

System architectures for intelligent goods

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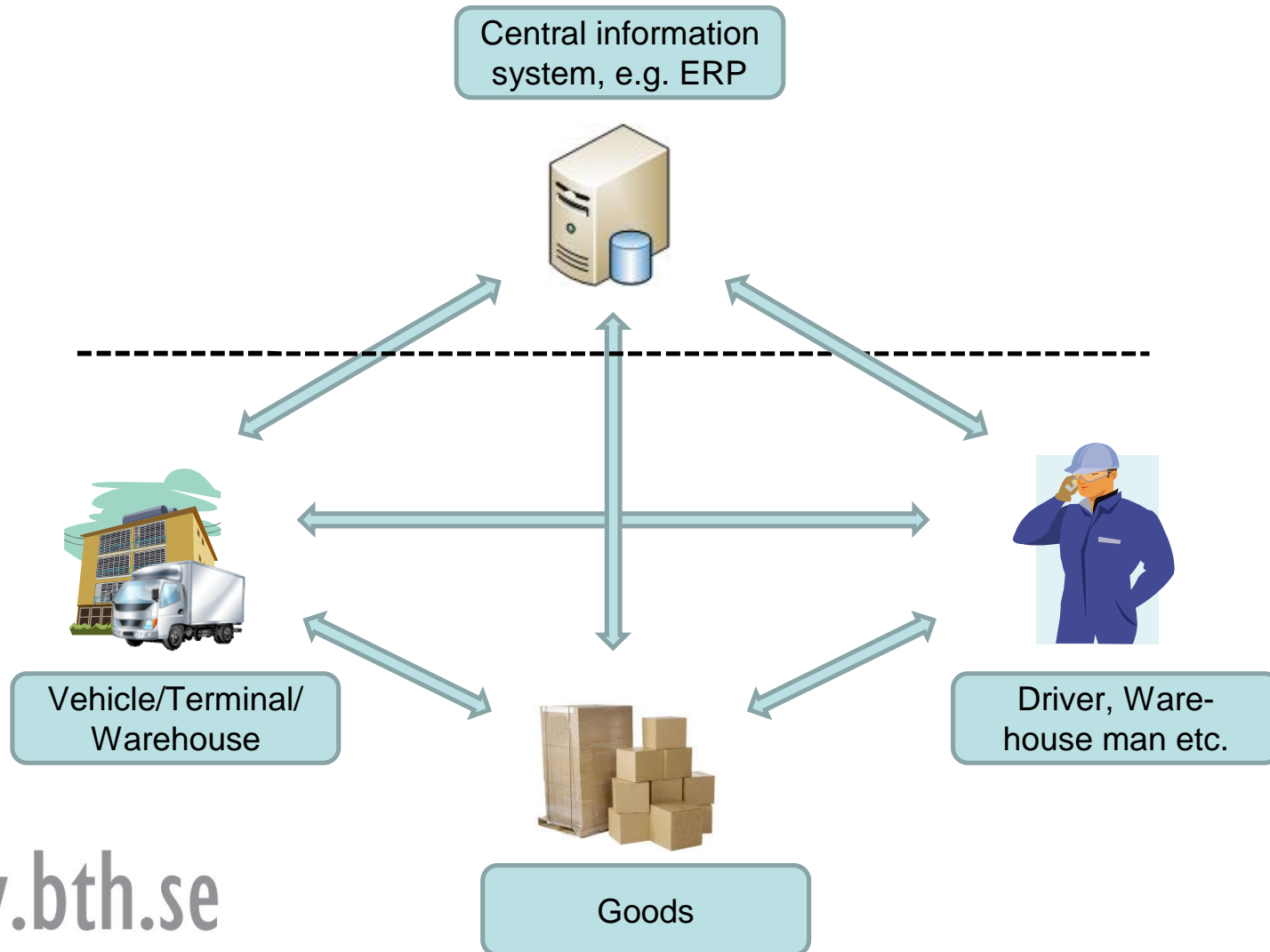
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Intelligent goods

