

3, &RQWDLQHUV \$VVHVVP HQW RI)XQFWL
DQ (QJLQH HUH 5RQDMLG QHUVSHFWLY

*HUDOG 0DK&KLQJHWLDQ /DDG<KRMJNU
*UDJ 8QLYHUVLW\ RI 7HFKQRORJULQVW\$XXWULR
&RUUHVS RQGLQJ DXWKRU PDKULQJHU#WXJUD

Abstract:

The idea of containerizing goods is a central component of the Physical Internet philosophy, as this containerization serves to abstract and standardize goods and shipments. This approach promises to simplify the handling of shipments on the one hand and deliver shipments more efficiently throughout the transport network.

In the present work, scientific publications were evaluated according to the terms Physical Internet, PI Container and containerization. Out of almost 300 examined scientific publications, more than 25 could be identified that had a strong focus on the topics of PI Containers and containerization. These identified articles were methodically compared by categorizing them according to aspects highlighting the technical view on the current state of development of PI containers.

Our research shows that over the past 12 years just a few cases were documented where specific engineering design solutions of a PI container were presented and tested in real-life applications. Thus, we conclude that further research into the technical design of PI Containers is needed to identify use cases where the concept of PI Containers has a significant positive impact, is accepted by users, and is accessible under economic, ecological, and technical aspects.

Keywords: Containerization, Physical Internet, Physical Internet Container, Transportation, modularization

Conference Topic(s): interconnected freight transport; material handling; Modularization; PI fundamentals and constituents; PI impacts; implementation; vehicles and transshipment technologies.

Physical Internet Roadmap (Link): Select the most relevant area for your paper: PI Nodes, PI Networks, System of Logistics Networks, Access and Adoption, Governance.

1 Introduction

7KH LGHD RI FRQWDLQHULJLQJ JRJRGV LFD O FQW MUQD HWF BRSG
WKLW FRQWDLQHULJLQJ DWLRQ WRUUVW D QXQD SBH QWYR RGV VD QSS
SURPLVHV WR VLP SOLI WKH KDQGG LQ R BH QLYIHUK WKLS PMIQ
HIILFLHQWO\ WKSRXJK RQXW ZRKHNRQDUKH ORWKHU

7KHUHIRUH LW LV XQDYRLGDEOB, WRQW DLQH XW XQHHGFWR DE
DQG XVHG ZLWKLQ WKH 3, QHWZRDNHGQLQKHD SD SW EOLRQ
KDG PDQ\ VKDSHV DQG IRUPV LQ GLIHURHQW RIFWKQWHLVFWZ
RQH WKLQJ LQ FRFRQD WWRPHJW QDQ DMK MVER QH V HDQJ HDIH
VFLHQWLILF LQYHVWLJDWLRQV KRZLPHKD D WURQPERDWHQ Y,
SXEOLFDWLRQV WKH 3, &RQWDLQH QVRMHUWHQ HDLVDPNRGV
PDWKHPDWLFDO PRGHO RU LQ YLVXDORLQDWLRQFK (DFVSWK
02'8/86+&\$ SURMHFW &ZQWDLQH 3, ZDV GHVHJQMHG ELQDWDO
VFHQDULRV ORVWRQB, WKHQ WDLQDWHQ KH QLRXFW KGVYE UWXD
PDWKHPDWLFDO PRGHOV RQ D VLPQ RD WKHQ 3KDWLFDV OLQFMHV
LQ

7KH 02'8/86+&\$ SURMHFW RQH FRM WHZ ZIRFNSXBQGF DMLHQWLW
WKH 3, &RQWDLQH OHDYH WKH YLUWXDVOLZRLQJ EXDQGV
WHVWLQJ D UHDOEWLQHJ 3QHZRQWDLQH QHJFRQWKOWURGVVK\
SURSHUWLHV VXFK DV PDVV DQG MWKVRQXW RI WKH BD
ZHOO DV FRVW HFRORJLFD EHQHFWRDSQHRSHQDWLQRQ
XVDELOLW\ PD\QRW EH FUXFLDOF DVGHQW WRRURXVLPXQD WU
SUREOHPV 6WLODQRQWDLQH DUV OQLSRUWKQWKWZKDNHMDQG ZLO
EH GHFLVLYH IRU ZKHWKHU 3, &RQWDLQH RWR FQGWXVQDVSQ

