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Timely Hybrid Synchronous Virtual Networks

Authors

Rasha Ghassan Hasan **Fernando Luis Dotti**

Pontificia Universidade Católica do Rio Grande do Sul (PUCRS)
Porto Alegre - Brazil

PLAN

1- Motivation: Hybrid synchronous models

2- Hybrid Synchrony Virtual Networks

3- Performance Evaluation

4- Related Works

Work motivation: Synchrony in Distributed Systems

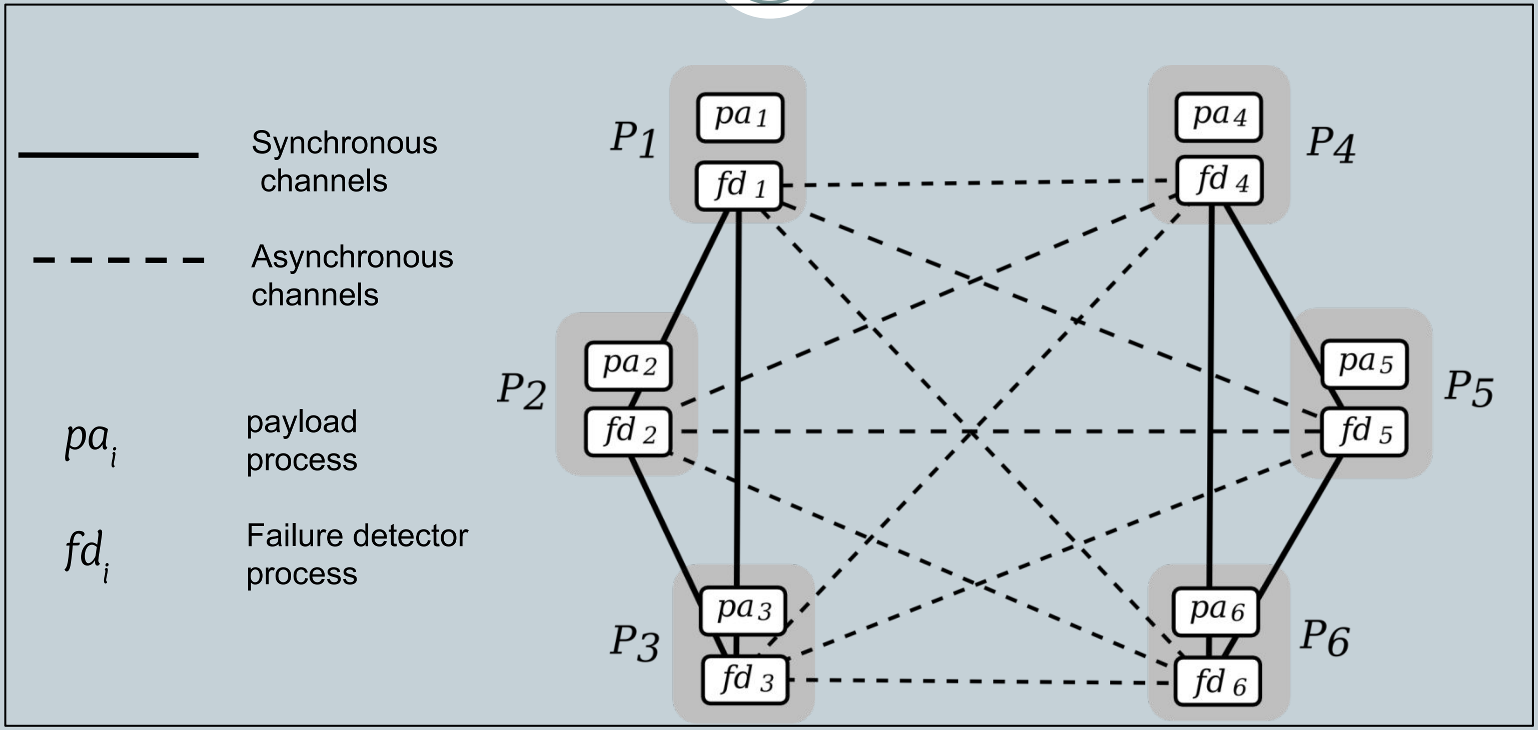
- Distributed algorithms take into account the synchrony level provided by the system

- **Asynchronous systems:**
  - Time bounds do not exist: The processing time and network delay may vary greatly
- **Synchronous systems:**
  - Time bounds exist: processing time and network delay are bounded

- **Hybrid Synchronous model:**
  - Assume intermediate levels between synchrony and asynchrony [1,2]

[1] Schneider, F. B. (1993). Distributed systems (2nd ed.). chapter What good are models and what models are good? ACM Press/ Addison - Wesley Publishing Co.
[2] Chandra, T. D. and Toueg, S. (1996). Unreliable failure detectors for reliable distributed systems. Journal of the ACM, 43(2).

