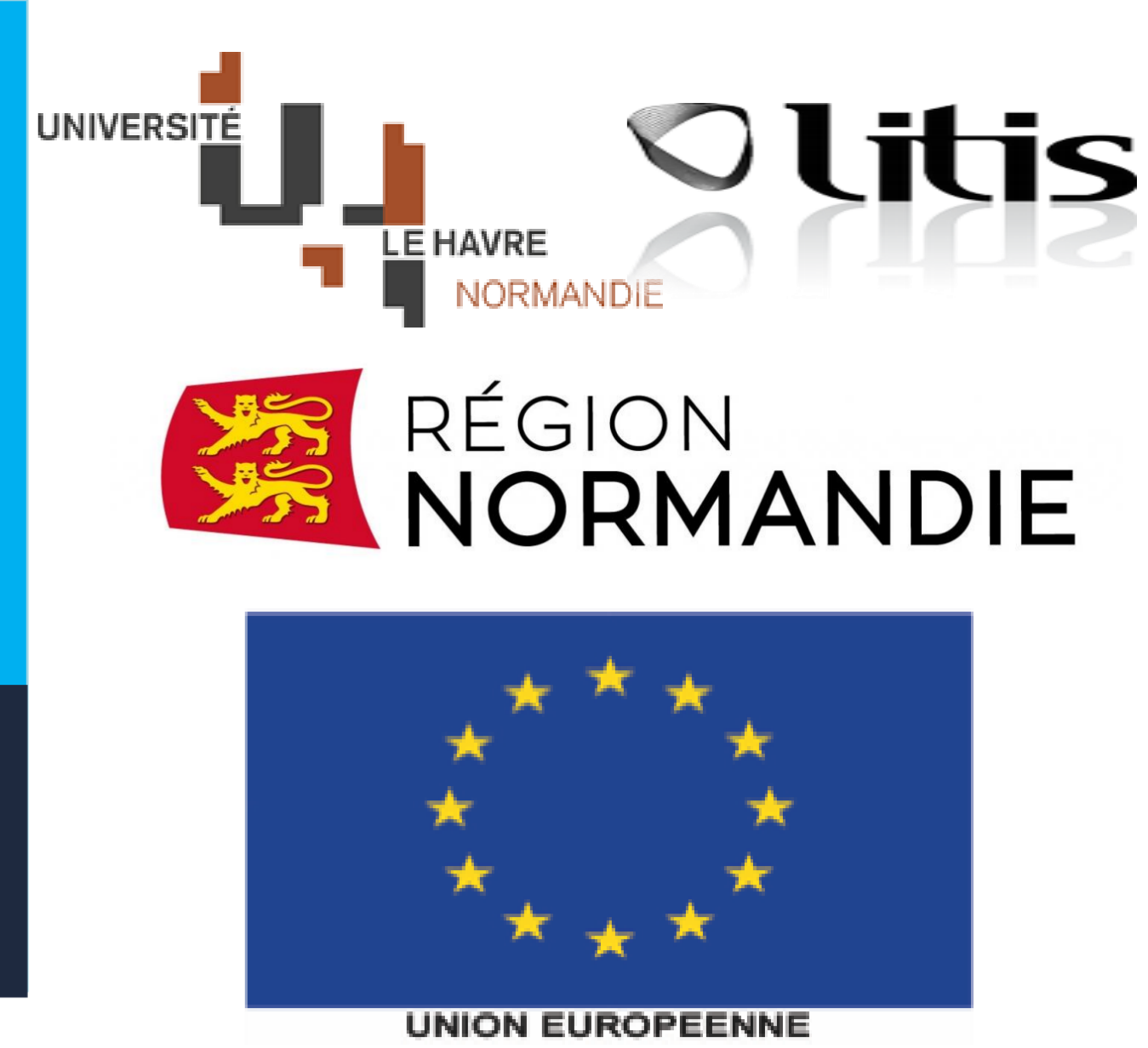


# Toward a formal language of interactions between the Physical Internet Layers



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## A Language for a Physical Internet

In a layered reference model for a Physical Internet (such as the OLI model in Montreuil (2009), or our NOLI model in Colin et al. (2016)), layers communicate between each other thanks to standardized interfaces. A layer N of a node “X” can exchange information with layers N-1 and N+1 of the same node (exchange of information inside the same node). It can potentially exchange information with the N layers located on other nodes too. This work is part of an attempt to define a formal communication language between the layers of a Physical Internet. Here we identify functionalities and patterns.

