reading ranges (some 10 centimeters) and larger data storage areas (8 kBit and more)
- Costs per tag a few Euros (estimated)
- Functions:
  - Identification
  - Data storage
  - Sensing of different environmental parameters

How is the information coded?	Hand or machine written	Machine readable label with object id	One or two dimensional barcode label of object ID	Passive Transponder, RfID Tag, electronic label	Active Transponder, Sensor tags
How is information read at I-Point?	By human eyes	Optical reading devices; charac-ter recognition (OCR)	Optical by mobile or stationary barcode scanner	Via radio waves in reading area of antennas (poles, gates)	Reading and/or writing via radio waves, antennas …
Where is the status information stored?	Maybe on label; More likely in central database	Data record on central server	Data record on central server	Data record on central server	Status updated directly at physical Object (resp. Tag)
Where/how is the required control activity triggered?		Centralized matching of „as is" and „to be"; triggering	Centralized matching of „as is" and „to be"; triggering	Centralized matching of „as is" and „to be"; triggering	De-centralized and permanent possible; auto-nomous alarms thinkable
Basic advantages	No additional costs	No or limited costs for the labels	Low costs for labels; automatization	Higher automation (no visual contact required; bulk-Reading (Multi-tagging)	Information available at the object; Additional options by sensor technology
Basic disadvantages /dangers	Reading errors, typos, lack of motiviations	Reading errors more likely, dirty, hidden labels	Single reading of barcode; dirty, hidden labels	Label costs; maybe jamming by radiation, metal, interference	Reading of status information requires reading devices; power supply and higher cost for the tags

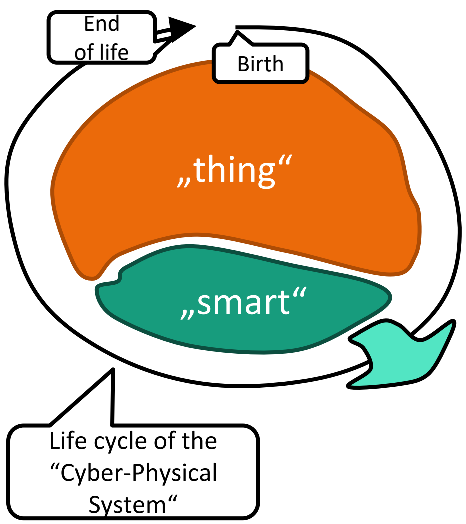
Harmonization or even integration of Information and Material Flow or iow “Cyber and Physical”world



Source: according to Elgar Fleisch, presentation during Conference »RFID. Radio Frequency Identification«, May 2004 in Düsseldorf.

Internet of Things – just one example for a digital technology

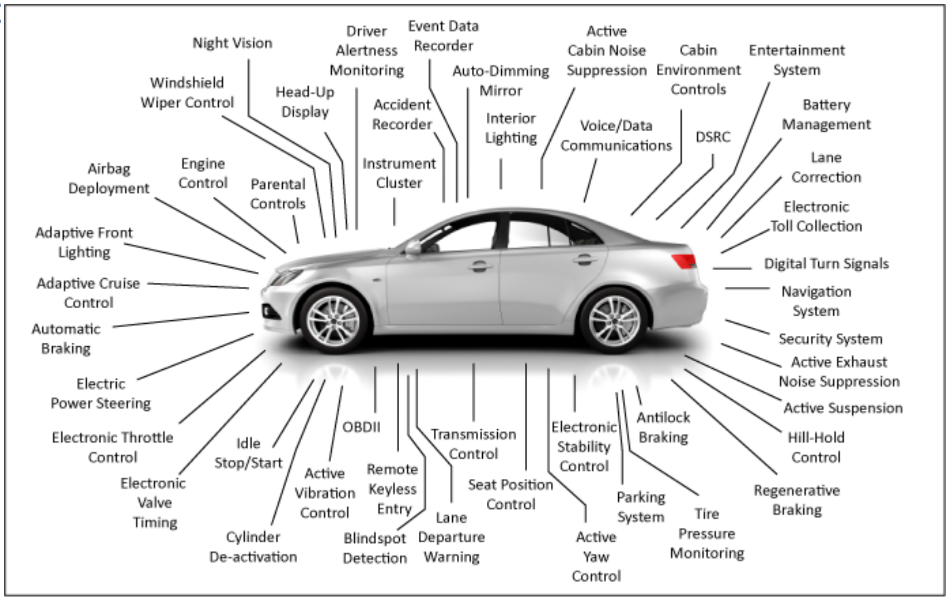
Cyber-Physical Systems are based on complex embedded microelectronics and deliver different functions – Towards a Definition of the term "Cyber-Physical System" (CPS)