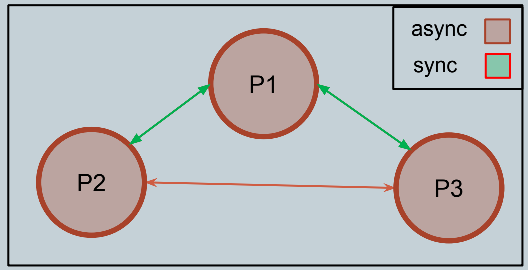
Distributed Systems hybrid in space example: failure detector



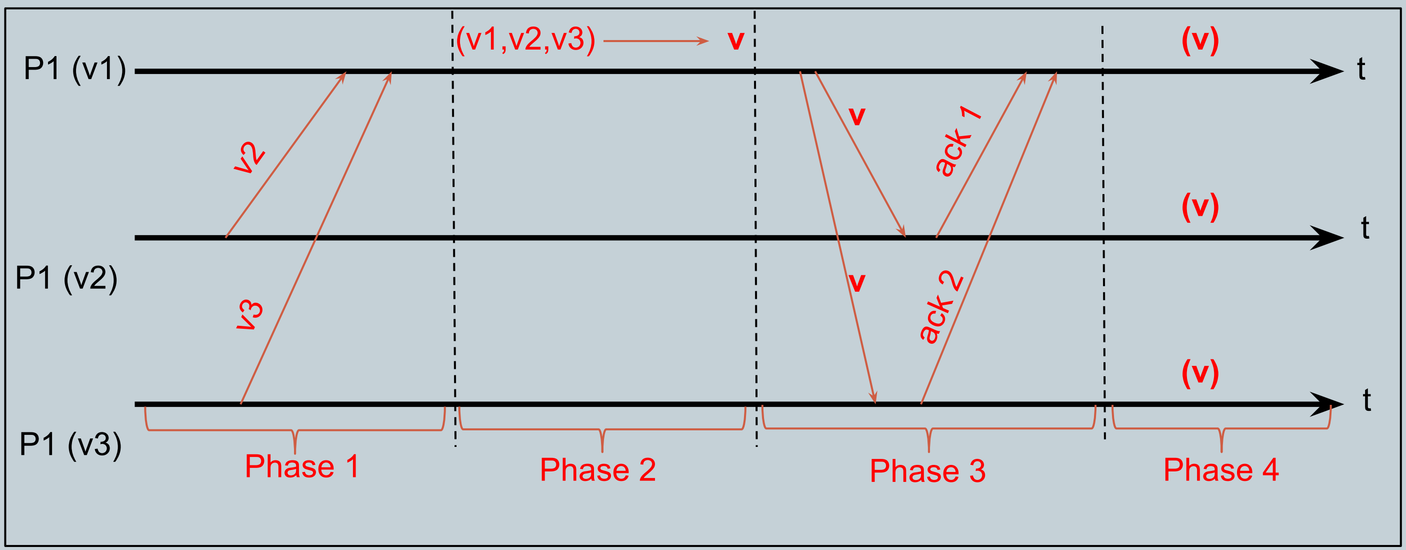
Perfect failure detector on hybrid synchrony environement [3]

[3] R. Macedo, S. Gorender, "Perfect failure detector in the partitioned synchronous distributed system model", In Proc. Of ARES, 2009.
[4] P. E. Verissimo, "Travelling through wormholes: a new look at distributed systems models", ACM SIGACT News , 2006.

Distributed Systems hybrid in time example: consensus problem



Scheme of DS with 3 processes



Consensus algorithm proposed in [5] , first round with P1 coordinator

[5] C. Dwork, N. Lynch, and L. Stockmeyer, “Consensus in the presence of partial synchrony,” Journal of the ACM, 1988

Hybrid Synchrony in time

- ➢The timed-asynchronous model assumes that the system alternate between synchronous and asynchronous behavior [5]

- ➢For each execution, there is a time after which the upper bound δ is respected by the system. This time is called Global Stabilization Time (GST).

