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THE COMPREHENSIVE INTERMODAL PLANNING SYSTEM IN DISTRIBUTED ENVIRONMENT

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ABSTRACT. Background: Goods distribution by containers has opened new opportunities for them in the global supply chain network. Standardization of transportation units allow to simplify transport logistics operations and enable the integration of different types of transport. Currently, container transport is the most popular means of transport by sea, but recent studies show an increase in its popularity in land transport. In the paper presented the concept of a comprehensive intermodal planning system in a distributed environment which enables more efficient use containers in the global transport. The aim of this paper was to formulate and develop new concept of Internet Intermodal Planning System in distribution environment, supporting the common interests of the consignors and the logistic service providers by integrating the transportation modes, routing, logistics operations and scheduling in order to create intermodal transport plans.

Methods: In the paper presented and discussed the new approach to the management of logistics resources used in international intermodal transport. Detailed analysis of proposed classification of variety transportation means has been carried out along with their specific properties, which may affect the time and cost of transportation. Have been presented the modular web-based distribution planning system supporting container transportation planning. Conducted the analysis of the main planning process and curried out the discussion on the effectiveness of the new web-based container transport planning system.

Result and conclusions: This paper presents a new concept of the distributed container transport planning system integrating the available on the market logistics service providers with freight exchange. Specific to container planning new transport categories has been identified which simplify and facilitate the management of intermodal planning process. The paper presents a modular structure of Integrated Internet Planning and Scheduling system that combines in one place freight exchange with logistics service providers along with all possible clients dispersed around the world. Comprehensive integration of many participants in the intermodal transport process creates new opportunities for access to distributed logistics services. Computed complex planned routes consisting of several carriers can become an important competitor to traditional Third Party Logistics providers.

Key words: planning, intermodal planning system, containers, distribution.

INTRODUCTION

The intermodal container called also freight container rely on a standardized reusable steel box which enable safe, efficient, secure storage and movement of materials or products within a global containerized intermodal freight transport system. Invention of container facilitate possibilities to build and manage intermodal transportation system. It is the transport system whereby two or more modes of transport are used to transport the same loading unit in an integrated manner. It is integrated activities like delivery to shipper dock, load with freight and sealed, release to transportation company and transport by truck, rail or ship. On the other hand multimodal transportation is the continuous movement of goods by more than one manner. It is actually physical good movement activities like: load pallets of freight, load into a truck than unload

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from it and load onto a ship and so on. Standardisation of transportation unit support convenient move from one mode of transport to another without unloading and reloading the contents of the container. The first standardised steel shipping container has its origins in the 1950s when commercial shipping operators and the US military started developing new logistics method named Container Express or abbreviation ConEx. The first standardisation by ISO for containers were published between 1968 and 1970. Later in 1972 the International Convention for Safe Containers was established for the safe handling and transport of containers. Organization decrees that every container travelling internationally has to be compliant with CSC-Plate unifying safe and handling conditions.

Using Containers for shipping goods enables standardisation and simplification of transportation process in many stages. Every logistic operator or any player involved in handling containers is prepared for the same logistic units which create possibilities to combine more logistics services. The intermodal freight transportation utilise those handling features and enables move cargoes from origins to destinations using two or more transportation modes such as air, ocean, rail, and road. The intermodal containers services are offered mainly by third party logistics companies which manage multimodal transportation services in behalf their customers. There are number of complex interrelated operations which nowadays require support by integrated systems like NPS (Network Planning System), NOS (Network Optimization System), and DSS (Decision Support System). Since third parties companies inters are to offer as much logistic services in intermodal transportation then they are reluctant to cooperate or to integrate some transportation modes between each others. It makes some drawback for customers which have to rely only on Third Party Logistic providers.

The aim of this paper was to formulate and develop new concept of Internet Intermodal Planning System in distribution environment. The solution should supports the common interests of the consignors and the logistic service providers by integrating the transportation modes, routing, logistics operations and scheduling in order to create intermodal transport plans. In addition new solution should help resolve some inflexibilities and heaviness of container logistics, which might lead to increase its popularity.

CONCEPT OF INTERMODAL PLANNING SYSTEM

The concept of new intermodal transport planning system combine in one place several logistics process which enable to more versatile planning and better resource utilisation. The two main fields have been extended and changed which bring new quality and flexibility into multimodal transport planning. First one is the resource management. The categories of resources have been extended to three types:

- fixed resources,
- rough resources,
- on demand resources

Introduction of more versatile resources categories opens more possibilities in smooth integration of different transportation lane in multimodal transportation plan. It helps to combine resource characteristics and their availability for multimodal container transportation. Each resource category varies in service time, economics of scale, geographical restriction and so on, which might influence on resource cost, speed of services or accessibility. Application of three resources categories provide one flexible solution which can cover wide geographical service area and allow to use many transportation modes.