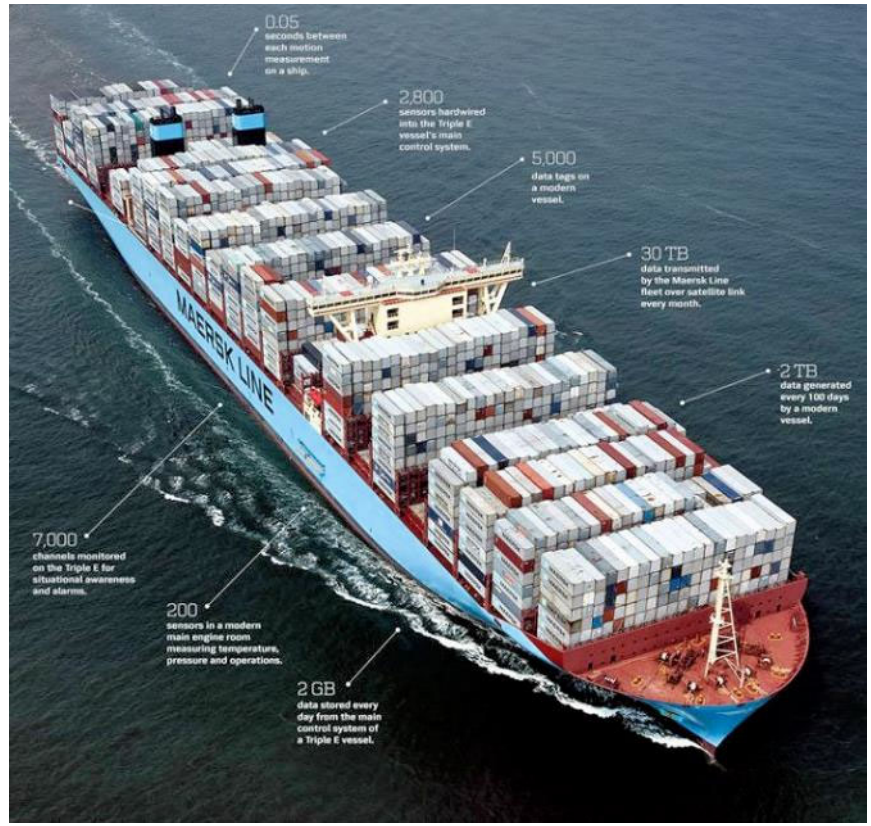


- **Definition:** "Cyber-Physical Systems" are (among themselves) interconnected and networked embedded systems. They monitor, govern and control the physical world via sensors and integrate the obtained data into the virtual (informational) world."
- **Functions:**
- Identification
- Sensing environmental parameters
- Localization
- Data processing and control
- Communication and networking