- ➢Since the upper bound cannot hold forever, it is accepted that it holds just for a limited time Δ_s .

- ➢In practical terms, Δ_s is the time needed for consensus to make progress or to be reached.

[5] C. Dwork, N. Lynch, and L. Stockmeyer, “Consensus in the presence of partial synchrony,” Journal of the ACM, 1988

Work motivation: Hybrid Synchrony in Practice

➢Many applications benefit from consensus and failure detection as building blocks in the distributed algorithms, for example Apache Cassandra [6]

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[6] Hewitt, E. (2011). Cassandra: The Definitive Guide. OReilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472.

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Hybrid Synchronous Virtual Networks (HSVN)

Virtual Networks (VNs) [7]

Distributed Systems (DSs) with Hybrid Synchrony [1,2]

- share resources→ cost
- tasks distinguishments
- resilience
- resources allocation
- ….

Hybrid Synchrony Virtual Networks

[1] Schneider, F. B. (1993). Distributed systems (2nd ed.). chapter What good are models and what models are good? ACM Press/ Addison - Wesley Publishing Co.
[2] Chandra, T. D. and Toueg, S. (1996). Unreliable failure detectors for reliable distributed systems. Journal of the ACM, 43(2).
[7] N.M.Chowdhury, and R.Boutaba,"Network virtualization:state of the art and research challenges," Communications Magazine, IEEE,vol.47,no. 7,2009

Work history

1. Space_HSVN [8,9,10]

2. Time_HSVN (current work)

[8] Hasan, R., Mendizabal, O. M., and Dotti, F. L. (2013). Hybrid synchrony virtual networks: Definition and embedding. In The Thirteenth International Conf. on Networks.
[9] Hasan, R., Mendizabal, O. M., Oliveira, R. R. D., and Dotti, F. L. (2014). A study on substrate network synchrony demands to support hybrid synchrony virtual networks. In 32o Simp´osio Brasileiro de Redes de Computadores e Sistemas Distribu´ıdos (SBRC).
[10] De Oliveira, R. R., Dotti, F. B., and Hasan, R. (2015). Heuristicas para mapeamento deredes virtuais de sincronia hibrida. In 33o Simp´osio Brasileiro de Redes de Computadores e Sistemas Distribu´ıdos (SBRC), pages 291–304.

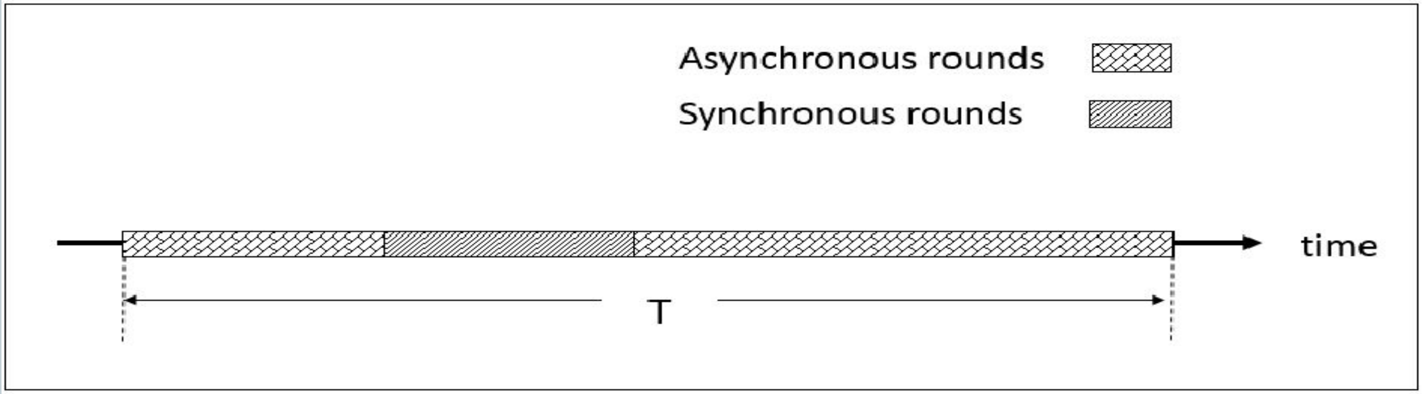
Timely Hybrid Synchronous Virtual Networks Work Contributions

1. Define the assumptions and abstractions needed to characterize both Substrate Networks (SNs) and Virtual Networks (VNs) suitable for Time HSVNs

2. Develope an embedding model for Time HSVNs that
   (i) answers the timely synchronous nature of the system
   (ii) aware of sparing synchronous resources which are relatively expensive.

