Supercomputing applied to Parallel Network Simulation

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Summary

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- Problem Statement
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- Analysis of the Parallel Simulation
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Introduction

- Simulation provides the basis to understand different system behaviors that are too complex.
- The actual research in networking requires a huge complexity in the models that must be simulated.
- The simulation usually are under conventional sequential simulation techniques.
- The capabilities of those techniques are inadequate to address large-scale simulation requirements, and the parallel simulation techniques must be brought to bear on these challenges.

Problem Statement

- Nowadays, large-scale network scenarios should be executed in a single processor with a single memory space.
- This is possible if the the scenario to resolve is a small and it does not have high traffic requirements or a large number of nodes in the simulated network.
- It is widely acknowledged that the capabilities of conventional sequential simulation techniques are inadequate to address the large-scale simulation requirements (memory and computation time).

Problem Statement

- Parallel and distributed approaches allow resolving large scenarios which cannot be resolved on a single machine (due to memory and computation time lacks).
- Parallel and distributed discrete-event simulations can be described in terms of logical processes that communicate with each other through message passing .
- To process the discrete-events produced in the simulation, the local processor implements a local clock witch execute the events according to it.

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Problem Statement

- These synchronization mechanisms are divided in three categories:
  - conservative - avoid the possibility of causality error occurrence.
  - optimistic - allow for the occurrence of causality errors.
  - lookback-based - allow considering only causality errors (require rollback but no anti-messages)

Parallel Network Simulators

- Nowadays, different network simulators offer the possibility to execute parallels or distributed simulations.
- The most extended simulators in the networking research are:
  - NS-2
  - NS-3
  - Omnet++

Parallel Network Simulators

- NS-2 is an open source object-oriented network simulation tool, which is used in academic research widely.
- The Parallel and Distributed NS-2 (PDNS) is an extension to the NS-2 simulator for parallel and distributed simulation of wired networks.
- It divides a model of a network in to models of subnet works and assigns each subnet to a separate logical process (LP).
- The LPs use a conservative approach for synchronization.
- It is based in an implementation of the RTI libraries.

Parallel Network Simulators

- NS-3 is a discrete-event network simulator for Internet systems. It is a new simulator (not backwards-compatible with NS-2).
- The distributed and parallel implementation is based on the null message algorithm. Basically, the network is split in partitions which have their own event queues and clocks.
- The event queue of each partition can then be processed until the partition clock has advanced to a date which is defined as the maximum date before neighboring nodes may send the new events.
- It is based on MPI libraries.

Parallel Network Simulators

- Omnet++ is a discrete event simulation environment. It is used not only in communication networks simulations (mainly) but also it has been successfully used in other areas.
- The distributed and parallel implementation is based on the null message algorithm as well as ideal simulation protocol.
- It is based on MPI libraries. An alternative communication mechanism is based on named pipes, for use on shared memory multiprocessors without the need to install MPI. Additionally, a file system based communication mechanism is also available.