Prockl and Pflaum 2012

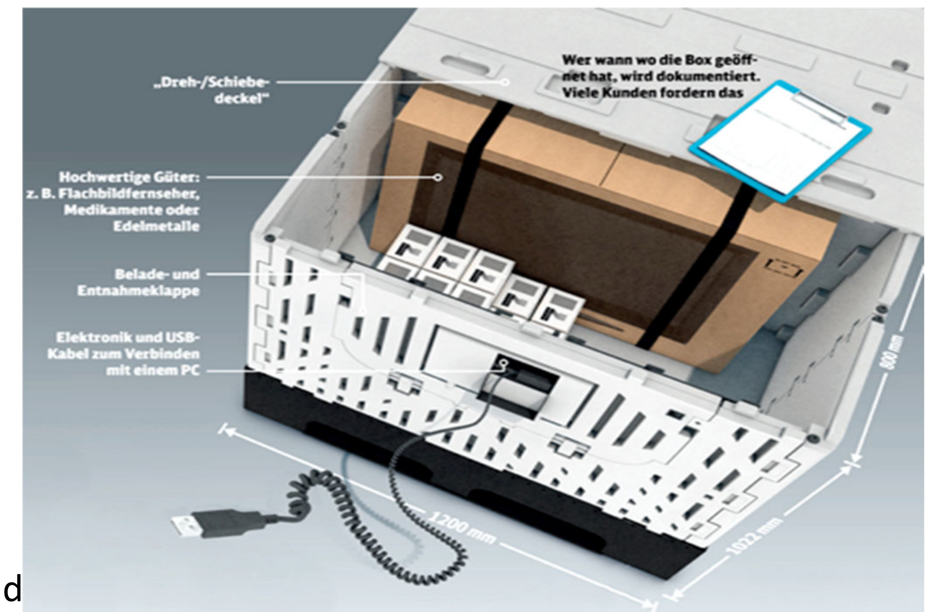
„Embedded systems“ – e.g. in vehicles





DB Schenker transforms standard transportation units into CPS and delivers new types of customer services - Examples for CPS in the real world

- Embedded microelectronics for returnable transportation items
- Functions of the „Secure Box“:
  - Identification and localization of the box
  - Monitoring of the interior space based on sensors
  - Monitoring & remote control of the closing mechanism
  - Route monitoring
- New services concerning theft prevention and documentation of transportation quality



Source: DB Schenker

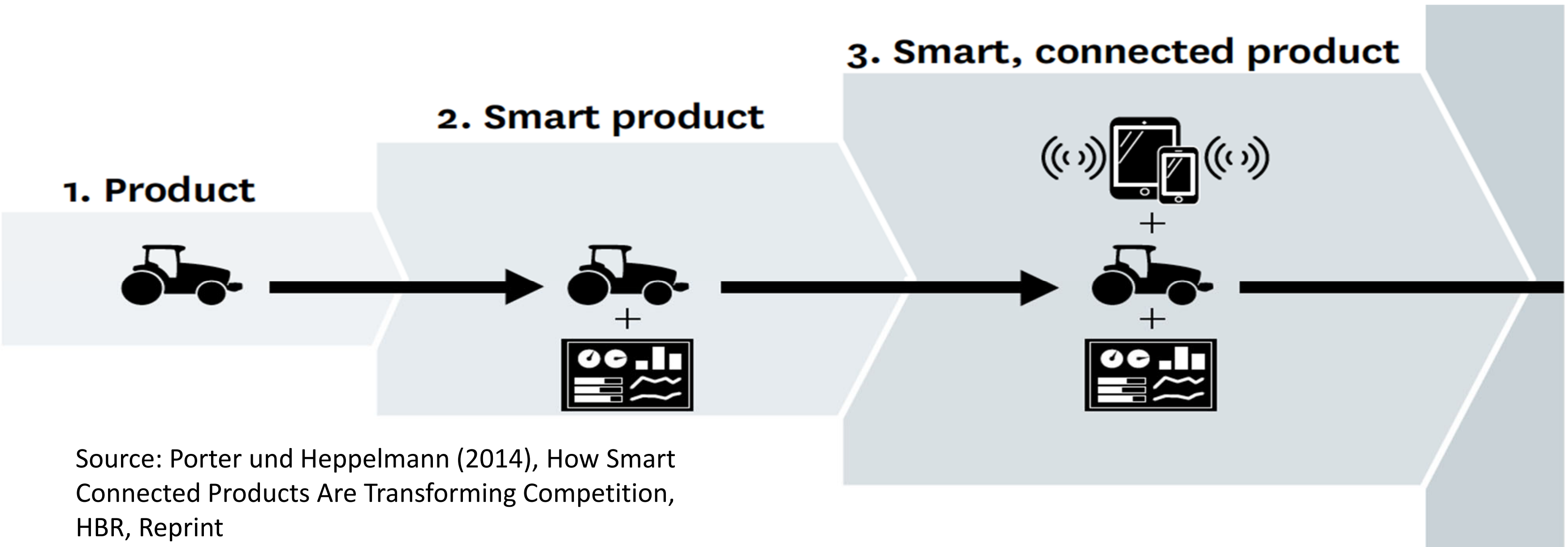
Würth uses smart containers in order to optimize C-Parts management processes in industry