In addition, the new concept of multimodal planning module utilise the notion of combining benefits of multimodal transportation network with flexibility of a freight exchange platform. The conventional concept of planning activities base on assigning available resources to planed in the future tasks. All attributes of resources like cost, performance and availability have to be known at planning time. Furthermore, resources should have defined services activities which are constant during planning

process. The fundamental differences between new and old planning method lay in managing logistic resources. From the point of view of availability there are two kinds of resources:

- Estimated availability of resources in the tool's data base;
- Request for available resources through the freight exchange

Now we might assume that there is possibility of establish delivery plan for estimated resources and their availability and cost. The first category allow to define the range of services and availability of resources. It is possible that transportation resource might start anywhere in defined region and end somewhere in another region. Only certain type or resources, which have flexibility and freedom in selection of start and destination might fall in this category.

The second type of resource comes from the freight exchange portals concept and it is modified to use for multimodal container transportation. The freight exchange portal is widely used for short and medium range distance transportation for Full Truckload - FTL and sometimes is used for Less Than Truckload - LTL. The notion of the freight exchange is extended to the containerised transports that may be performed on road chassis, container trains, barges or feeders and large vessels.

The introduction of request for available resource type has substantial influence on planning concept. It divide planning process into two stages. At the first stage basing on current demand the Request for Resources - RFR is coming from the demand for transportation services. At the second stage all available resources available at the market are confirmed and converted into available for planning resources. The actual planning process integrate all demands - transportation request with all three types of resources in one planning activity. The system at one point in the time has on one side transportation request and on the second side all possible resources organized by three categories which might be assigned in order to build intermodal transportation plan.

The new concept of multimodal transport planning introduce another useful feature for Logistic Service Client. He might have opportunity to see more than one possible planning solution using different available resources types. The ICT application operator can rank proposed plan by the:

- cost category,
- delivery due time,
- CO2 emission,
- handling flexibility.

SYSTEM ARCHITECTURE OF INTERMODAL PLANNING

The intermodal Transportation Planning System is composed of five modules responsible for handling dedicated areas:

- resource,
- constrains,
- demand,
- negotiation and approval of a plan and
- execution.

Figure 1 presents schema of the multimodal transportation system. The process begins at the order management rectangle located in demand management module. This module is responsible for managing demand and calculation integrated intermodal plan. The resource constrains management deals with of all kind of constrains which need to be fulfil by calculated transportation plan.

The negotiation and approval module helps to conduct communication with service providers in obtaining additional resources form transport exchange and helps to conduct negotiations between partners involved in delivery planning. Once the plan is approved it goes to the execution module were final confirmation from resources are received.

New concept of intermodal Planning system compose of five main modules. Each one provides services for dedicated domain. There are number of interactions between modules and their sub modules.

Resource Management module - This module handle all three types of resources. The fixed and rough types that are stored in database and are ready to use. The requested

resource coming from transport exchange are obtained on demand from external services. This module helps to convert them to be ready to use by planning part of the system.

Demand Management module - is a module responsible for providing and managing the transport orders. Logistics service clients who are registered in the system can provide their transport inquiries to the system using user interface or electronic message. The transport inquiries are managed also by logistics service clients, they might be confronted with existing transport services on which the initial plan or offer is being built. Users then may choose the interesting offers for them and negotiate them or agreed with logistics service providers.

Offers and Negotiation module is a place where users may negotiate or re-negotiate the initial offers. The logistics service clients may propose changes in a few parameters like cost, service time and transport mode. This module is responsible for approval of requested resources from transportation exchange and confirmation of multimodal delivery plan for all services providers.