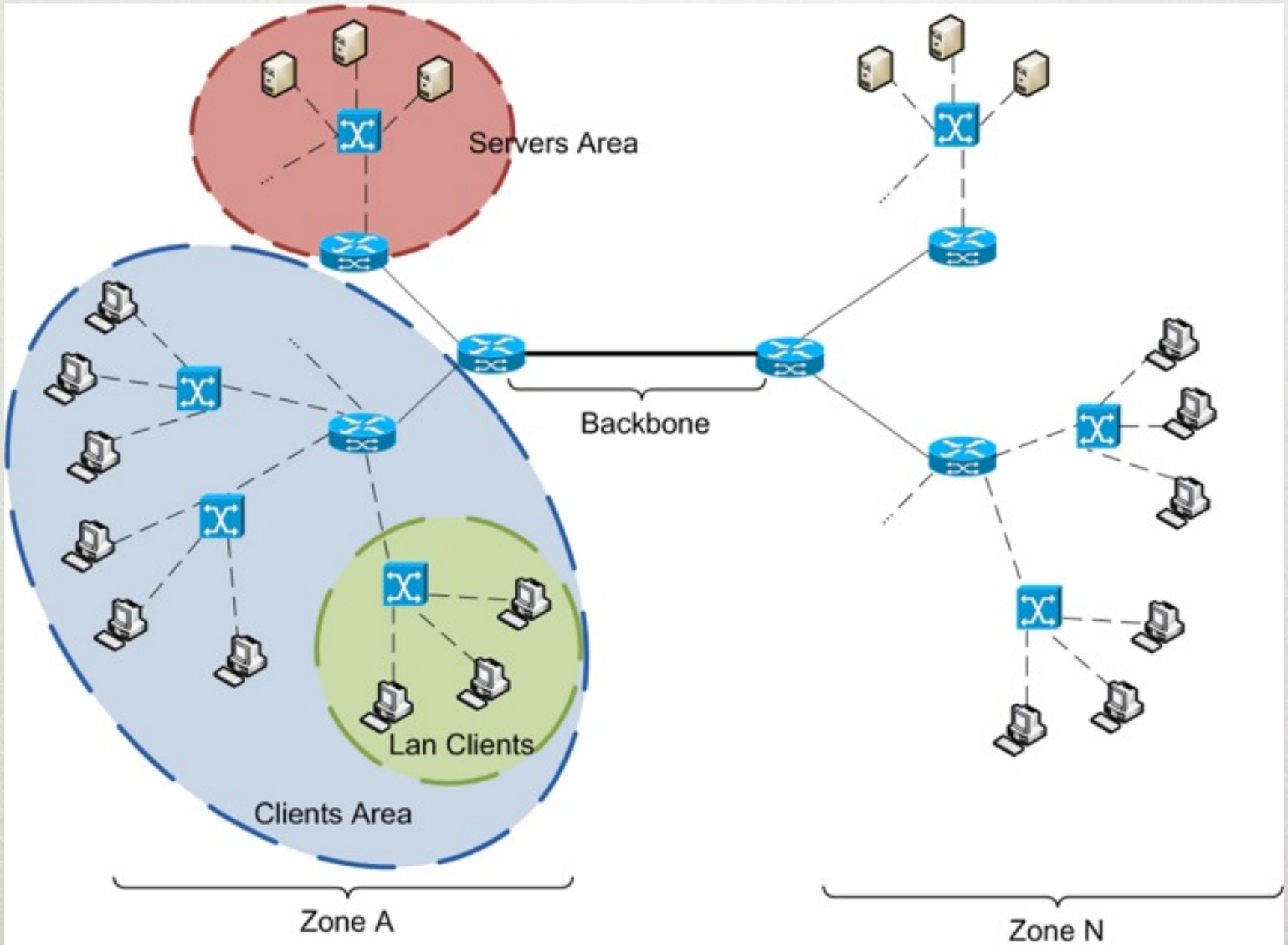
Parallel Execution in the supercomputer

- We have deployed the parallel network simulators presented on the last section in Lusitania Supercomputer.
- Lusitania is composed by 2 HP Integrity Superdome sx2000. Its main characteristics are:
  - 256 Cores @ 1,6GHz
  - 2 TB Ram memory
  - 265 TB Disk memory

Parallel Execution in the supercomputer

- Lusitania is a shared memory supercomputer with architecture MIMD (Multiple Instruction Multiple Data).
- This implies that all the processors can direct to the whole memory installed to the supercomputer (2 TB).
- In this paper, we have made different simulations using NS-3 in Lusitania Supercomputer to study the impact of the supercomputers in the simulation.

