15 Service flow networks for functional design of distribution centers

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The work deals with the determination of an approach for concept planning of distribution centers. For this purpose, the "Distribution Center Design Process" is defined. Solution concepts for distribution centers are developed and evaluated in an eight-step process. In particular, the formalization of the functional area, which has not yet been considered scientifically, will be focused on. This results, among other things, in the definition of services and basic transformation properties of handling units. These can be used to create and semantically test service flow networks, which describe the functional sequence and transformations in distribution centers.

INTRODUCTION

Distribution Centers

- Distribution centers are complex systems and indispensable components of modern supply chains
- They contribute significantly to the quality of the entire network
- More than 3 million sqm of new logistics space in Germany in 2016
- Flexibility as a success factor

Conceptual Design

- Complex, ill-structured decision problem
- Carried out by interdisciplinary collectives
- Design approach is heuristic: mathematically optimal solution does not exist
- Goal: the best possible solution

Conclusions and Questions

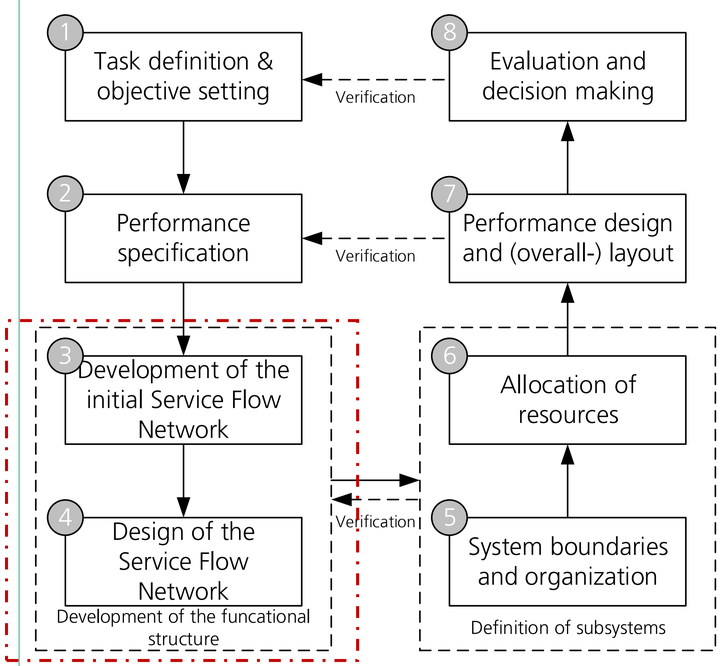
- It follows from the fact of the structural deficiencies that the legitimation of the planning result results from the intersubjectivity of the heuristic used.
- This also means that the derivation of heuristics – as far as possible – meets the requirements of formal rationality, i.e. the process of decision-making should be rational, while the goals guiding the process may be subjective.
- Thus, the scientifically founded derivation of the partial problems, their arrangement in a planning process as well as a suitable documentation of these contents are tasks of outstanding importance for the quality of the planning results.

Using Service Flow Networks within DCDP for Functional Design of Distribution Centers

DCDP

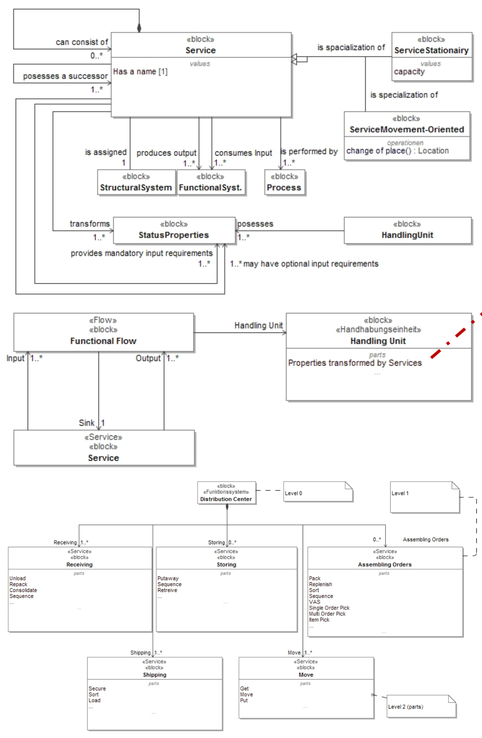
Functional design, incl.
Top-down problem analysis

