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Enabling Effective Port Resource Management:

Integrating Systems of Production Data Streams

by

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Effective resource planning requires knowing other actors' plans and progress

Each actor in a self-organizing ecosystem provides value to the larger value network, such as the transport of a consumer product from the warehouse to the pick-up point, and the pick-up point's actions to inform and hand-over an arrived product. In businesses today, high demands are placed upon each participating value provider to ensure a high-degree of capacity utilization. For providers in a self-organizing ecosystem to pursue optimization, they need to be informed about related actors planned actions and outcomes. Ideally, the sum of all optimization decision pursued by each actor in the value chain should contribute to ecosystem optimization, but this is not always the case.

Within the transport sector, the spatial and temporal dimensions need to be captured for planned and actual physical movements and service provisioning. By knowing when, where, and what for each object, actors are better informed to coordinate related operations.

Sea Traffic Management (STM) addresses maritime transports taking the scope of berth-to-berth. This means that actors in the whole chain of activities from the berth at the point of origin, the sea voyage, and the berth at the point of destination should also be part of an information chain. For a port to plan its operations with high precision, it needs to be informed about the plans and progress at the previous port, the sea passage, and hinterland transport serving the port. Different elements of STM define service domains to promote (digital) service distribution in the berth-to-berth sea transports. These concepts are Voyage Management, Flow Management, and Port Collaborative Decision Making (PortCDM), which are supported by SeaSWIM as the digital infrastructure providing inter-operability within and between the service domains.

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Different types of coordination

A core goal of STM is to minimize the resources required to steam between two ports, while maximizing the utilization of resources within a port, with increased safety. For shipping companies the turn-around process at a port should be is as expeditious as possible to enable high utilization of the ship in their fleets. The PortCDM concept builds upon two principles of coordination to provide a basis for enabling just-in-time operations and optimal resource utilization:

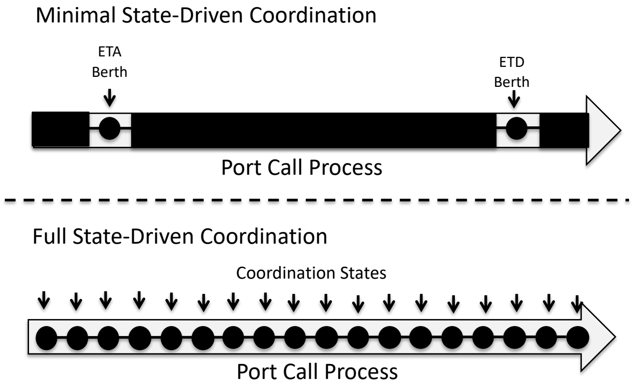

Figure: Variants of process driven coordination

- *Minimal state-driven coordination* in which involved actors share critical spatial-temporal data and state data about the time and location of a state change to allow others to coordinate their actions in relation to these plans. As only critical data are shared, a majority of the states in the port call process are black-boxed and just a few of them are shared among actors.
- *Full state-driven coordination* in which the actors share spatial-temporal and process data about the duration and location of all substantive port visit processes. All states, except the most minor, of a port call process are shared among involved actors.

Minimal state driven coordination is a first step towards enabling port actors to align their actions in relation to a common goal. It provides an entry point to improved coordination, and also should provide a motivation to full state coordination because of the benefits.

Port planning builds upon data produced by different systems of production

The successful operation of a port requires its independent parties to share data to ensure efficient episodic tight coupling, such as when a tug aids in berthing a ship. PortCDM concentrates on data sharing capability whereby parties shared data necessary for planning and executing a ship's visit to a port. To move beyond an operational perspective to long-term resource management, a greater level of data exchange is required. Referring to the different coordination principles above, the ideal effective

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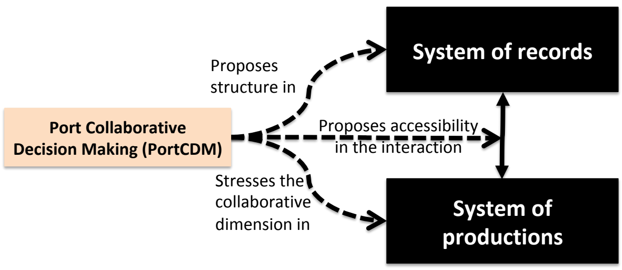
resource management builds upon full state-driven coordination, but an important first step is to achieve minimal state-driven coordination.

A port and its independent parties have a system of production for fulfilling its most important tasks, where a system of production *is a repetitive sequence of coordinated actions that might be divided among actors to achieve a goal.* We can think of a ship's visit as a system of production with each of the actors performing its specific task, but we also need to recognize that each of the parties has a separate system of production (e.g., the terminal) and an associated separate system of record. For PortCDM, two aspects are currently important:

1. The sharing of accurate and detailed real-time data
2. Alignment of each actor's intention to enable effective and efficient episodic tight coupling in a timely manner

These two ingredients create a "system" of data sharing, giving rise to well-coordinated port call processes based on high degrees of predictability and situational awareness. PortCDM thus brings collaborative dimensions into port call coordination (port internal collaboration) and port call synchronization (port external collaboration) into focus. This does not mean that the port call process is optimized, but it does mean that some, though incomplete, data are available for others to start an optimization process for port calls and other operational services. PortCDM creates a system of records, based on a port's actors' systems of production, which can fuel data analytics, artificial intelligence, and machine learning.