\$V FRQWDLQHULJLQJ WURQLDQ RQD QXW RSHWZKMLQ DGGUI
WKH HYROXWLRQURIP3W &RQWDLQH QHVLQDQJ, QWWKH3W 3KLO
WR WKH SUHVQHULQRPGELHQWYHDMQFGSGHQJSHVKH D
KRZ WKH GHVLJQ RI 3, &RQWDLQH WKDW SHYSHUHGGOOKHHRW
QXPEHU RI SURMHFWVQDZLSBWKHSGHQVLDQDQDVSROGKFW
&RQWDLQHUV RQVHSDUWKH QRFWVLFV QHWZRUN

7KHUHIRUH RYHU 3, UHODWHG SXEOLFDQDQJDSQSHUVD
IROORZLQJ D 6\VWHPDWLF/LWHUDWXUH 5XVYVHG ZLWKUQW
ZLOO EH HODERUDWHG RQ DQG H[SHQWQRIQ LQ WKHZPHWKRW
ZLOO IREFXV RQ WKH RYHUDUFKLQJ TXHVWLQR

- \$FFRUGLQJ WR DQ (QJLQHULQJ 'HVLJQD HIODWKH 3KLU
,QWHUQHWR &RQWDLQH

2 Methodology

\$ 6\VWHPDWLF/LWHUDWXUH 5HYLHZV 6WKHDSXSRDQ\LDQWKS
RI LQIRUPDWLRQHDPQ DVKSHOFLWLDVWR 3LF &RQWDLQHULJLQJ LQ WK
ILUVW VVHS DOO UHOHYDQW LQRDQDFWLRQDQGG UHLYWHZB
WR VFUHHQ WKH DSHQWFLDQHYDQWKHLDQWLDGULFKJ TXRIVWLQRQV
WKH OLWHUDWXUH UHYLHZ IREFXVHGGBQHSDVSHVKH DQGSBFR
,QWHUQHWR &RQWDLQHUV)XUWKHULRQFRIJMLQH LQIRVLPDVL

&RQWDLQHUV WKH PRVW UHOHYDQWJSXEOLFDVRIQRQVZHU
DVSHFWV \$FFRUGLQJ WR WKH VFKHQIRIDQVWHKPDZRENL
5HYLHZ WKH IROORZLQJHWWHGSV;ZDUR HW DO

- 3UREOHP 6WDWHPHQW SUREOHP)RUPXODWLRQ
Objective: &ODULILFDWHVRIQDRIFWKH HVWLRQ
- 'HYHORSPHQWYRHZVSHURWRFRQ
Objective: 6HWXS RI H[SRQH[LFDXVLRQXVUR WHULD
- 'DWD DFTXLVLWLRQ
Objective: 6HDUFK RI UHOHYDQW HZWWHLDQVXUH
- 'DWD VFUHHQLQJ
Objective: 6FUHHQ IRU LQHYLXZLSHQV WUDFW
- 'DWD TXDOLW\
Objective: \$VVHV V XSHOLW\)XOO WH[W
- 'DWD ([WUDFWLRQ
Objective: 9DOLGDWH DQG FDWHJRUL]H GDWD
- \$QDO\VLV DQG 6\QWKHVV
Objective:)LQGLQJV RI WKH /LQVZDWHVWKH5HYLHZDUFK 4X

&KDSWHU VKRZQVRKHWRB\$OLFDFW\$FX6/5HQWHSHVHQWKH

3 Systematic Literature Review – Method application

,Q FKDSWHU WKH PHWKRQ RI WKH GHVWHPELW F7/KLWHU
VKRZ WKH DSSOLFDFWLRQ RI WKLVPRIWKRQ PIHQFQRQ
UHVHDFK TXHVWLRQ \$OO SURFHVV WWHSHVHJDULQJ I &
DSSOLHG DQG GHVFUQEMKSHVIRSDUFDZLQJ VHFDFWLRQ W

3.1 Problem Statement

7KH DLP RI WKLVPRIWKRQVKRZ over the last years as well
as the technology readiness of specific solutionsSKHUHIRUH WKLV OLWHUDWXU
UHODWHG ZRUN ZKLFK GLUHFWO\ IRU, LQGLWDEOHU DGRG
IROORZLQJ UHVHDFK TXHVWLRQV