Physical design, incl.
Bottom-up solution synthesis



Service flow definition

Handling Unit	Transformed by	Service	build	Service Flow Network
Subjects / reference objects of (functional) flows		Describes the function of a distribution center at different hierarchy levels		Functional structure of a distribution centre; Network of services connected by function flows



Handling Unit Properties

Services			Properties 1 Received	2 Need to be stored	3 Need for VAS	4 Loaded	5 Assembled for Shipping	6 Collection of multiple	7 Stored	8 Buffered	9 Sequenced	10 Sorted	11 VAS requirement fulfilled	12 Partial Order	13 Ready to ship	14 Loading equipment	15 Location	16 Predecessor	17 Successor
1	Load	IN	y			n	y		n							y			
		OUT	n			y	y		y	y							new		n
2	Unload	IN	n			y			n									n	
		OUT	y			n			n		n	n					new		
3	Sort	IN	y			n			n		n	n			n	n			
		OUT	y			n			n	n	n	y			n	n	new		
4	Put-away	IN	y	y		n			n	n									
		OUT	y	n		n			y	n	n	n					new		6
5	Move	IN	y			n			n										
		OUT	y			n			n	n							new		
6	Store	IN	y			n			y	n									
		OUT	y			n			y										

Predecessor-successor relations (exampl.)

Predecessor		Successor 1 Load	2 Unload	3 Sort	4 Put-away	5 Move	6 Store
1	Load	-	-	-	-	-	-
2	Unload	x	-	x	x	x	-
3	Sort	-	-	-	x	x	-
4	Put-away	-	-	-	-	-	x
5	Move	x	-	x	x	-	x
6	Store	-	-	-	-	-	-

Formalization

$$\Sigma = (A, \Phi, K, \Pi)$$

Functional system ΣF, consisting of attributes (A) and functions (Φ)

Structural system ΣS, consisting of parts (K) and relations (Π)

$$\Phi = S$$

Function = Service

$$s_i \subset \alpha_i \times \alpha_j$$

Services are defined as relations s_i between attributes α_i, α_j of a function system.
The attributes of the function system are interpreted as function flows within the DCDP.

The services s_i determined within the scope of service decomposition are linked to an SFN.
An SFN G_{SFN} (A, S) is a directed graph with the node set A and the edge set $s_i \subset (\alpha_i \times \alpha_j)$,

in which each node $\alpha_i \in A$ represents a (functional) flow (Handling Units with specific (flow) properties) and each edge $(\alpha_i, \alpha_j) \in S$ a transition between flows.

The SFN defined in this way thus becomes a reflection of the functional system:

$$\Sigma F \leftrightarrow G_{SFN}\ (A, S)$$

SUMMARY & OUTLOOK

- Distribution Center Design Process (DCDP): 8-step process for conceptual design of distribution centers as a blueprint for model- and system-engineering-based concept planning of distribution centers: Symmetrical process, with each 4 phases of functional design and physical design
- Development of the Service Flow Network concept (SFN) to describe the functional structure and the logical linking of functions respectively services with each other within a distribution center

→ Integration of DCDP and SFN concepts into digital design environments (see Poster 20 - Digital design of intralog. systems)