PortCDM (see figure to the left) is positioned as a concept that through its recommended message format stresses the importance of running the production system without any misunderstandings on key episodes (such as the estimated time of arrival), but also as a creator of a system of records.

For example, planning a port call cannot solely rely on the situation in the port. It builds upon insights on the status of related actors, such as the previous port, and movement of ships, and hinterland transports. Today, the system of record is often incomplete and thus not well-suited for learning through data analytics.

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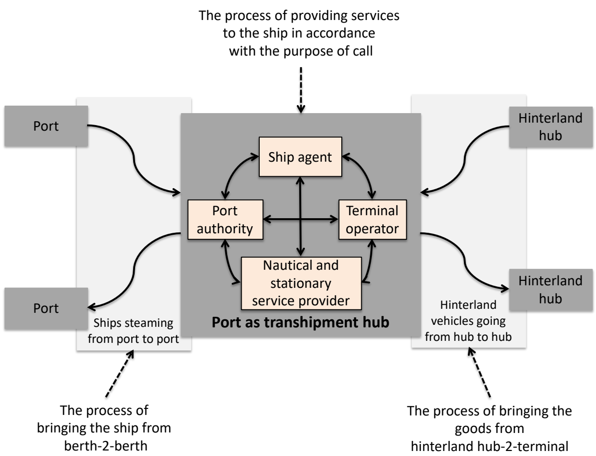
An implemented system building upon PortCDM according to its objectives can address this issue. It will require standardized message formats and interfaces for a port's systems of production. In this way, the system building upon PortCDM, would enable each actor to plan what resources need to be available in different future coupling episodes contributing to an optimized port. The concept of PortCDM's current system of record reveals what operations were planned for and conducted during in a visit, but it has no details of what resources in total were available at the time of the visit or the pattern of resource usage over an extended period. This requires additional details of resource utilization to be aligned with PortCDM.

Port call processes build upon patterns of activities among actors. There are at least three simultaneous ecosystem-oriented systems of production processes that needs to be inter-lined:

1. Sailing ships berth-to-berth
2. Serving ships according to their needs to realize the purpose of call
3. Bringing goods from a hinterland hub to the terminal, or vice versa.



In the figure to the left, these systems of production are depicted. The system of records revealing the progress of actions in the systems of production is a complementary product of the actions pursued in the systems of production.

A port's operations rely on insights from all these three production processes since each production process is dependent on consuming data from all three systems of records and about the progress in other production processes. PortCDM must provide the logic for identifying data sharing needs for each situation by 1) providing situational awareness and 2) aligning different actors by revealing diversities and unrealities in their timing of episodic tight coupling and ensuring that essential data for the coordination of a port call are shared in a timely manner.

PortCDM works well within the current resource mix, but the prime goal of minimizing ship turnaround and enhanced predictability for essential states is limited by insufficient data resources. It is therefore necessary that PortCDM works in alignment with integrating additional types of data from systems of production to ensure a port has the

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right long-term mix of resources to minimize ship turnaround. For example, data analytics might reveal that the presence of an additional pilot would over a year reduced ship turnaround by 10% due to the ability to conduct more parallel assignments of pilotage and thereby avoiding unnecessary waiting times.

Planning for one visit can improve efficiency, as PortCDM has shown, and planning for hundreds of visits will give efficiency another major boost.

Some concluding remarks

The two principles of coordination elaborated in this note can support actors to optimize their resource utilization. In the first case, the minimal state-driven coordination, each actor's consecutive progress of the port call process is not shared with other actors, but foundations are created for each actor to optimize its contribution related to a desired outcome (e.g., when a ship will depart). In the second case, the full state-driven coordination, sharing data, from the systems of records of the respective production systems should enable each actor to more precisely align their operations, such as in sequence or parallel, in relation to those of others. Naturally, such tight alignment is dependent on the timely sharing of accurate and relevant data. Both principles of coordination, whereas minimal state-driven coordination is the foundation for full state-driven coordination, is the basis for enhanced collaboration and data sharing within the port environment providing stakeholders foundations for optimized operations.

Traditionally, it has been the captain's (and the shipping company's) responsibility to provide estimates on arrival to berth (ETA berth) and departure from berth (ETD berth), while it is the terminal's responsibility to provide the captain with estimates and actuals on ready-to-sail (RTS). Other operations need to be related to these event times. Use of a full state-driven approach would, however, also provide the captain with insights on the preparations and possible outcomes of all services expected to be provided during a port visit.

STM adopt two perspectives; ship-centric view and port-centric view. This means that the port, with its actors, could also use the shared systems of records from all four arenas of collaboration (ship-2-port, port-2-port, port internal, port-2-hinterland) to balance its resource utilization to serve ships in a coordinated and optimized way and still keeping some flexibility for managing disruptions.

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The current and future performance of a self-organizing ecosystem is determined by a holistic efficiency-oriented analysis of the many episodic tightly couplings of its various actors. The two coordination principles discussed in this concept note provide insights on the data required to support both short- and long-term ecosystem efficiency gains. Realization, however, will require actors to willingly share key data, some of which they might regard as essential to their competitiveness, to achieve a greater good benefitting all actors. In today's connected world, ecosystem data sharing provides a path to higher capital productivity and business opportunities.

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