- 54 +RZ PDQ\ ZRUNV DGGUHVHVG WKSHF3, LQFQWGL
GHYHORSPHQW RYHU WKH ODVW \HDUV
- 54 :KDW V WKH GHVWHPELWRIIDWKHWH &LQWDEKQHGULMHU
- 54 7R ZKDW H[WHQVSDUHVSIQVIRQDGHGKQWK&RQHW

3.2 Development of the review protocol

7KH ,QWHUQDWLRQDOW3&RQIHQHQW ZB, &SHRIFQHIDQV
VRXUFH IRU SXEOLFDFWLRQV 7KHUHWRUJ, &DUSHBFWHGL
DV D VRXUFHQWIOULWCHUDWXUH
\$V D VHFRRQ VRXUWHUHSXUWHQVHIDQV 228/186K &\$LWUR
SXEOLFDFWLRQV ZHUHQVQHVSQRQDQDQV &OLFDFWLRQV
,Q DGGLWLRQ IXUWHQJUSRVXPUDVPHHQW 6FKZPDNU 5HV
DQG 6FRSXV ZHUHXVSHGEVGHDLQQRQWKWKLWDO ,QWHUQH

ZLWK WKH VXE WRSLQ HW 3K\VLFDQ ,QWHUQHW RU 3, RU Æ
GHILQH

3K\VLFDQ ,QWHUQHW RU 3, RU Æ
DQG

&RQWDLQHUL]DWLRQ
)XUWKHU LW ZDV GHILQH data acquisition (Review 8) FDQ
screening (Review Abstract) ZLOO EH DSSOLHG VLPXOWDQHRXVO\

3.3 Data acquisition

\$V D ILUVW VWHS DOO SRWHQWDO DUHDQW \$FDSHULG
UHYLHZ SURWRRO WKH PDMRU SDUW IRRQWKLLVE DWE RQXOD
,QWHUQDWLRQDO 3K\VLFDQ ,QWHUQHW DRIQRQVHZKLFKDFLY
02'8/86+&\$ SURMHFWLSXZPEFDWL,QQDGRGLQXREHU DPILSXEOLF
DQG SDSHUV ZHUH FROOHFWHG YLWLMWDQGDNG VHQDVRH
GHVFULEHG LQ VHFWRQ
7KLV OLVW RI SXEOLFDWLRQSDQGLQSDZEHVM SXEOLFDWLRQ
YDOLGDSWHG URXJKO\ E\ UHYLHZDQJ DWQH[ZRVVWHSWZKMOHVHD
WR VRUW RXW DOO SXEOLFDWLRQWZSLFKRISUREQDQDGRHQ
VLJQLILFDQW PDWWHU 7KHUHIRUK\VSFSDULVQDGHGQHHW&RQ
FRQWDLQHUL]DWLRQHWLWOGHVZEHWKHQDEGMBUEGXMZLVDHU
OLVW 25 potential publications DQG VHUYHV DVHD IEQVHVWRLWDXULVRQV L
VWHS quality VHH VHFWRQ

3.4 Data quality

7KH ILUVW URXJK UHYLHZ RI WKH SRWHQWLIKROZHSXVACKLFDW
publications SRWHQWLDQO\ WLVJQWKHFWDQVLOA DQGGLKIRQHMDLQWHS,
SXEOLFDWLRQV ZHUH UHYLHZHG LQGHKMDILQF XWRQHWH&RQ
7R UHGXFH WKH QXPEHU RI UHOHYDQWSDQGLQSDMUGRHVQLQRWDQ
UHODWLRQ WR 3, SRWHQWDLQHUL]DWLRQDQVWZSLFKRISUREQDQDGRHQ
PHQWLRQV JHW VWUXFN IURP WKH ORUVW LW KDIDHEYDIQVGBLE
PHQWLRQV RI WKH 3K\VLFDQ ,QWHUQHW&RQMBIGQW&HZLWKH
WKH 3K\VLFDQ ,QWHUQHW IXQGHQWQHWXDO RUW DNDUWKLSXSEOE
XQGHU IXUWKHU FROOHFWLRQDWLRSQGLVWKLKZRZQLQ7DEO