REFERENCES

McGinnis, Leon F.; Goetschalckx, Marc; Sharp, Gunter; Bodner, Douglas; Govindaraj, T.: Rethinking warehouses design research. In: International Material Handling Research Colloquium (eds.): Proceedings of the 2000 International Material Handling Research Colloquium, 2000; Rouwenhorst, B.; Reuter, B.; Stockrahm, V.; van Houtum, G. J.; Mantel, R. J.; Zijm, W.H.M.: Warehouse design and control: Framework and literature review. In: European Journal of Operational Research 122 (2000), Nr. 3, S. 515–533. – DOI 10.1016/S0377-2217(99)00020-X; Apple, James M. [Jr.]; Meller, Russel D.; White, John A. [Jr.]: Empirically-based warehouse design: Can academics accept such an approach? In: Progress in material handling research (2010); Baker, Peter; Canessa, Marco: Warehouse design: A structured approach. In: European Journal of Operational Research 193 (2009), Nr. 2, S. 425–436. – DOI 10.1016/j.ejor.2007.11.045; Gu, Jinxiang; Goetschalckx, Marc; McGinnis, Leon F.: Research on warehouse design and performance evaluation: A comprehensive review. In: European Journal of Operational Research 203 (2010), Nr. 3, S. 539–549. – DOI 10.1016/j.ejor.2009.07.031; Marrenbach, Dirk: Entwicklung einer referenzbasierten prozessorientierten Planungsmethodik für Logistiksysteme am Beispiel der Paket- und Palettenlogistik: RefPlan-Logistik ; Schlussbericht ; (Bewilligungszeitraum: 09/2008 - 08/2010). Stuttgart, 2010; Schmidt, Michael: Distribution Center Design Process – Ein systemtechnikorientiertes Vorgehensmodell zur Konzeptplanung von Logistikzentren. In: ten Hompel, Michael (ed.): Logistik für die Praxis. Praxiswissen, Dortmund. 2018; Prockl, Günter: Logistik-Management im Spannungsfeld zwi-schen wissenschaftlicher Erklärung und praktischer Handlung. 1. Aufl. s.l.: Gabler Verlag, 2007 (neue betriebswirtschaftliche forschung (nbf) v.359). – ISBN 9783835009684; Pfohl, Hans-Christian: Logistikmanagement: Konzeption und Funktionen. 2., vollst. überarb. und erw. Aufl. Berlin u.a.: Springer, 2004. – ISBN 978-3-540-00468-4; Delfmann, Werner: Kernelemente der Logistikkonzeption. In: Klaus, Peter (Hrsg.): Gabler-Lexikon Logistik : Management logistischer Netzwerke und Flüsse. 3., vollst. überarb. und ak-tualisierte Aufl. Wiesbaden : Gabler, 2004. – ISBN 3409395024, S. 235–239; Blanchard, Benjamin S.; Fabrycky, Wolter J.: Systems engi-neering and analysis. 4. ed. Upper Saddle River, NJ: Pearson Prentice Hall, 2011 (Prentice-Hall international series in indus-trial and systems engineering). – ISBN 0131869779; Aslaksen, Erik W.: Designing complex systems: Foundations of design in the functional domain. Boca Raton, Fla.: CRC Press Taylor & Francis Auerbach, 2009 (An Auerbach book). – ISBN 9781420087536; Ropohl, Günter: Allgemeine Technologie: Eine Systemtheorie der Technik. Zugl.: Karlsruhe, Univ., Habil.-Schrift, 1978. 3., überarb. Aufl. Karlsruhe: Univ.-Verl., 2009. – ISBN 978-3-86644-374-7; Hompel, Michael ten; Schmidt, Thorsten; Nagel, Lars: Materi-alflusssysteme: Förder- und Lagertechnik. 3., völlig neu bear-beitete Auflage. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg, 2007 (Intralogistik). – ISBN 9783540732358; Gudehus, Timm: Logistik: Grundlagen, Strategien, Anwendungen. 3., neu bearb. Aufl. Berlin/Heidelberg: Springer-Verlag; Springer, 2005. – ISBN 3-540-24113-2; Sharp, Gunter; Goetschalckx, Marc; McGinnis, Leon F.: A systematic warehouse design workflow: Focus on critical decisions. In: Ellis, Kimberly (Hrsg.): Progress in material handling research: 2008 : [based on invited papers submitted for ... the 10th International Material Handling Research Colloquium (IMHRC) held in Dortmund, Germany, from 28 May to 2 June 2008]. Charlotte, NC : The Material Handling Inst, 2008. – ISBN 9781882780150; Jobi, Boris Sebastian: Rechnergestützte Planung von Distribu-tionszentren durch Einsatz der Graphentheorie. Stuttgart: Shaker, 2013; Institute of Electrical and Electronics Engineers: IEEE Standard for Application and Management of the Systems Engineering Process. IEEE, 2005. – ISBN 0738146919; Estefan, Jeff A.: Survey of Model-Based Systems Engineering (MBSE) Methodologies. Pasadena, CA, 2008; Verein Deutscher Ingenieure (VDI): Methodik zum entwickeln und konstruieren technischer systeme und produkte. Berlin, Beuth Verlag, 1993; Kühling, Martin; Technische Universität Dortmund (Mitarb.): Gestaltung der Produktionsorganisation mit Modell- und Methodenbausteinen. 2002

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