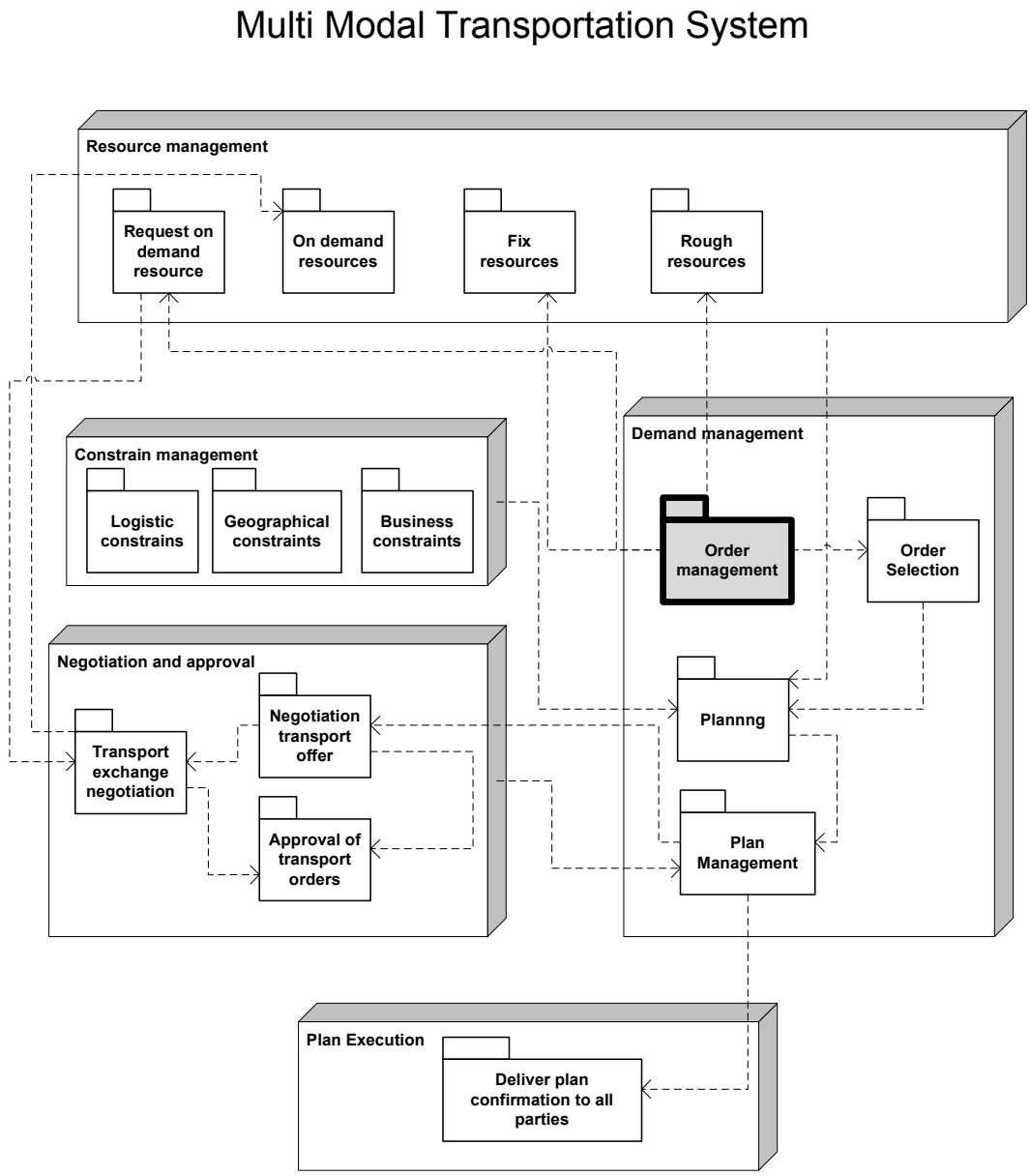

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Fig. 1. Architecture of the Intermodal Transport Planning System
Rys. 1. Struktura Systemu planowania transport intermodalnego

Constrains management - It contains subsystem responsible for handling business, logistic and geographic constrains. The first one helps to define condition and restriction for cooperation of service providers. Some logistic companies might not be open to accept all external services. The second subsystem helps to defines condition on logistic locations like service hours or available equipments. The last subsystem deals with calculation of distance between physical locations. Since system supports many resource types the distance calculation might be provided by linear equation computing cost of transportation means by covered distance. The anthers computation method rely on service area or zone of services. It does not require direct distance calculations but simple estimation of location beginning and ending of logistic services

Execution of transport plan - this module distribute message with confirmation of booking resources for multimodal transportation plan. The clients are able to trace the current status of delivery stage provided by the service providers. It can also support communications between clients and service providers for helping notify some emergency conditions and coordinate payments for rendered services.

USER PROFILES

The new concept of Intermodal Transport Planning System utilise phenomenon of Internet and enable to meet all logistics parties in transportation chain. System support the following business roles:

Logistics Service Provider (LSP)

Logistics service providers represent companies rendering logistics and transport activities with the use of all modes of transportation. That include road transport hauliers, operators of intermodal transport, owners of large container vessels as well as feeders. Beside direct carriers, owners of transport means there are numerous companies managing supply chains as freight forwarders, 4thPL integrators offering door-to door service sub-contracting selected carriers on particular sections of the route.

Logistics Service Client (LSC)

Logistics Service Client deals with all activities defining the need for transport and identifying the appropriate services (in industrial transport mostly based on pre-existing agreements especially in case of large shippers). Logistics Service Client in some cases can be Consignor in other Consignee or shipper. Always the one who pays for the transport service. Freight forwarders sub-contracting carries may also be the service client.