Table 1: List of relevant publications after data acquisition

Source	PI Container as significant content	Comment
Montreuil et al. (2014)	✓	Introduction and development of the concept of Pi Container
Pach et al. (2014)	✓	PI Container as a Hexader for packaging simulations
Walha et al. (2014)	✓	PI Container with different dimensions, mathematical model
Tran-Dang et al (2015)	✓	PI Container with different dimensions for packaging simulations
Tretola et al. (2015)		Definition of Data Sets based on MODULUSCA
Landschützer et al. (2015)	✓	Specific design and prototype of PI Container for field testing

Chakroun et al. (2016)		General description of PI Container
Kaplmüller et al. (2016)	✓	Specific design of a PI Container incl. specific dimensions and functions
Hao et al. (2016)	✓	General description of PI Container, function of PI Container in PI Hub
Salley et al. (2016)		General description of PI Container, focus on information exchange
Faugere et al. (2017)	✓	Description of dimensions and functions
Di Febbraro et al. (2017)	✓	Mathematical Model of PI Container incl. different dimensions
Krommenacker et al. (2017)		General description of PI Container
Tran-Dang (2017)	✓	Description of functions of PI Containers, several simulations
Chargui et al. (2018)	✓	General description of PI Container, function of PI Container in PI Hub
Buckley et al. (2018)	✓	PI Container with different dimensions, mathematical model
CLUSTEC		

5HOHYDQFH RI HQJLQHHULQJ DQG SK\VLFDQ GHVLJQ
VWDJH RI SODQQHQJ DQG GHVLJQ SURFHVV

DKULQJHU HW DO

UHODWHG SHUVSHFWLQJ and Design Process
PHQWLQHG 3, &RQWDLQHUV LQWPLQJ and Design
Process 3DKO %HLW]