Parallel Execution in the supercomputer



Analysis of the parallel Simulation

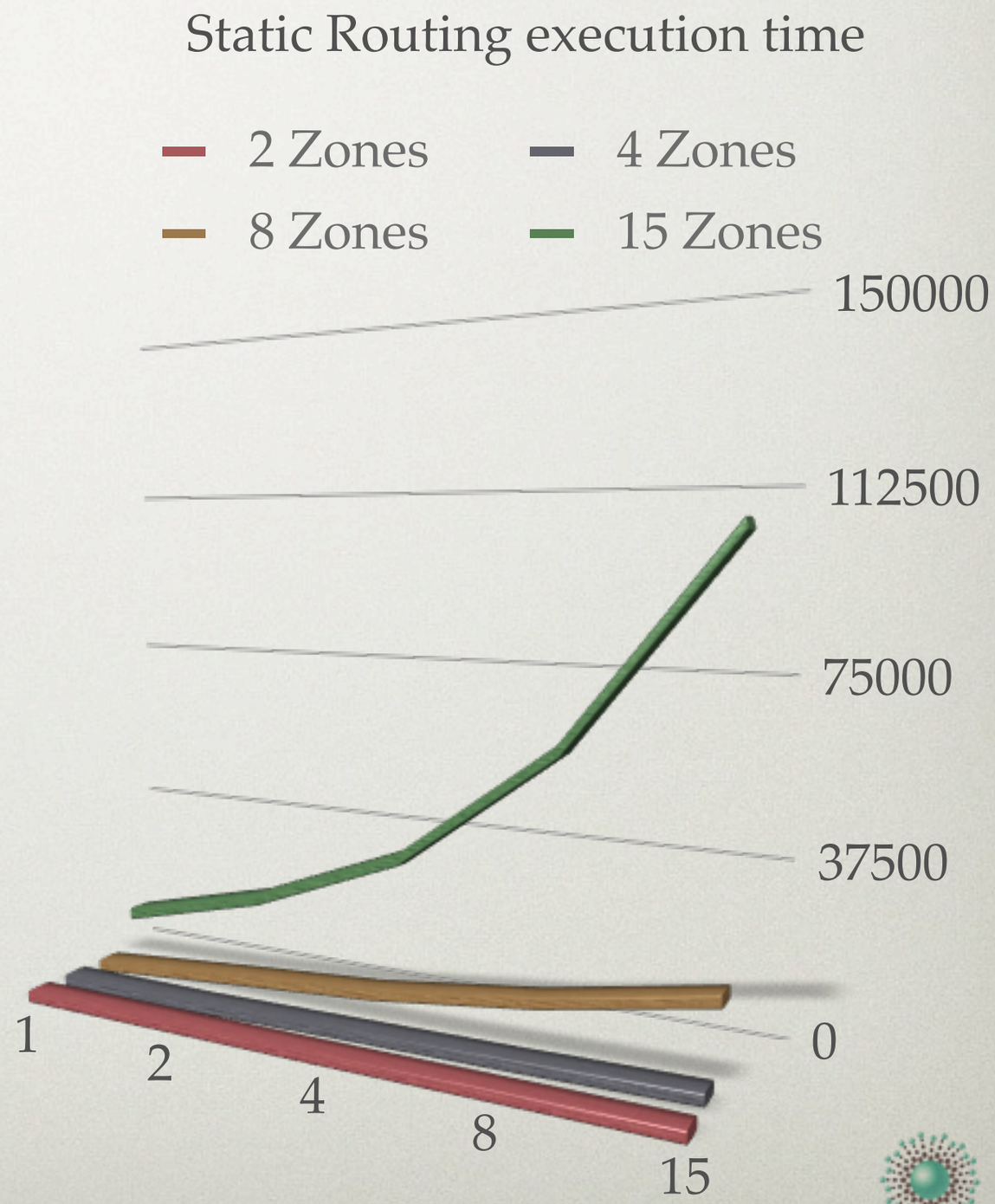
- The main objective of the analysis is to measure the benefit introduced when the simulation is parallelized, using different data conjuncts and distribution in the topology.
- To organize the results, we have compared:
  - two routing methods: dynamic and static method.
  - communication method between logical processes (LPs): communication in the same zone, communication between zones.

Analysis of the parallel Simulation

- The performance of the scenario parallelization hardly depends of the routing method chosen.
  - static routing method calculate all the possible routes of the network scenario when it is loading in memory.
  - dynamic routing method calculates all the routes of the packets in execution time and the resolution of the problem is faster.