Examples for CPS in the real world

- Embedded microelectronics for monitoring of filling level of containers
- Functions of the „iBin“:
  - Imaging the interior using a miniaturized camera
  - Calculation of filling level based on image processing algorithms
  - Generation of a business event in case of a level below the limit
  - Wireless networking and communication with the environment
- Fully automated and highly efficient c-parts management as a service

Source: Würth

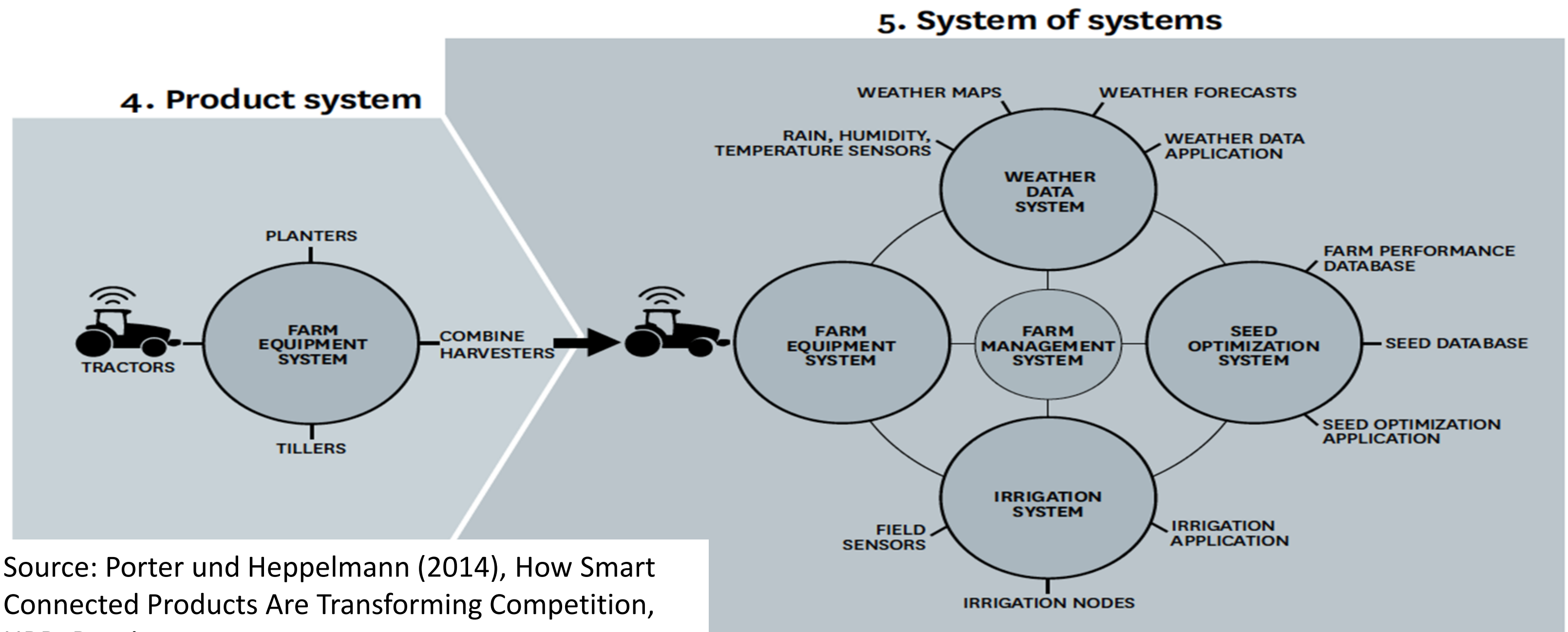
During the transformation process the „tractor“ becomes a smart and networked product ...
.... and an example from the farming industry