- o 3ODQQHQJ DQG FODUL\
- o &RQFHSWXDO GHVLJQ
- o (PERGLPHQW GHVLJQ
- o 'HWDLO GHVLJQ

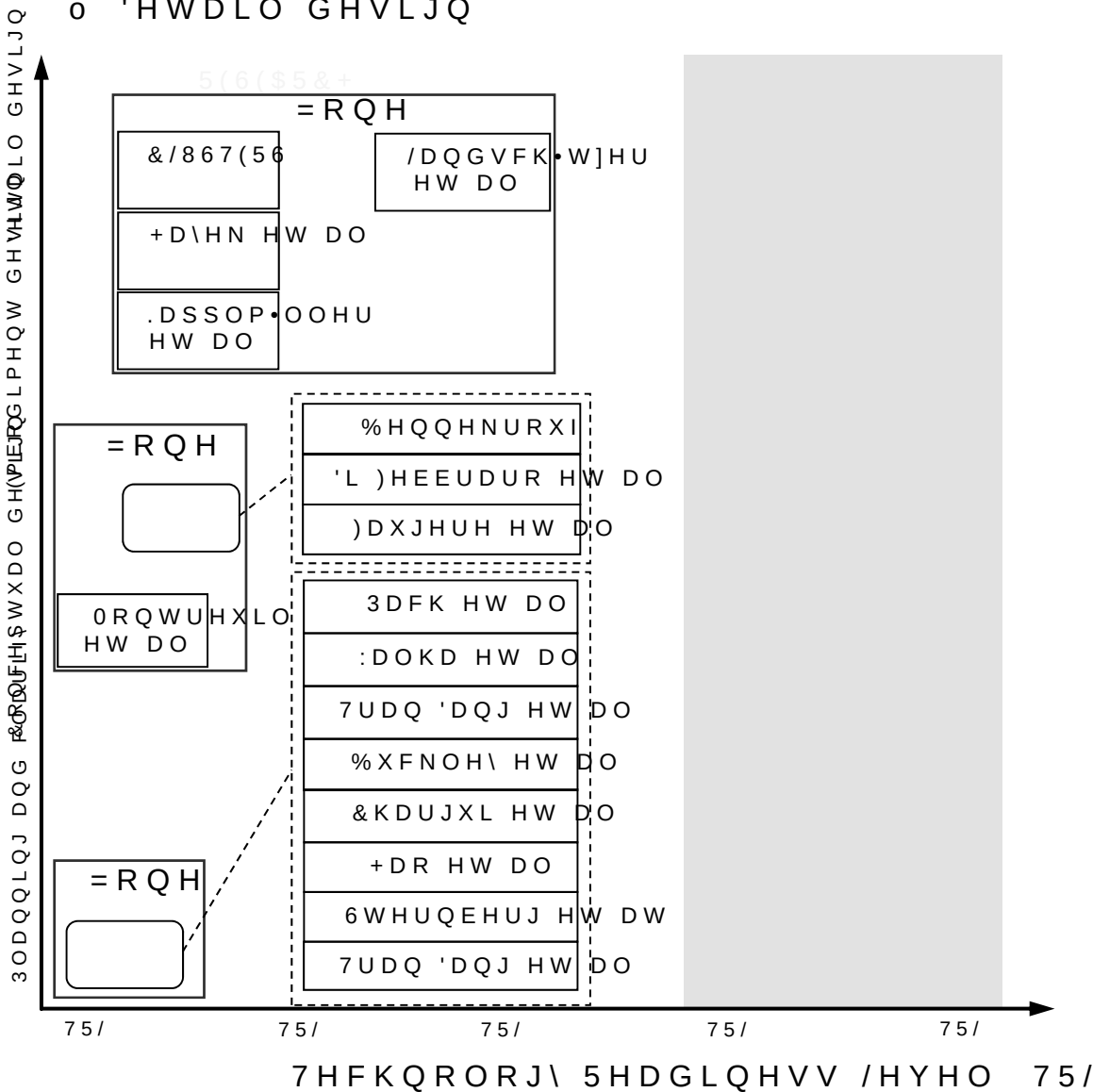


Figure 1: Classification of relevant publications

)XUWKHU WKH UHOHYDQW SDSHUV FDERDQVQJ EMRFDWKHU
SXEOLFDFWLQJ ZKQWKWKHURZVHDQVQJ VFKDFQHGUL

- 54 +RZ PDQ\ ZRUNV DGGUHVHVG WKHLF3, &RQWDLQHUV
LQFOXGLQJ GHYHORSPHQW RYHU WKH ODVW \HDUV

7DEOH VKRZV WKH FDFWHJRULJDWLRQV LQWKH VPHPEULHU
WKH GHJUHH RI VFLHQWLILF LQYHQWLRQV WKH RQFHUHQW
RI 3, &RQWDLQHUV LQWPLQJ and Design Process 3DKO
WDEOH UHSUHVHQWV WKH WRWDOVFKRQVDFR\HODHYDQW S

Table 2: Evaluation of the development of relevant publications from 2014 to 2022.

2014	2015	2016	2017	2018	2019	2020	2021	2022
Montreuil et al.	Landschützer et al.	Hao et al	Tran-Dang	Buckley et al		Sternberg et al.	Tran-Dang et al	Hayek et al.(2022)
Walha et al	Tran-Dang et al	Kapplmüller at al	Di Febbraro et al	Chargui et al				
Pach et al.			Faugere et al					
3	2	2	3	2	0	1	1	0

3.6 Analysis and Syntheses

7KH UHVXOW RI WKH SURFHVVHG 6\VVWLRQDQGR'HXORQSBHQMHULRJ DQVLJQ 5H
IROORZLQJ takeaway

- 2XW RI 300 papers DQG VFLHQWLILF ZRUNV DGGUHVVLQJ , QWHUQHWW 28 publications DGGUHVVLQJ 3, &RQWDLQ HLQ GLWHF VHFWRU
- 2XW RI 125 publications DGGUHVVLQJ 3, &RQWDLQ HLQ HLQ GLWHF VHFWRU XQLTXH VWDWHPHQWV RU QHZ ILQGLQJ EH DFDHU GLQJ papers VHH VHFWRU
- 7KH UHP10 publications ZHUH DQDO\]HG DFFRUGLQJ WR WK 7KLV DQDO\VLV IRFXVVHG RQ WKHLU GHYHODWLRQSRHQQ ZLWKLQ WKH ODVW \HDUV RQ WKH RQH WKHQ DQGR'HXORQSBHQMHULRJ ZLWKLQ WKHRSXVEXDQGR'HXORQSBHQMHULRJ WKH RWKHU