Transport Manager, Administration, Security (TMA)

All activities that are directed to setting up and monitoring adherence to rules and regulations in freight transport belong to this domain. One example is monitoring movement of dangerous goods. Another is customs clearance. A third task is related to security along the supply chain. Responsible for proper functioning of the system

Transportation Network Manager(TNM)

Transportation Network Manager extracts all information available regarding the infrastructure (static or dynamic) related to planning and executing transport and makes this information available to the Transport Service Client and the Transport Service Provider. The typical example may be container terminal being independent offering its handling services to the transport companies. On the other hand many inland container rail terminals are part of the intermodal operators' networks and do not offer independently handling services.

MANAGEMENT OF NETWORK RESOURCES

The new concept of intermodal planning system support all earlier mentioned type of

resources. The fixed resources like mostly ports, logistics hubs and terminals or geographical locations are managed in database of the system. They might be entered and stay in database record for long time. We assume that resource description along with services are provided to the system by service providers using the user interface or electronic messages. For the ad-hoc resources system keeps the information about logistics service providers and about the type and region of their services. We distinguish three major types of resources:

Fixed resources - long lasting connections between ports and logistics hubs. Mostly rail and sea connections but also air, in-land water and road. During planning process those resources are always in the same state and all attributes are known for planners. In the negotiation phase planer can obtain second quote for usage of those resources (next to contained in the data base).

Rough resources - in road transport there is practically unlimited number of locations that may be involved. It refers to the road transport service covering whole route as well as road pre-carriage and on-carriage of containers linking the delivery starting and final points with fixed transport hubs as sea ports or rail terminals. The problem of multitude of locations and distance calculations is simplified to new rough resources. The definition of location might be carried by zip code or by range of longitude and latitude.

On demand resources -are the resources found on an open market of transport services, the logistics service client requests transport services and he will get transport offers from logistics service providers. Before those resources are used for planning they have to be approved and converted to known services called on demand resources.

The Locations are critical part of intermodal planning system. They are geographical addresses defined in the transportation systems. Locations are needed for define fixed connections between ports and logistics hubs or city areas. Every fixed services like rail and vessels, system support storing the locations as the starting and ending point of services in the database. Besides these scheduled services there are many others, which starting or ending point might be different with the following transport orders. In addition, for any distance calculation the location defines nodes in distribution graph. Upon these distances the service costs might be calculated or determined by transport service providers.

NETWORK STRUCTURES

Transport networks are the rather fixed connections or transport corridors which exists because of geographical regions or long term business relationships and contracts. Example of that might be the transport corridor from Hamburg to Poland where most of containerized imports of Poland are coming this way. Network structure is built based on the defined services in system database of logistics services. We can have the following types of logistics services: transport services, terminal handling services, warehousing and storage, documents preparation, insurance, customs clearance services.

In the following picture below, the example of possible network structure from Hamburg to Poland is presented. This example shows the transport network with different alternative routes from Hamburg in Germany to Poznan in Poland. There are three alternatives by feeder and truck, truck and railroad and only by truck. Those solutions vary in terms of cost, delivery time and number of services. Depending on transported volume and requested speed of delivery in some case one solution might be more favourable then other.

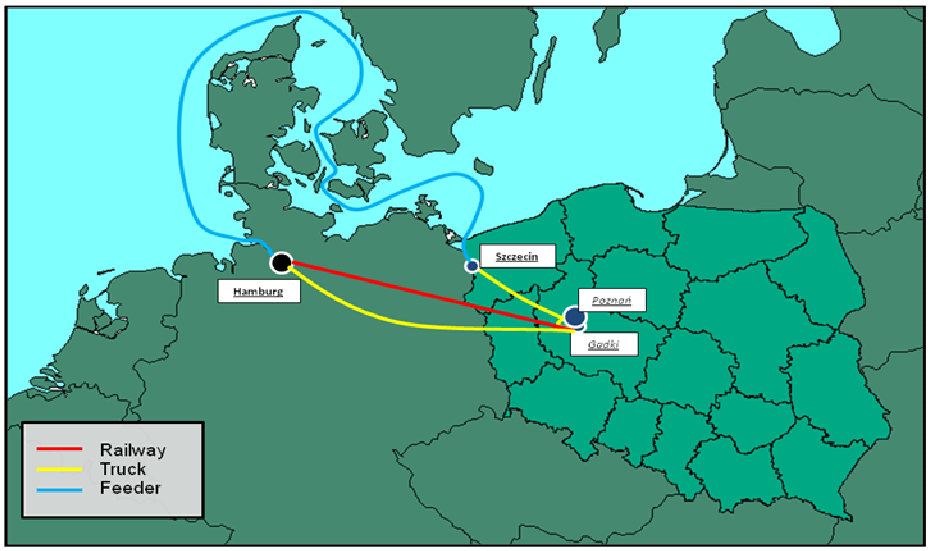

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Fig. 2. Example of transport network from Hamburg to Poznan
Rys. 2. Przykład sieci transportowej z Hamburga do Poznania