- É Some degree of intelligence implemented close to the goods, which follows the goods throughout the whole transport, using e.g.
 - ó RFID (passive or active)
 - ó Microprocessors
 - ó Mobile communication
- É Original idea: make the goods, to a certain extent, resemble human travellers
- É Overall purpose: instrument for a more efficient transport system
 - ó More efficient solutions
 - ó New type of automated services

Local decisions and actions



Service examples

É Identification services

É Context detection services

É Monitoring services

É Other reactive or autonomous services

such as

ó Automatic updates of the priority of the goods

ó Automatic updates of route/transport operators

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Intelligent goods definitions

- É Different denotations for identical or similar concepts
- É Different definitions of the characteristics of intelligent goods
- É We have created a **framework** for describing intelligent goods systems:
 - ó Definition based on capability dimensions of goods (and housings)
 - ó Information entities related to goods and housings
 - ó Primitive functions
 - ó Description of the context in which the goods function

Capability dimensions - goods

A. Memory storage:

1. Ability to store ID
2. Ability to store goods data
3. Ability to store algorithms/decision rules

B. Memory dynamics:

1. Static memory
2. Ability to change/add/delete data
3. Ability to change/add/delete alg./decision rules

C. Communication out:

1. Data can be read by external units
2. Ability to send short-range messages
3. Ability to send long-range messages

D. Communication in:

1. None
2. Ability to receive short-range messages
3. Ability to receive long-range messages

E. Processing:

1. None
2. Ability to execute decision rules
3. Ability to execute algorithms

F. Autonomy:

1. None
2. Reactive capability (actions must be triggered by an external unit)
3. Proactive capability (no ext. trigger needed)

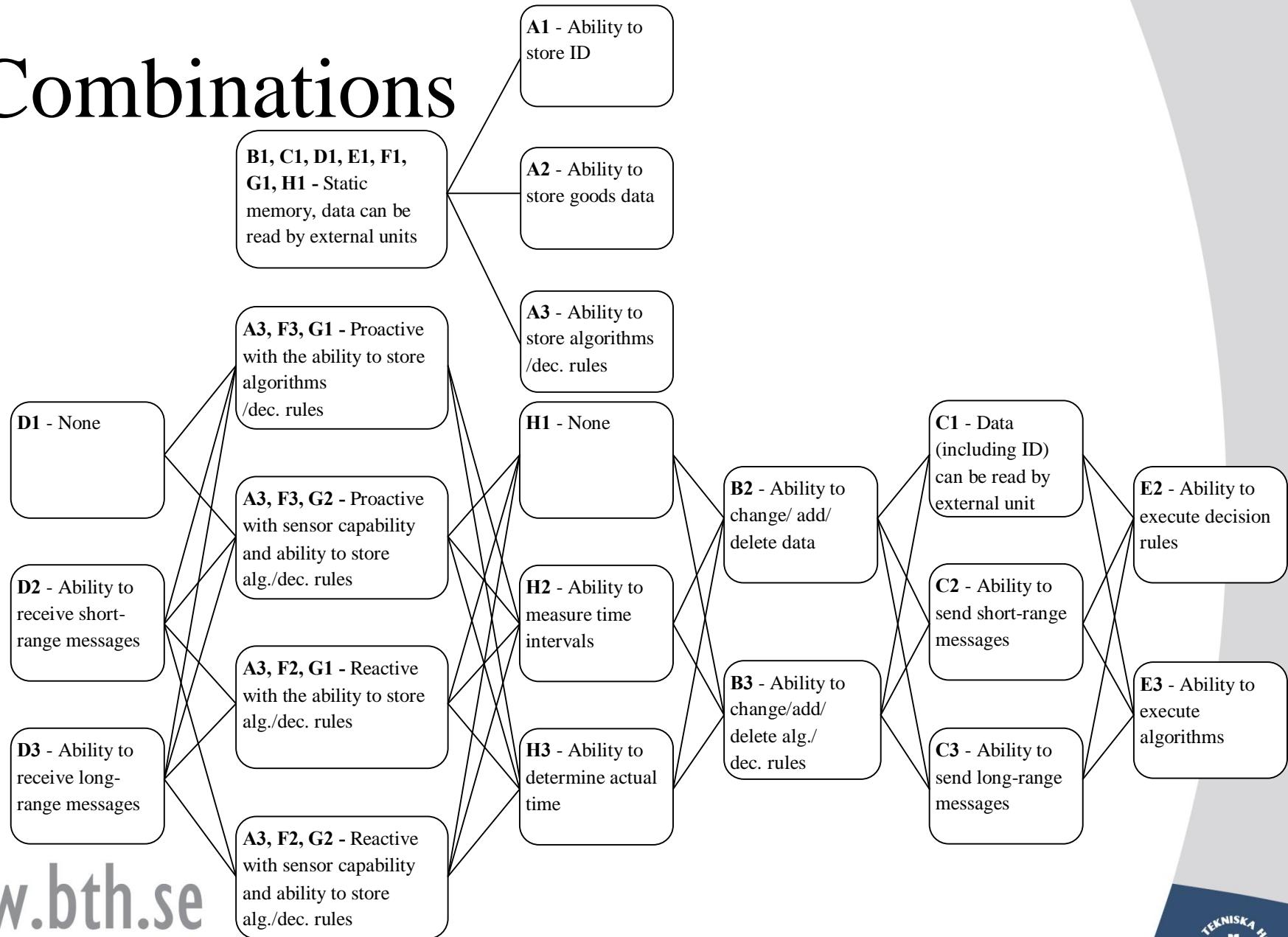
G. Sensor:

1. None
2. Sensor capability & ability to read sensor data

H. Time:

1. None
2. Ability to measure time intervals
3. Ability to determine actual time

Combinations



Capability dimensions - housings

A. Memory storage:

1. Ability to store ID
2. Ability to store data and algorithms/decision rules

B. Memory dynamics:

1. Static memory
2. Ability to change/add/delete data and algorithms/decision rules

C. Communication out:

1. None
2. Data can be read by external unit
3. Ability to send short-range messages
4. Ability to send long-range messages

D. Communication in:

1. None
2. Ability to receive short-range messages
3. Ability to receive long-range messages

E. Processing:

1. None
2. Ability to execute decision rules
3. Ability to execute algorithms

F. Autonomy:

1. None
2. Reactive capability (actions must be triggered by another entity)
3. Proactive capability (no ext. trigger needed)

G. Sensor:

1. None
2. Sensor capability & ability to read sensor data

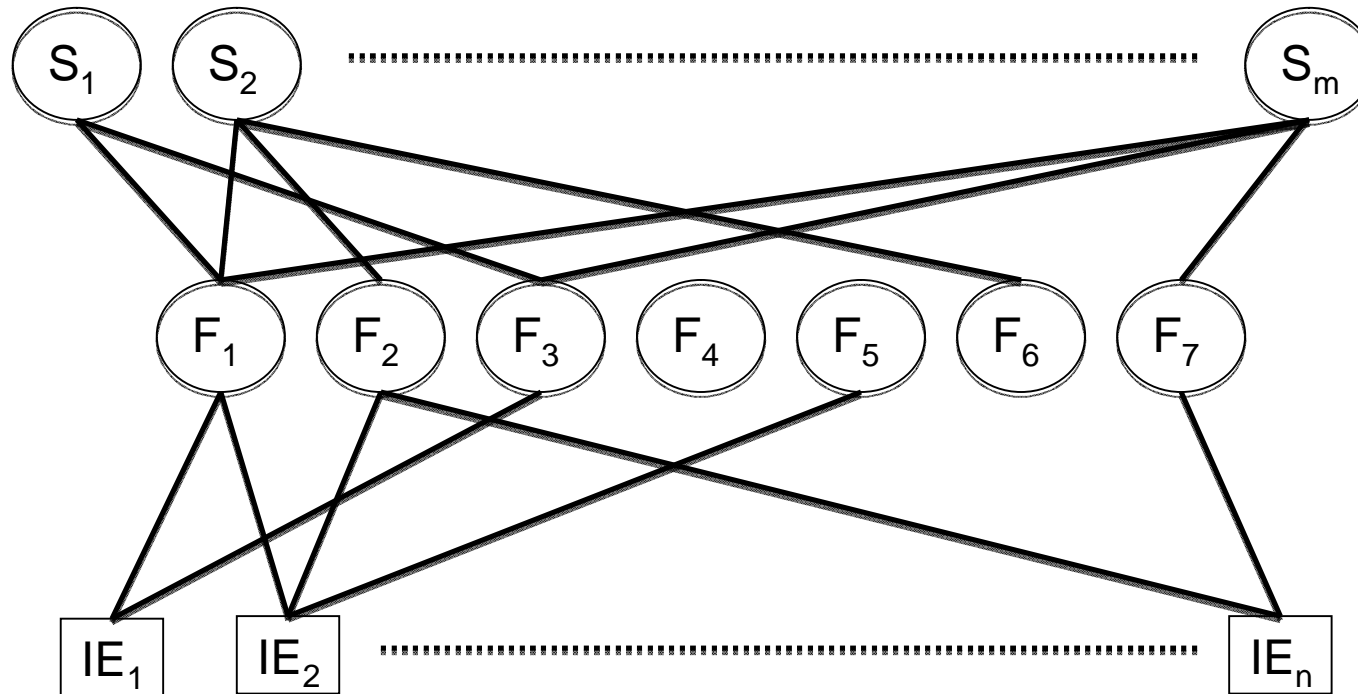
H. Time:

1. None
2. Ability to measure time intervals
3. Ability to determine actual time

Information entities

No	Goods information entities (GE)	
1	ID	Unique goods identity, e.g. SGTIN, SSCC
2	ContainerID	Unique identity of the current container of the goods (i.e. HE-ID), e.g. SGTIN, SSCC, GRAI, some vehicle id (e.g. VIN, IMO)
3	Sender	Original sender of the goods
4	Receiver	Final receiver of the goods
5	Content	Description of the content of the goods
6	Weight	Weight of the goods
7	Volume	Volume or measurements of the goods
8	Priority	Delivery priority of the goods
9	Classification	Classification of the goods, e.g. based on the classification system specified by EU (95/64/EG)
10	DangerousGoodsClass	Dangerous goods class, preferably based on the classification system of dangerous goods specified by UN
11	ForbiddenClosebyClasses	List of classifications of goods that may not be co-located with this type of goods, i.e. a set of <Classification>
12	GeofencingAreas	List of areas that can be used to trigger a geofencing action for this goods, i.e. a set of <seq. no, sequence of (at least three)< coordinates>>
	Etc.	
Housing information entities (HE)		
23	ID	Unique container identity, e.g. SGTIN, SSCC, GRAI, some vehicle id (e.g. VIN, IMO)
24	ContainerID	Unique identity of the current container of the container (i.e. HE-ID of next level), e.g. SGTIN, SSCC, GRAI, some vehicle id (e.g. VIN, IMO)
25	HousingID	Unique, at least within the organisation of the accountable actor, identity of the current terminal/warehouse or vehicle, e.g. VIN, IMO
26	AccountableID	Unique identity of the actor (for instance a transport company) currently responsible for the container, e.g. GLN
27	Content	Content of the container, a set of < GE-ID>
	Etc.	