7KH qualitative takeaway, KRZHYHU ZLOO EH VXPPHG XS DQG DQDO\]HG

4 Results

\$IWHU SURFHVVVLQJ WKH VWHSV RD 6\SWUDRWLGRQDQVLJQ 5H FTDX WKH LQYHVWLJDWHG SXEOLFDFWLRQV DQGR'HXORQSBHQMHULRJ DQVLJQ 5H VLPLODU FKDUDFWHULVWLFV

- 7KH 7HFKQRORJLH 5HDGLQHVV /HYHO 75\ ZLWKLQFRIQ LQYHVWLJDWHG SXEOLFDFWLRQV SRORQSDRQFHUMLQ SXEOLFDFWLRQV VKRZ ORZHU 75\ PRSXUEGLFWLPRQ5\ WKH JRDO RI LQWURGXFLLQJ 5HDG\ WRHPSHVIRORWWDA LQ)LJXUH E\ WKHLUHQVLLQJWKHGHSLOR\PHQW VHFWRU
- \$ IHZ LQYHVWLJDWHG SXEOLFDFWLRQV\QDGDURWSHFF SDUDPHWHUV LQWR WKHLU VROXWLRQKLDQGVD\$SRZQ FODVVL\LQJ WKH SXEOLFDFWLRQVWRIRQDQGR'HXORQSBHQMHULRJ ZL VROXWLRQV H[FHHGHG WKH VWDJH RIIWKHHLQRYSHLVQV SXEOLFDFWLRQV DJJH VWXGHNVBWL SWLHRQV DIQV KIIR UFXV IXQFWLRQV RI WKHRSXVEXDQGR'HXORQSBHQMHULRJ GHVLJQ
- 7KH 02'8/86+&\$ SURMHFW\HUDQGR'HXORQSBHQMHULRJ Z FRPELQHV D WKRXJKWIXO GHVLJQDQGR'HXORQSBHQMHULRJ WKHFK UHDGLQHVV OHYHOU 75\QFH+VXHHQ VQRRQXEGHEDVGLIF SXVKLQJ RI SURMHFWWRHRSXVEXDQGR'HXORQSBHQMHULRJ 75\86+&\$ SURMHFWW 75\867(56 ZKLFK FDQ EH VHHQ DV D86+&\$RGRZK\$VS FDWFK XS RQ WKH SUKHVLFYDQGR'HXORQSBHQMHULRJ 3DQGR'HXORQSBHQMHULRJ +RZHYHU WKH 1HZ ORGXODU /RJLVWLFRHQQHMFVHHLQ / GHVLJQ SKDVH DQG GLG QRW OHQJ\WKHRSXVEXDQGR'HXORQSBHQMHULRJ

VKRZV WKH GHWDLOHG GHYHORSPI\$QWWRD WDL R Q & R Q WHNL E
 6WLOO WKLV SXEOLFDWLRQQ WR R Q V W KOH Z P7SR UOWH
 LQWURGXFLOJ W XFW KHR W XMDIQRVSRUW QHWZRUN
 • WKH 6/5 KDV VKRZQUWKDSX EOKLF DQXIPRQV FQWDDLOQHJUL W
 SK\VLFDQ FRQWDLQHUV KDYH LQFUHDVHG LQ UHFHQW V
 •)XUWKHU WKH IRB K W B R Q D G H , Q H C H B Q V K W H F B Q W D H L Q H R U V H K V
 \HDUV 7KLVDQ EH XQGHUOLQHGG E Y D E R I P E L Z K L F K Y V K Z R
 WKDW QHDOU\ DOO VROXWLRQV D Q G L Q F S H S U R D Q K H H G R W R B
 FODVVLILHG DV O R a n n i n g a n d D e s i g n W o r k s s Q V W Z H O O D V 75/

\$OWKRXXJK WKH 3, &RQWDLQHU LV FRQHSRII W K N W P D L Q H S L V F L
 SXEOLFDWLRQV IRFXV RQ PDWFKLQJOBF D V R I Q W D I E Q H G W Y I H P O U
 GHVLJQLQJ EXLO G L R Q W D Q L G H V U V O N Q I E R W F , H Q