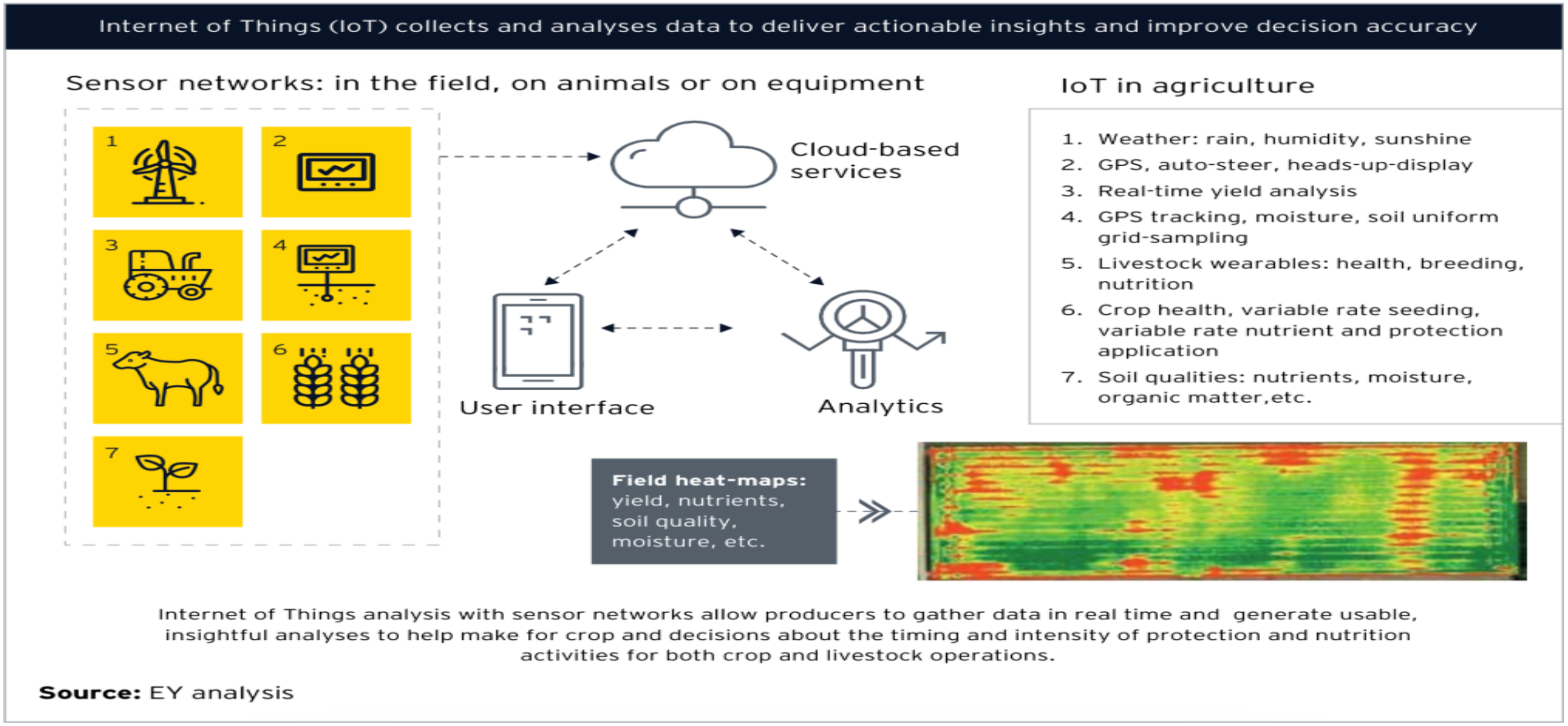
Source: Porter und Heppelmann (2014), How Smart Connected Products Are Transforming Competition, HBR, Reprint