Primitive functions and services



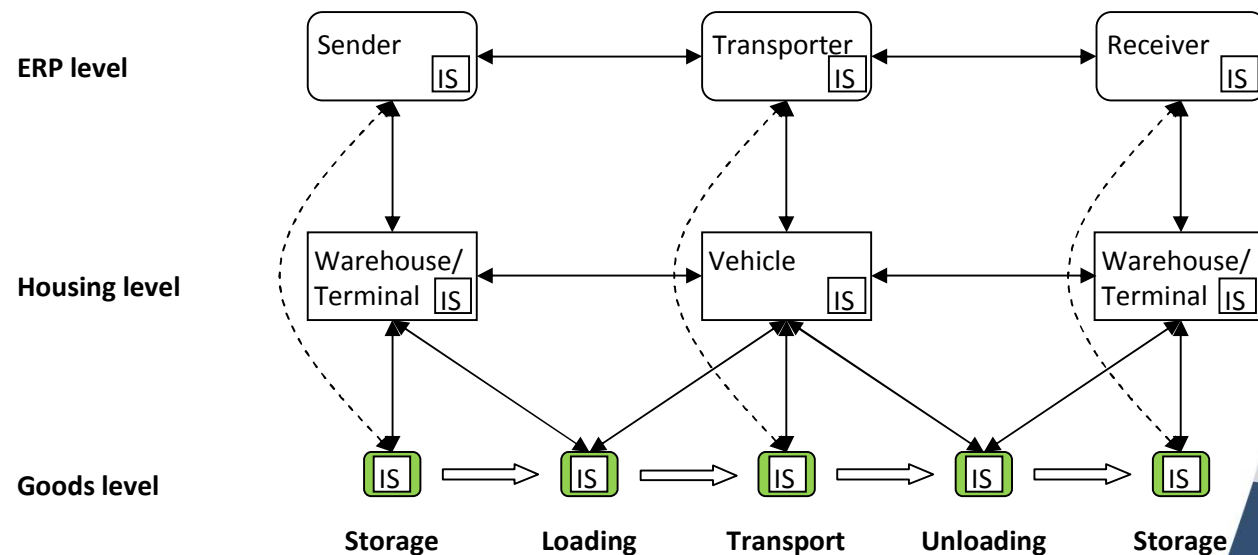
If using agents, the functions and services can be implemented as separated agents which interact with each other

Primitive functions

No	Function	Description
1	Read IE	Reads and returns the value of an IE
2	Write IE	Updates the value of an IE
3	Monitor IE	Monitors an IE and returns the new value whenever the value changes according some specified event, e.g. when it is simply modified or when it passes some upper/lower limits
4	Read sensor data	Reads and returns sensor data, e.g. temperature, humidity, position or fuel consumption
5	Monitor sensor data	Monitors a sensor and returns the sensor data whenever the data changes according some specified event, e.g. when it equals some value or passes some upper/lower limits
6	Read other data	Reads and returns other data than sensor data or internal IE values, e.g. external data stored in close-by RFID tags
7	Send message	Sends a message, which is either broadcasted or sent to some specified set of receivers, using for instance short range communication or a PLMN

Critical design factors

- É Where to place the capabilities (goods, vehicle or ERP level) and which capability levels to choose
- É Which information to store and where
- É Which communication paths are needed



Local processing and information storage

É Advantages

- ó Avoid or reduce long-range communication of data (which might be expensive and limited)
- ó Reduce time delays (caused by communication with back-office)
- ó Support integrity (sensitive data are kept hidden from, for instance, competitors)
- ó Enable new types of services

É Disadvantages

- ó Costs (many units with processing and information storage capabilities)
- ó Some services will always demand central processing and information storage anyway

Factors influencing the decision of location

- É **Processing frequency:** how often the service needs to process information
- É **Processing moment:** when the service executes; when there is a communication link to the central management or when there is not (e.g. at stops or any time)
- É **Input data origin:** the origin of any input request and corresponding input request data (e.g. from the local or central level)
- É **Output data destination:** the destination of the output data (if any) (e.g. to the local or central level)

Factors influencing the decision of location cont.

- É **IE update frequency:** how often the values of required IEs are changed
- É **IE update moment:** when the values of required IEs are changed; when there is a communication link to the central management or when there is not
- É **IE update origin:** the origin of the updates of required IEs (e.g. local or central level)

Quality attributes

1. Time to response
2. Reliability of response
3. Quality of response
4. Integrity
5. Short-range wireless communication
6. Long-range wireless communication
7. Goods processing power
8. Vehicle processing power

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Future research

É Try our architectures and quality analysis in simulations and/or using calculations

É Local intelligent goods based method for calculation of environmental load of transported goods

- ó New/complementing calculation methods taking empty/return transports and co-loading into account

- ó Few methods exist today with focus on goods level, more established on vehicle level

- ó Interesting for both consumers and authorities

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