5 Conclusion and Outlook

7KH VWUXFWXUH G X D Q W L R Q L W K B Q B G F W K D W Q I G V F D K S H U W K H D 3 , &
 VWLOO VHHPV WR EH VHHQ DV D Q H R E M W F F R X Q G W E K H V H H Q
 SKLORVRSK\ RI 3, D V V X P H V W R D Q F H W W P D L Q H H [W V V Q W W R K D W I
 DQG REMHFWLYHV RI WKH 3K\VLFDQ H Q B W H L Q F D W D Q G H W R H E W
 WUDQVSRUW QHWZRUN +RZHYHU WKK Y L U F D Q V 3 D V L V F D I I R Q W
 &RQWDLQHU (YH Q W K H S D W M S H D H L Q F E L Q H 3, W & R Q W D S Q H U G H F
 TXDOLW\ DQG LQWHQVLW\ 6LQFH 02'8/3,6 & R Q S W I R M Q H W \ S Z H U
 GHYHORSHG GHVLJQHG EXLOW D Q R W H V P R H U G Y L K U W X D Q R Q
 WKHQ RQ 7KLVDQ W K H U H L V D U S H W K R Z F K L Q D S W D L W H S D
 7KLVDQ JDS FRYHUV WKH QHHG IRU H 3, K V X E F D I G , R Q R Q W D I R Q H
 ZHOO DV GHFUHDV L Q W L W K D Q G I R Q W Q R D X Q H U V X F K 3 , &
)XUWKHU WKH WUDQVSRUW QHWZRUN K D V O X Q H Q H J U R Q Y H R D V
 \HDUV H J WKH LQFUHDVLQJ Q X P E F D S D I F 3 R Q L H E D J D Q G L P H W H
 IRU WUDQVSRUWDWLRQ DQG GHOLYHF H S W D Q W H U I R V X Q Q W U L R
 &RQWDLQHU WR W K W Q H L W Z R Q W K D Q W S K S H Q W H Q Q G H W Q H Z D
 DQG GHVLJQ V X J J H V W I L R Q V F D R H V Q Z R W R L Q H W Z R U W U D I Q H S H
 LQWURGXFWRQ R G 3 Q H R Q W D L Q Q U Q R P D Q J E H Q I E W B Q B G H V
 WHVW 3, &RQWDLQHUV IRU WKDW DSSOLFDWLRQ
)RU WKDW UH D V R Q W K H U H Z L O O W H F K R X S O R Q X S K W H L Q G U Q K
 SDSHU DQG WU\ WR ILQG VRPH QHUZSDXFWVL RQ R I F 3, Q D R Q W D L Z
 KHOS WR SXVK WKH 3K\VLFDQ , Q W R H U Q K F K , G H W X U 3 R W H Q M L W
 FRXOG EH

- 7KH GHILQLWLRQ DQG GHVFULSWLRQ Q H W S R I F N I L Z L S W K K
 SRWHQWLDO WKDW WKH XVDJH RIRB, H% R F H L W Q F D Q U H H D Q C
 KDQGOLQJ LQFOXGLS H F W O R S K D V R F D Q R V L W D L Q K U L F D
- 0HWKRGLFDQ GHVQHQ ZKDFB, Q D R Q W D L Q T K L U R I W K H 8 V H &
 GHILQH E H I R U H W L Q S E D X G L Q S Q H R W Q W D W L R Q
- 'HILQLWLRQ RI FRQGLWLRQV DQ G H S W L R Q H H G V B Q & R Q W D I L Q H

6 Acknowledgements

3DUWV RI WKLW ZRUN UHFHLYHG IXQGVQJ ERUW&OL\$XWM
(QYLURQPHQW (Q,QUJRYDWEERQLWQG 7HFKQRORJHVVHDOUFK
ORELOLWIW GHUJEXDQVQIQXPXEQGHU 3K\V,&\$/