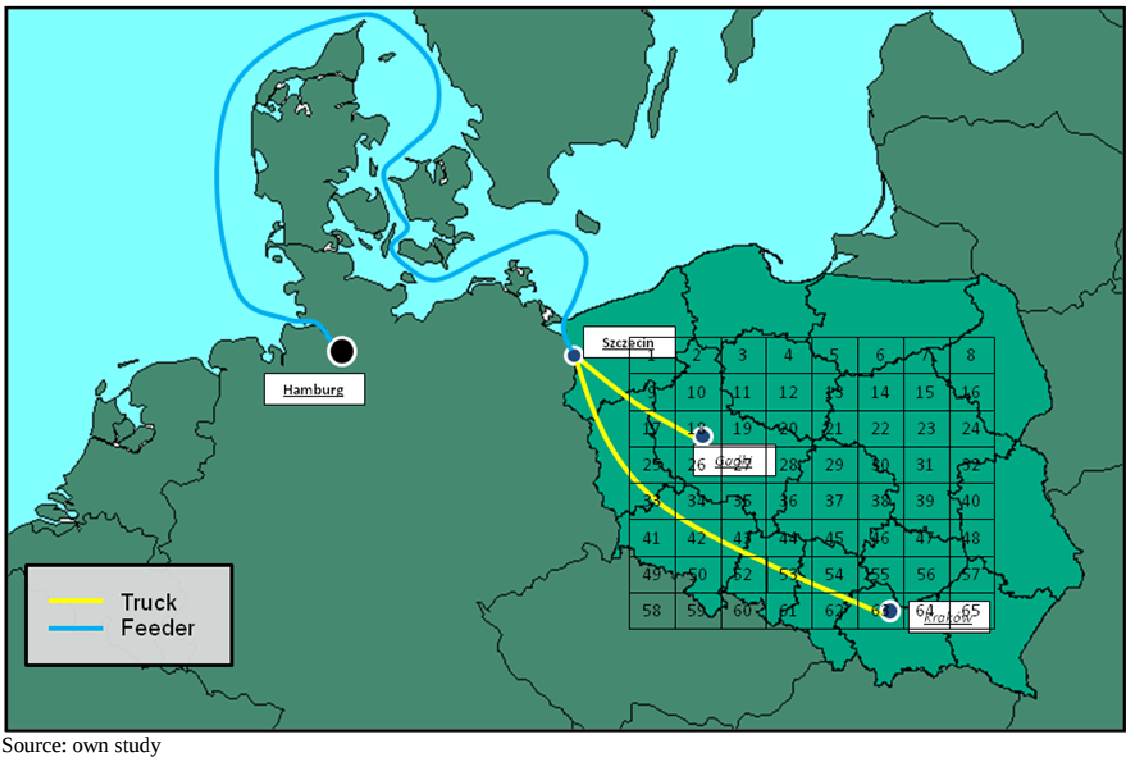

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Fig. 3. Flexible resources - zones of services
Rys. 3. Zasoby elastyczne - strefy usługowe

There are three types of service providers: fixed resources, resources on demand and rough resources. Each services provider corresponds to one of above resource type. Once he was classified the planning system will handle it differently. The railroad connections between two cities or freight transport by sea ports are typical fixed logistics resources. They are fixed by nature of geographical infrastructure which for planning horizon cannot be changed.

Handling rough resources

The notion of rough resources was introduced in order to support pickup and delivery containers form any geographical locations. It is common practice that service providers distinguish price of delivery service by regions. In the picture below there is scenario of delivery containers from Hamburg by feeder to Szczecin and then by truck to Gądki and Kraków. The truck services are provided by rough resources with different quotation for every defined region. In this example there are sixty five regions and Gądki belongs to region 18 and Kraków to 63.

In the following picture flexible resource are provided by service area. There is defined central location and range of distances from it. The further pickup or delivery place are the more expensive service are. Both types of flexible resources can help cover waste geographical area and make feasible calculate of intermodal plan for any number of customers.