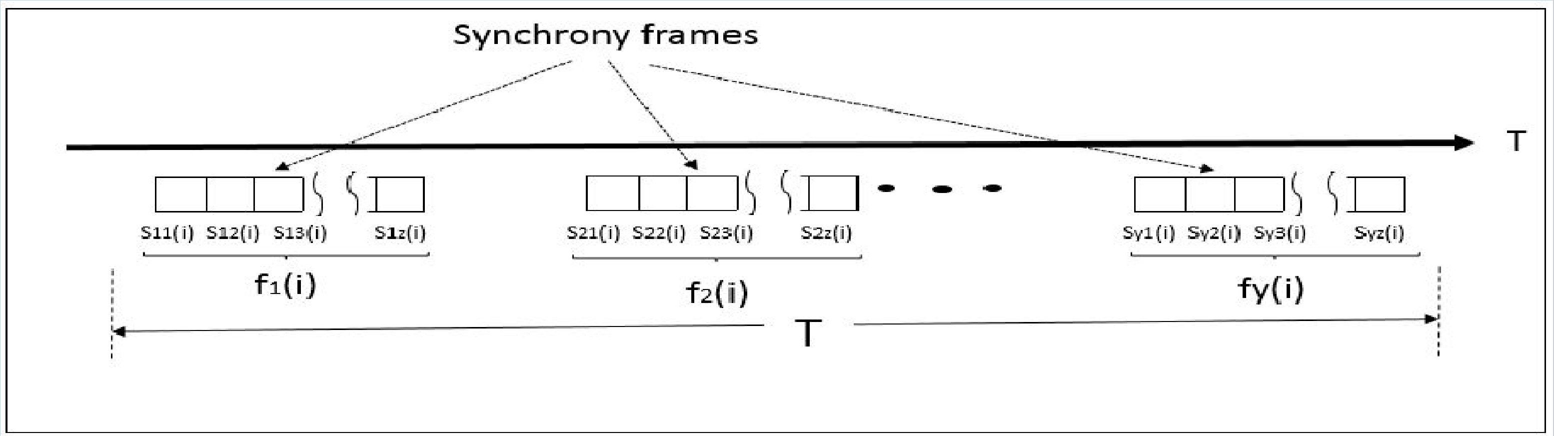
Timely Hybrid Synchronous Virtual Networks
1. Time-HSVN charactarization

- Reflect the nature of timely synchronous distributed systems, which repeatedly demand eventual synchrony during the system life,
- VNs with a cyclic pattern - cycle T time units,
- During T, each virtual node and link demands synchrony once, for a certain period,
- The client needs to be provided the required synchrony eventually within T .



Time - HSVNs cyclic pattern

Timely Hybrid Synchronous Virtual Networks
2. Substrate Network charactarization



Substrate Network design inspired from [11]

- ➢ The HSVNs demand synchrony once during T → 1 synchronous frame / T,
- ➢ The synchronous frame is partitioned into synchronous slots,,
- ➢ The virtual demands mapped to a synchronous slot should not violate the physical BW capacity to eliminate competition and assure synchrony,

[11] Zhang, S., Qian, Z., Tang, B., Wu, J., and Lu, S. (2011). Opportunistic bandwidth sharing for virtual network mapping. In Global Telecommunications Conference, pages 1–5.