... and changes into a „ product system“ or rather a „system of systems“ in another evolutionary step

.... and an example from the farming industry

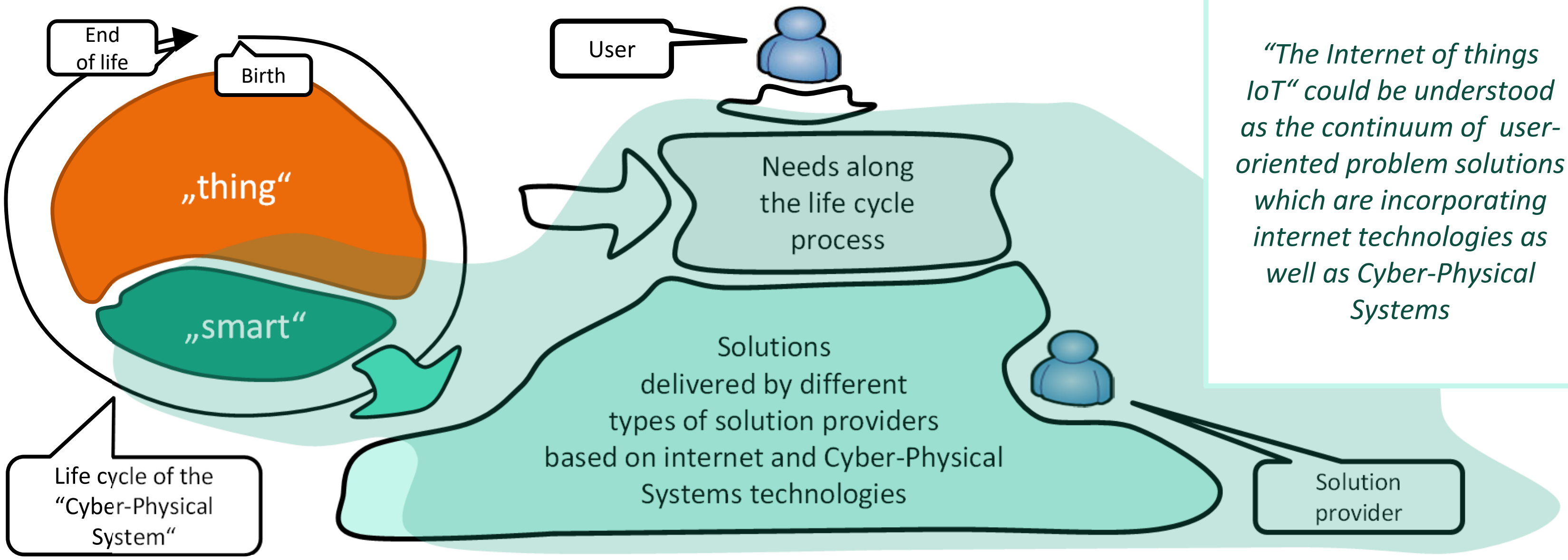


Source: Porter und Heppelmann (2014), How Smart Connected Products Are Transforming Competition, HBR, Reprint