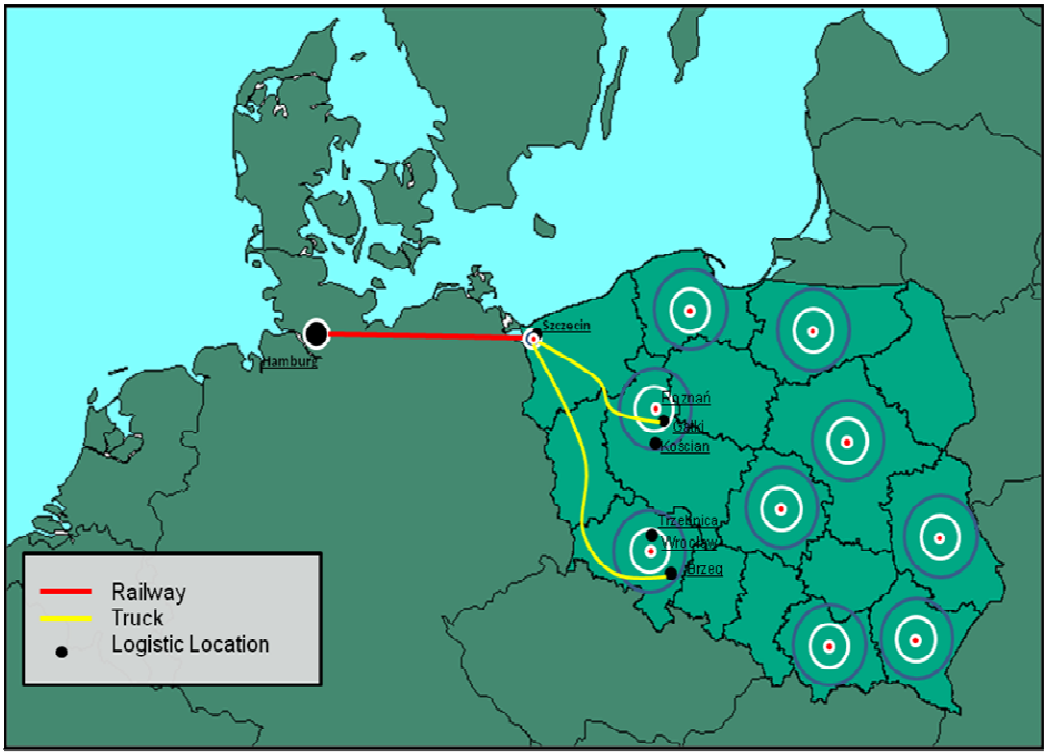

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Fig. 4. Flexible resources - service area
Rys. 4. Zasoby elastyczne - obszar usług

CALCULATION INTERMODAL TRANSPORTATION PLAN

The actual calculation process of delivery plan is executed after selection all orders, and gathering available resources. In addition system has to fulfill all defined constrains which include business, logistics and geographic conditions. Planner might decide that he has all resources to which he wants assign transport orders or he need more from market. In order to extend available logistic resources or find better alternatives he might substitute one resource by current offer from freight exchange market. After he get reply and confirm market transportation offers he can include them to planning process. Planer can even negotiation with all service providers which open possibility to request for better quotations. It can be particular useful in case of

planning bulk transportation where services provider might give lower price in this case.

Planning of intermodal transport services

The concept of intermodal transport planning is depicted in UML sequential diagram in the picture below. It is composed of five main stages:

- collecting transportation market offers,
- gathering all system and resources constrains,
- calculate plan,
- negotiation with service provider for better transport service
- selection the best transportation plan.

The system constrains include business, geographic and logistics condition which need to be fulfilled during computation of plan. Horizontal axes correspond to four actors of the system.

- user who wants to calculate intermodal delivery plan,
- information system,
- external transport exchange system,
- service providers which can render services for this particular plan.

The process begins at user channel from entering orders and sending request for resources to Planning System. In response the external system can provide market offer which users need to approve and convert to resource used for planning. At this stage system gather all defined fixed and flexible resources from his local database and begin calculation of intermodal plan. Since the plan is computed users can began negotiation with service providers by requesting them for current quotation. He can get those information from freight exchange and from service providers. Again system compute intermodal plan. After users approve it the appropriate information about booking resources are send to transport exchange and all service providers. At this stage plan is ready for execution.