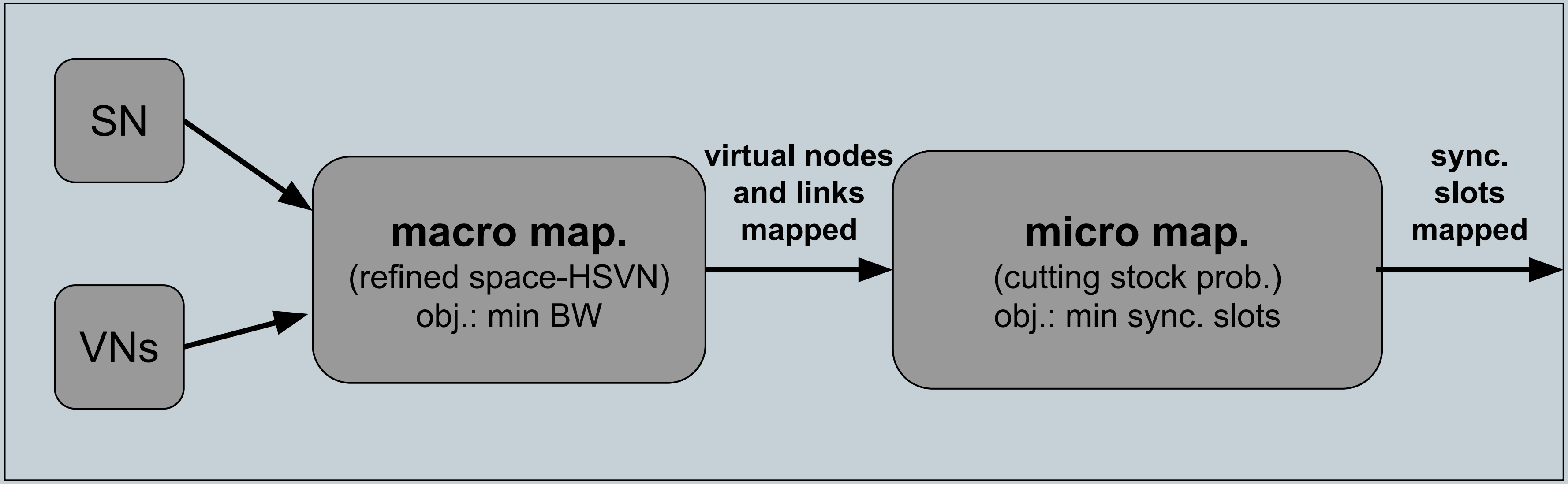
Timely Hybrid Synchronous Virtual Networks
3. Embedding approach

Objective: How to map the virtual synchronous slots to the physical synchronous slots, with the objective of minimizing the mapping cost represented by the used BW?

Approach: 1. refine the model of Space HSVNs mapping [8,9,10]
2. enhanced the achieved solution to allow more VNs to be mapped.

[8] Hasan, R., Mendizabal, O. M., and Dotti, F. L. (2013). Hybrid synchrony virtual networks: Definition and embedding. In The Thirteenth International Conf. on Networks.
[9] Hasan, R., Mendizabal, O. M., Oliveira, R. R. D., and Dotti, F. L. (2014). A study on substrate network synchrony demands to support hybrid synchrony virtual networks. In 32o Simp´osio Brasileiro de Redes de Computadores e Sistemas Distribu´ıdos (SBRC).
[10] De Oliveira, R. R., Dotti, F. B., and Hasan, R. (2015). Heuristicas para mapeamento deredes virtuais de sincronia hibrida. In 33o Simp´osio Brasileiro de Redes de Computadores e Sistemas Distribu´ıdos (SBRC), pages 291–304.

Timely Hybrid Synchronous Virtual Networks
3. Embedding phases



Time - HSVN mapping block diagram inspired from [11]

SN: Substrate Network
VNs: Virtual Networks
BW: Band Width
snc.: synchrony

[11] Zhang, S., Qian, Z., Tang, B., Wu, J., and Lu, S. (2011). Opportunistic bandwidth sharing for virtual network mapping. In Global Telecommunications Conference, pages 1–5.