7KH DXWKRUV RI WKLW SDSHU UHFHLYHGQSDWNLFXEDULY
IURP KLV H[SHUWLVHVRDQG, JLYQVWLHGLWRULDO VXSSRU

5HIHUHQFHV

- %HQQHNRXIOOptimizing the management of containers for Physical Internet.0DVWHU
7KHVLV 8QLYHUVWLW%RDN\$ERX 7OHPFHQ 8\$%7
- %XFNOH\ 6 0RQWUHXactOf Modular Containerization and Continuous
Consolidation on Hyperconnected PartLogistics Hub Design and Performance^{WK}3K\VLFDQ
,QWHUQHW &RQIHUHQFH ,3,&
- &KDUJXL 7 %HNUDU \$ 5HJKLRAMathematical Formulation and Tabu
Search Approach for the Road-Rail Assignment Problem.3K\VLFDQ ,QWHUQHW &RQ
IHUHQFH ,3,&
- &KDNURXQ \$ \$EEDU + 7DQWVRXQHyperconnected City Logistics and Last Mile
Delivery in Casablanca City.^{UG}3K\VLFDQ ,QWHUQHW &RQIHUHQFH ,3,&
- &/867(56 Specification sheet of designated NMLU(/,9(5\$%/(
)UDXQKRIHU ,0/
- 'L)HEEUDUR \$ *LJOLRTowards the Physical Internet with Coloured Petri
Nets. ^{WK}3K\VLFDQ ,QWHUQHW &RQIHUHQFH ,3,&
-)DXJHUH / 0RQWUHXHyperconnected Pickup & Delivery Locker Networks.^{WK}3K\VLFDQ
,QWHUQHW &RQIHUHQFH ,3,&
- *DUfD \$UFD - &RPHVDxD %HQDYLG\$R \$7 *RUJGRH\$3DQ
: Rethinking the Box forSustainable Logistics.,Q 6XVWDLQDELOLW\
KWWSV GRLRUJ VX
- +DR * *XH . 5A Two-Sided, High-Density Rail-Rail Hub.^{UG}3K\VLFDQ ,QWH
&RQIHUHQFH ,3,&
- +D\HN 0 0DKULQJHU * 6HJQHU 5 /Development of a Physical 6LK
Internet container for an optimized wood supply chainZUDQVSRUW 5HVHDFK \$UHQ
SUHV
- .DSSOP•OOHU + *UDI + & +RHUWBRQRDQ%SmartBox :LGPDQ
an Austrian PI solution leading to small loads mobility.^{UG}3K\VLFDQ ,QWHUQHW &RQIH
UHQFH ,3,&
- .URPPHQDFNHU 1 &KDUSHQVACollective Intelligence Approach for the
Composite PI-Containers Management.^{WK}3K\VLFDQ ,QWHUQHW &RQIHUHQFH
,3,&
- /DQGVFK•W]HU & (KUHQWUDQWainers for the Physical Internet:
requirements and engineering design related to FMCG logisticsQ /RJVLWLFV 5HVHDFK
'2, V (((
- 0DQNLQV - Technology Readiness Levels.GYDQFHG &RQFHSWV 2IILFH
\$FFHVV DQG 7HFKQRORJ\ 1\$6\$

- 0DULQR) 6HLWDQLGLV , 'DR 3DOY %GRQKOTQ Rabling P&DVWROGL towards hyperconnected and interoperable smart containers.^W 3K\VLFD O , QWHUQHW & RQIH
- 0RQWUHXLO Towards a Physical InternetMeeting the Global Logistics Sustainability Grand ChallengeR JLVWLFV 5HVHDUFK
- 0RQWUHXLO % %DOORW Modular Design of Physical Internet Transport, Handling and Packaging Containers WK , 0+5 & 3URFHHGLQJV
- 3DFK & %HUJHU 7 \$GDP ('RPSWH of a potential design approach to solve routing in a rail-road-hub. Rendement et efficacietransport: un nouvel indicateur de performance^V 3K\VLFD O , QWHUQHW & RQIHUHQFH , 3, &
- 3DKO % . %HL Engineering Design: A Systematic ApproachS ULQJHU %HUOLQ
- 6DOOH\ < 3DQ 6 %RQWUHXLO %DOORW Activeness of intelligent Physical Internet containers, Q & RPSXWHUV LQ , QGXVWU\ YROXPH
- 6WHUQEHUJ + 6 'Toward the Physical InternetLogistics Service Modularity and Design Implications, Q -RXUQDO RI %XVLQHVV2 / R JLVWLMEO
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