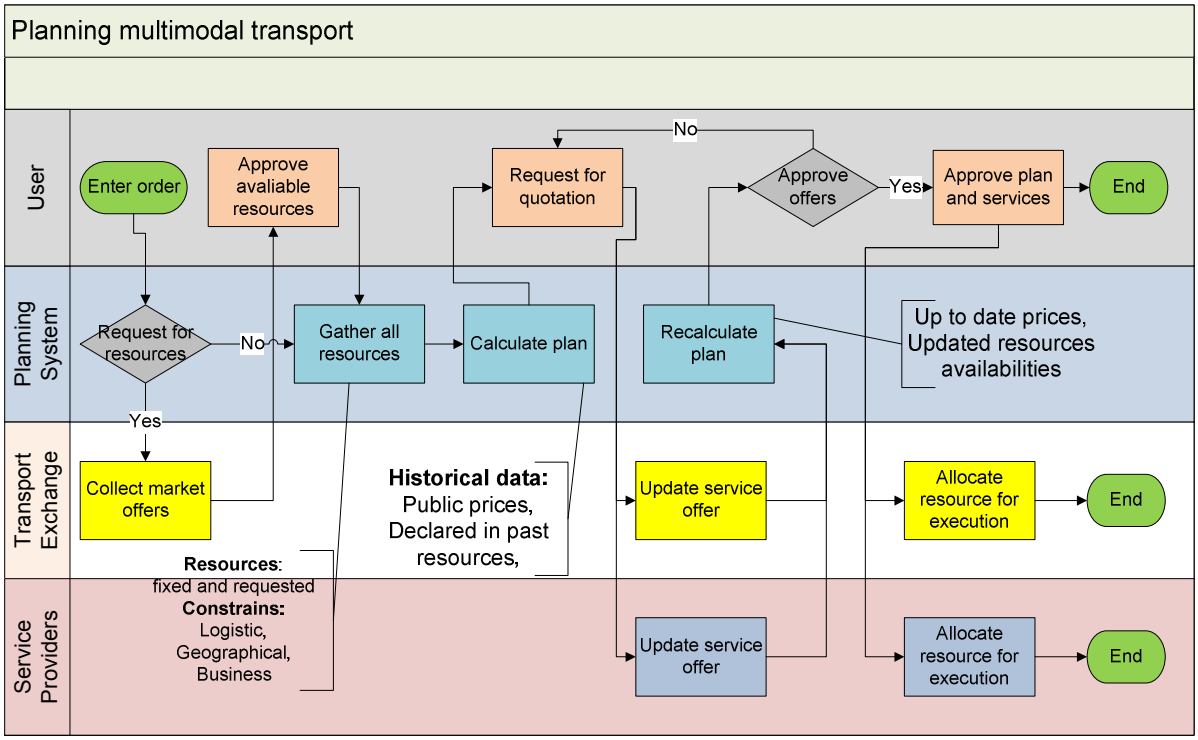

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Fig. 5. The concept of the intermodal transport planning
Rys. 5. Koncepcja planowania transport intermodalnego

SUMMARY

The advent of new ICT systems supporting rational and well balanced decision making open new opportunities in restructuring multinational transport networks into more sustainable according to the co-modality concept. The main idea behind implementation decision support systems lay in supplying shippers with objective market information concerning all possible transport opportunities along with multimodal corridors. With on-line access to time schedules and tariffs of carriers and freight forwarders the decision makers may fully exploit intermodal container advantages.

The new concept of Intermodal Planning System comes with flexible support for all partners in intermodal container transportation network. Tanks to seamless integration of versatile logistic resources with easy access to service provider all kind of users can meet in one virtual place. They have unique opportunity to see consignors demand and available logistics services at one location. The ultimate benefits of described system comes from computation one intermodal transportation plan which is visible at the same time to all users. This plan on one side sits in virtual space but on the other is already confirmed by all services providers and accepted to execute by consignors.

The objective of the paper was presumption that there is possibilities to apply modern Internet technology in building efficient distribution plan for intermodal transportation. The research reviled the versatile of logistic resources, they characteristic in many dimensions like time, space and accessibilities. Paper comes with proposition of comprehensive integration of demand for logistics services along with available resources capable to perform requested services. Application the Internet technology to meet in one virtual place consignor, consignee and all available on the market logistic services opens new competitive market place for cheaper and better logistic services. It can lead to create new platform offering competitive services to Third Party Logistics Providers. This prove the usefulness and legitimacy to build described in paper new Intermodal Logistic Planning System both for buyers of services and all kind of logistic services providers.

Author assume that describe Internet system can create new environment and market place for wider application intermodal transportation means. It can contribute into decrease transportation cost and improve overall logistics services. In addition, it eliminates barriers to access to container transport services and enrich it with new flexible management mechanisms. Since proposed solution utilize modern Internet technology bringing customers and all involved in logistics operations players in one virtual place it will open undisputed possibilities for grow of intermodal transportation services.

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KOMPLEKSOWY SYSTEM PLANOWANIA INTERMODALNEGO W ŚRODOWISKU ROZPROSZONYM