## Functionalities and Patterns

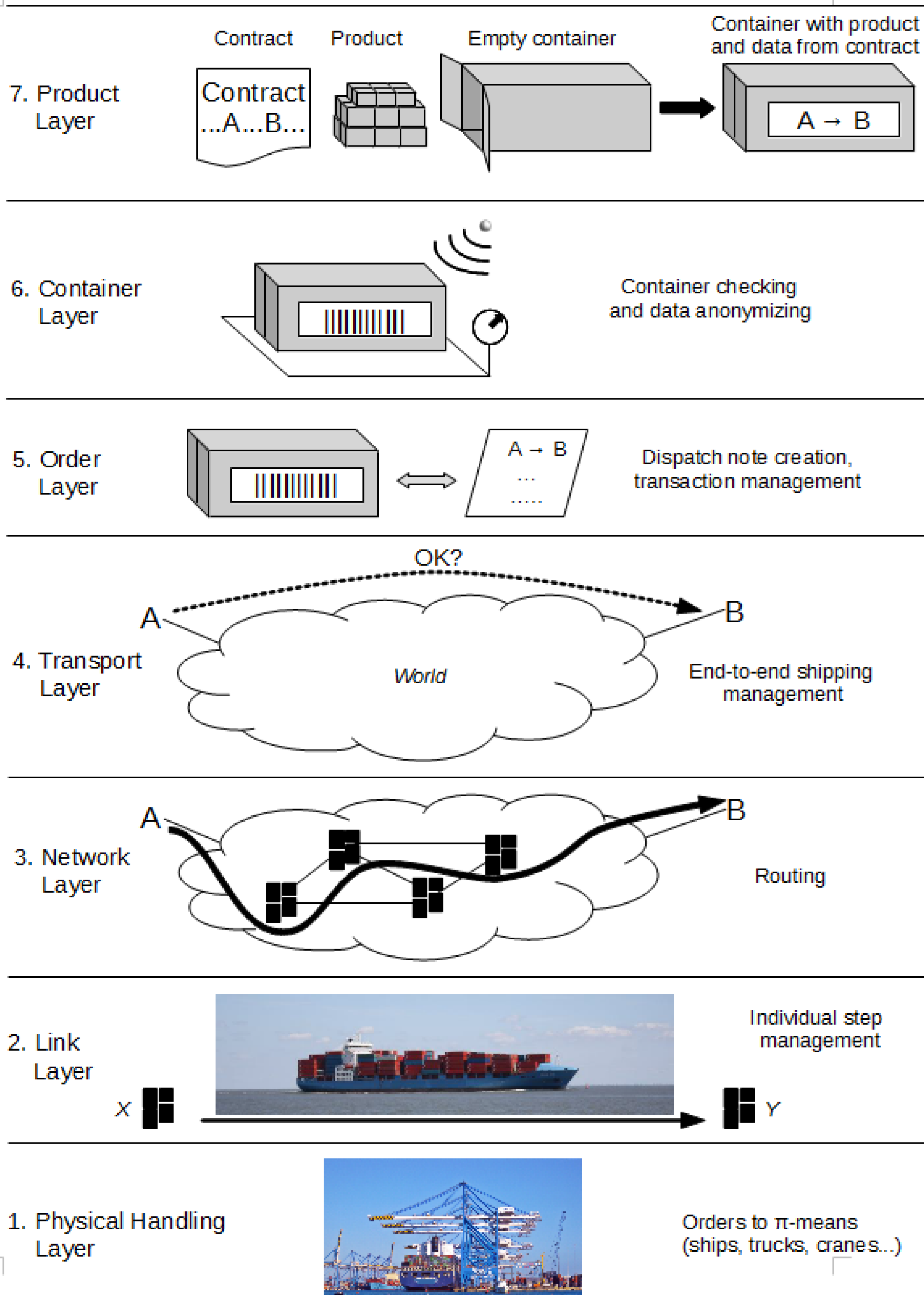
(Based on *CommDP* in Lascano et Clyde (2016))

- **Request-Reply**
- **Request-Reply-Acknowledge**
- **Idempotent Retry**: for request without any side effect
- **Intermediate State Messages**: checkpoints, etc.
- **Multiple Channels**: separating data and control
- **Front End**: pooling requests
- **Proxy**: Data and physical actors acting on behalf of other data and physical actors to manage authentication, logging, etc.
- **Synchronisation of Operations**
- **Publish-Subscribe**: to manage and connect multiple requests and offers

Tools:

- **Universal Resource Identifier (URI)** : for data, and for physical objects
- **“Mailbox”** : for data, and for physical objects

## The NOLI Reference Model



## Example of exchange between Layers

Example of exchange between Layer 6 and Layer 5 about the handling of filled, closed, and duly validated containers:

```
<PQ,6,5,#22 : infos > // Ask for the taking over of containers
<DA,5,6,#77, Re: PQ,6,5,#22 : infos > // "OK to take over" the containers
<PA,5,6,#34, Re: PQ,6,5,#22 : infos > // Physical order to take containers over
Legend: P=Physical/D=Data; Q=Query/A=Answer. The numbers identify the orders and their answers.
```

## Conclusion and Remarks

We identified functionalities and patterns for a formal communication language between the layers of a physical internet.

Additional points still open are, among others:

- Force **Strict Layering** or not ?
- Geographically Separated Layers: **keep the stack notion** ?
- Is **strict synchronisation** really needed ?

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