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Work load and tools

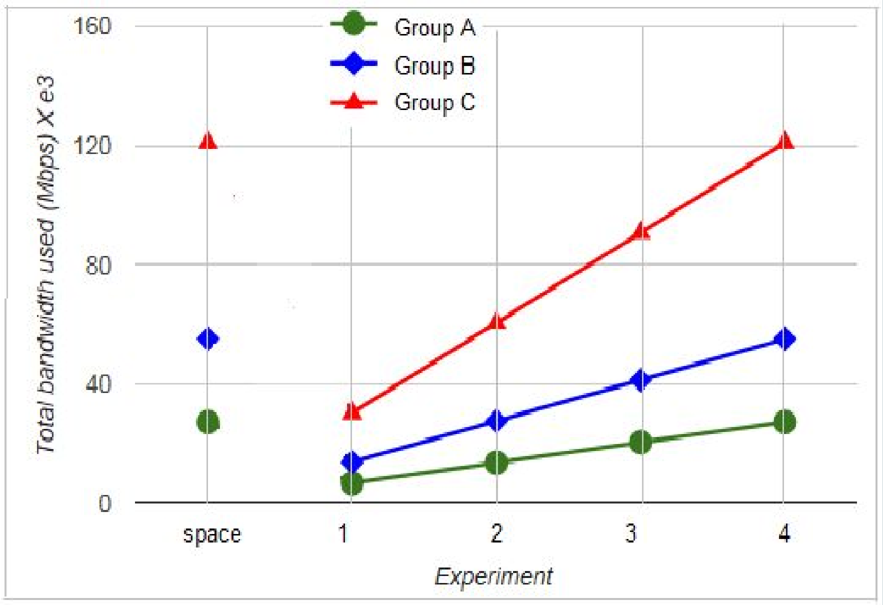
- ➢ MIP implemented in ZIMPL language,
- ➢ BRITE tool for generating topologies,
- ➢ CPLEX optimizer.

Expe.	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4
VN size	10 nodes				20 nodes				30 nodes			
Virtual links sync. slots	1	2	3	4	1	2	3	4	1	2	3	4
Virtual nodes sync.	1 slot per T											
each VN size	3,4,5 nodes											
VNs BW	uniformly distributed: 100Mbps-1Gbps											
VNs CPU	10,15,25 % of SN nodes CPU											
SN size	15 nodes											
SN BW	uniformly distributed: 1 Gbps-3 Gbps											
SN CPU	nodes fully free initially											

Experiments parameters

MIP: Mixed Integer Program
ZIMPL: Zuse Institute Mathematical Programming Language
BRITE: Boston university Representative Internet Topology gEnerator

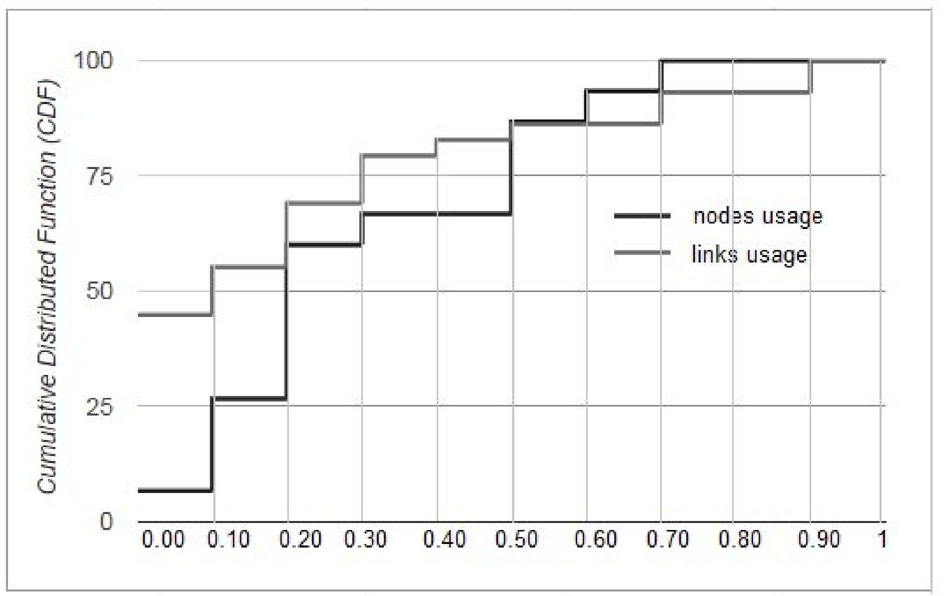
Used bandwidth



Used bandwidth

- within each experiment's group, the BW used with the space model is equal to the maximum BW used within the group, and the spared ratio increases when the synchronous demands within T decreases.