Internet of Things (IoT) collects and analyses data to deliver actionable insights and improve decision accuracy
Sensor networks: in the field, on animals or on equipment
1
2
3
4
5
6
7
Cloud-based services
User interface
Analytics
IoT in agriculture
1. Weather: rain, humidity, sunshine
2. GPS, auto-steer, heads-up-display
3. Real-time yield analysis
4. GPS tracking, moisture, soil uniform grid-sampling
5. Livestock wearables: health, breeding, nutrition
6. Crop health, variable rate seeding, variable rate nutrient and protection application
7. Soil qualities: nutrients, moisture, organic matter,etc.
Field heat-maps: yield, nutrients, soil quality, moisture, etc.
Internet of Things analysis with sensor networks allow producers to gather data in real time and generate usable, insightful analyses to help make for crop and decisions about the timing and intensity of protection and nutrition activities for both crop and livestock operations.
Source: EY analysis

CPS are always embedded in something larger like the Internet of Things

CPS in the context of the Internet of Things (IoT)

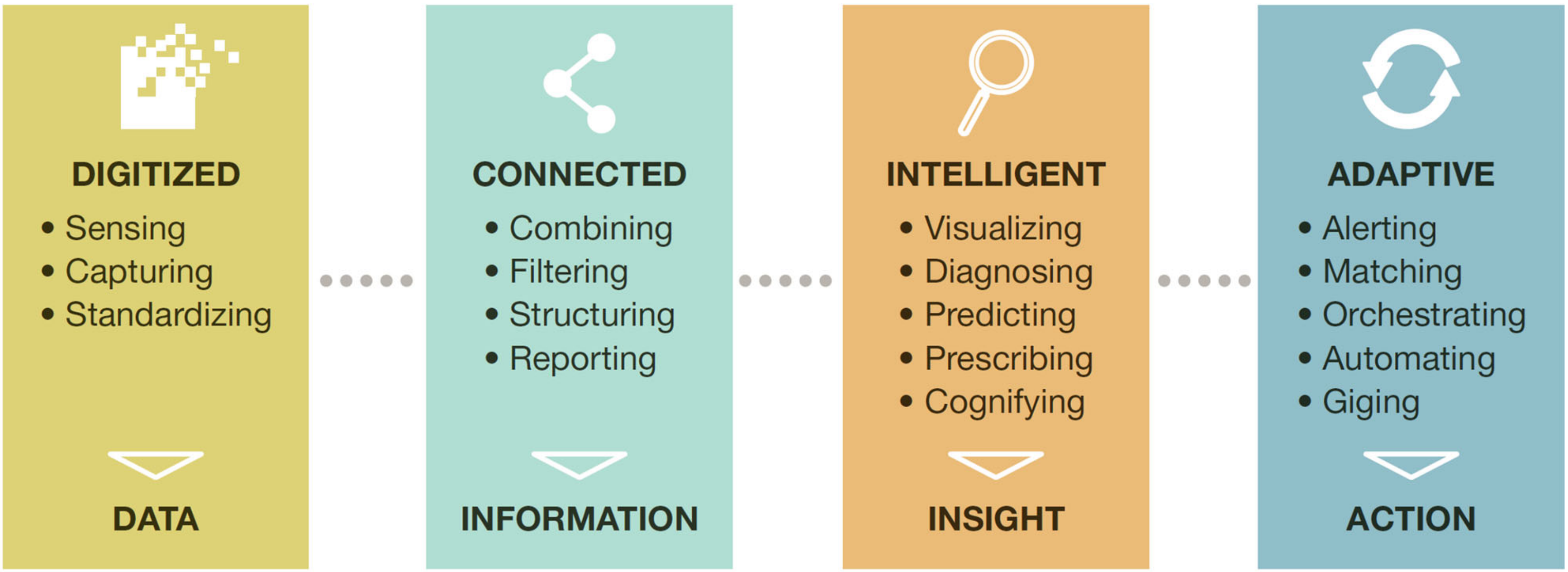


“The Internet of things IoT“ could be understood as the continuum of user-oriented problem solutions which are incorporating internet technologies as well as Cyber-Physical Systems

Prockl and Pflaum 2012

FIGURE 1

Core attributes of digital supply chains



Source: Authors