STRESZCZENIE. **Wstęp:** Dystrybucja towarów kontenerami otworzyła nowe możliwości ich dostarczania w globalnej sieci logistycznej. Standardowe jednostek transportowych pozwalają uprościć operacje logistyczne oraz umożliwiają integrację różnych typów transportu. Obecnie transport kontenerowy jest najbardziej popularnym środkiem transportu drogą morską, ale ostatnie badania pokazują wzrost jego popularności w transporcie lądowym. W pracy zaprezentowana została koncepcja kompleksowego systemu planowania intermodalnego w środowisku rozproszonym jako propozycja bardziej efektywnego wykorzystania kontenerów w transporcie globalnym.
Celem pracy było stworzenie koncepcji Internetowego intermodalnego systemu planowania, spełniającego oczekiwania odbiorócw i dostawców usług logistycznych poprzez połączenie w procesie procesie planowania transportu takich elementów jak typu transportu, wyznaczanie tras, operacje logistyczne oraz harmonogramowanie.
Materiały i metody: Przedstawiono i przedyskutowano nowe podejście do zarządzania logistycznymi zasobami wykorzystywanymi w międzynarodowym transporcie intermodalnym. Przeprowadzona została szczegółowa analiza zaproponowanej klasyfikacji środków transportowych oraz ich specyficznych własności, które mogą wpływać na czas i koszty transportu. Przedstawiony został modułowy internetowy system planowania dystrybucji dostępny dla wszystkich uczestniczących w transporcie kontenerowym. Przeprowadzono analizę głównego procesu planowania oraz przeprowadzono dyskusję nad efektywnością nowego internetowego systemu planowania transportu kontenerowego.
Wyniki i wnioski: Praca prezentuje nową koncepcję rozproszonego systemu planowania transportu kontenerowego integrującego dostępnych na rynku przewoźników z giełdę transportową. Zidentyfikowane zostały specyficzne dla planowania nowe kategorie środków transportu, które upraszczają i ułatwiają zarządzanie procesem planowania intermodalnego. Praca prezentuje strukturę modułową zintegrowanego internetowego systemu planowania, który łączy w jednym miejscu giełdy transportowe, logistycznych dostawców usług ze wszystkimi możliwymi klientami rozproszonymi na całym świecie. Kompleksowa integracja wielu uczestników w intermodalnym procesie transportowym stwarza nowe możliwości w dostępie do rozproszonych usług logistycznych. Tak zaplanowane złożone trasy składające się z kilku przewoźników mogą stać się istotną konkurencją dla tradycyjnych operatorów logistycznych.

Słowa kluczowe: planowanie, kontener, system planowania intermodalnego, dystrybucja.

KOMPLEXES SYSTEM FÜR INTERMODALE PLANUNG IM ZERSTREUTEN WELTWEITEN UMFELD

ZUSAMMENFASSUNG. Einleitung: Die Güterbeförderung mittels der Container eröffnete neue Möglichkeiten für Warenlieferung im globalen Logistik-Netz. Standardisierte Transport-Einheiten erlauben, Logistik-Operationen zu vereinfachen und unterschiedliche Transporttypen weitgehend zu integrieren. Heutzutage stellt der Transport per Container das populärste Transportmittel im Seetransport dar, wobei die letzten Untersuchungen auf den Wachstum dessen Popularität auch im Straßentransport hinweisen. Im Rahmen der Arbeit wurde ein Konzept des komplexen Systems für intermodale Planung im zerstreuten weltweiten Umfeld als ein Vorschlag einer effizienteren Inanspruchnahme von Container innerhalb des globalen Transportes projiziert.
Material und Methoden: Es wurde eine neue Herangehensweise an das Management von logistischen, im internationalen und intermodalen Transport beanspruchten Ressourcen dargestellt und durchdiskutiert. Demzufolge wurde eine eingehende Analyse der vorgeschlagenen Klassifizierung der Transportmittel und deren spezifischen Eigenschaften in Bezug auf die Zeitdauer des Transports und die Transportkosten durchgeführt. Es wurde das Konzept

eines modulartigen Internet-Planungssystems für Warendistribution für alle am Container-Transport Beteiligten dargestellt. Der Haupt-Planungsprozess wurde einer Analyse unterzogen, wobei man sich mit der Effektivität des neuen Internet-Planungssystems für den Container-Transport auseinandersetzt hat.
Ergebnisse und Fazit: Die Arbeit präsentiert ein neues Konzept des zerstreuten Planungssystems für den Container-Transport, das die auf dem Markt bestehenden Transport-Dienstleister mit der Transport-Börse zu integrieren vermag. Es wurden dabei die für die Planung spezifischen neuen Kategorien der Transportmittel, die das Management des intermodalen Planungsprozesses erleichtern und vereinfachen, ermittelt. Die Arbeit weist eine modulartige Struktur des integrierten Internet-Planungssystems auf, das die Transport-Börsen und Logistik-Dienstleister mit allen möglichen, in der ganzen Welt zerstreuten Kunden an einem virtuellen Ort in Verbindung setzt. Die komplexe Integration von mehreren, an dem intermodalen Transportprozess beteiligten Nutzern stellt neue Möglichkeiten hinsichtlich des Zugangs zu den zerstreuten logistischen Dienstleistungen her. Die anhand des Systems geplanten Fahrrouten, die von mehreren Transport-Dienstleister bedient werden, können den herkömmlichen Transport-Anbietern gegenüber eine wesentliche Wettbewerbsfähigkeit darstellen.

Codewörter: Planung, Container, intermodales Planungssystem, Warendistribution.

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