Resources usage



Cumulative Distributed Function for resources usage in exp. C2

- The Substrate Network resources seem to have load distribution

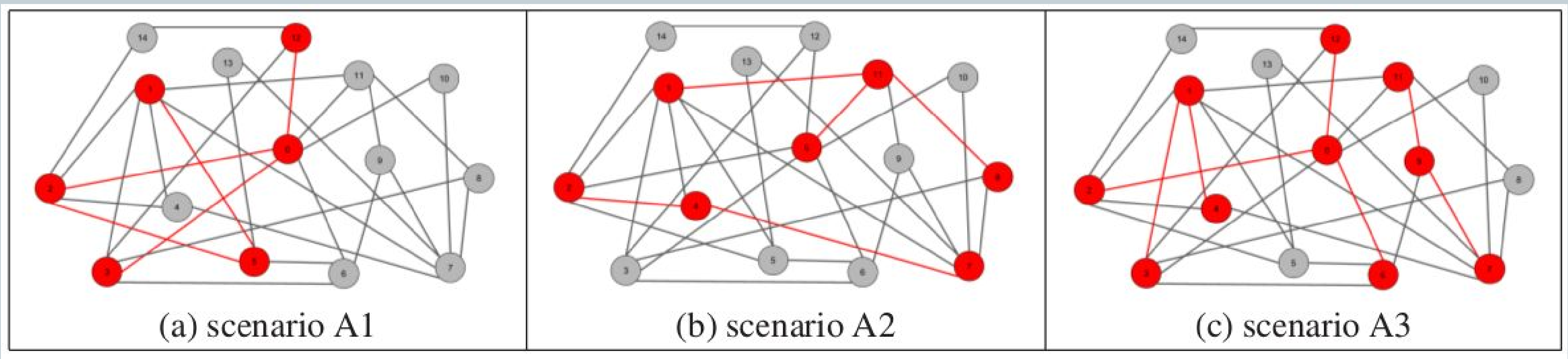
Embedding time

Group.	space	exp.1	exp.2	exp.3	exp. 4
A	0.13	0.07	0.08	0.09	0.19
B	0.75	1.46	1.16	5.31	18.13
C	8	15.09	46.55	65.95	38.89

Optimization time (in minutes)

- most of the scenarios demanded optimization time that is less than 20 minutes,
- The time model demands more time than the space model. And we notice that the difference between both increases with the increment of the problem size.

Topological study



Topology divergence of used physical resource

- ➢ The model tends towards reserving more physical elements with the increment of the synchronous slots demanded by the VNs,
- ➢ the model tends also towards distributing the synchrony load.

Micro - phase effeciency

Scenario	VNs load/SN capacity	$sync(i^k, j^k)$=1,2,3 slots	$sync(i^k, j^k)$=1,2 slots	$sync(i^k, j^k)$=1 slot
K	(0-20] %	9	13	16
L	(20-40] %	6	8	12
M	(40-60] %	5	6	8
N	(60-80] %	1	2	4
O	(80-100] %	1	2	4

Number of mapped virtual links with different load and synchrony demands

- The efficiency decreases when the virtual links load increases,
- the efficiency increases when the maximum number of synchronous slots demanded decreases,
- the micro model efficiency is the same in group N and O: both groups are with high virtual links load → NO slots sharing → NO optimization for the macro-map solution.

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Related Works

→ Xie, D., Ding, N., and Hu, Y.C. andKompella, R. (2012). The only constant is change: Incorporating time-varying network reservations in data centers. In SIGCOMM 12.

→ Zhang, S., Qian, Z., Tang, B., Wu, J., and Lu, S. (2011). Opportunistic bandwidth sharing for virtual network mapping. In Global Telecommunications Conference, pages 1–5.

→ Zhang, S., Qian, Z., Wu, J., and Lu, S. (2012). An opportunistic resource sharing and topology-aware mapping framework for virtual networks. In Proc. to IEEE INFOCOM conference, pages 2408–2416.

→ Zhang, S., Qian, Z., Wu, J., Lu, S., and Epstein, L. (2014). Virtuail network embedding with opportunistic resource sharing. IEEE Journal of Transactions on Parallel and Distributed Systems, 25(3):816–827.

Conclusion

Timely Hybrid Synchrony Virtual Networks

- What ?

Virtual Networks with subsets of nodes and links that eventually obey time bounds for processing and communication

- Why?

Hosting distributed systems with hybrid synchrony in time with while economizing the use of the synchronous resources

- How?

→ A substrate network with hybrid synchronous resources in space
→ embedding model that uses the synchronous resources attentively

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rasha.hasan@acad.pucrs.br
fernando.dotti@pucrs.br