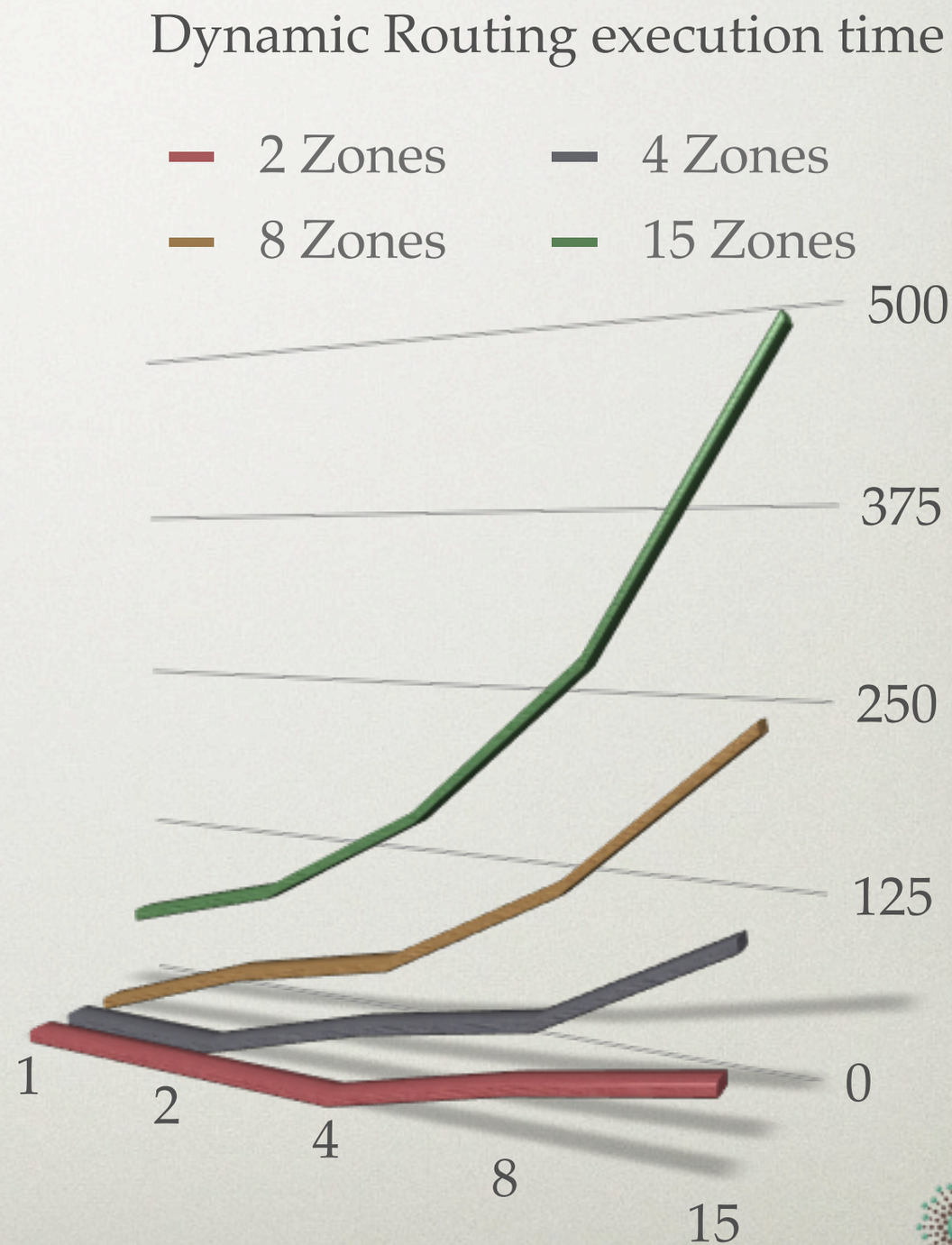
Analysis of the parallel Simulation

- Static routing method increases the resolution of the simulation in large partitioned scenarios.



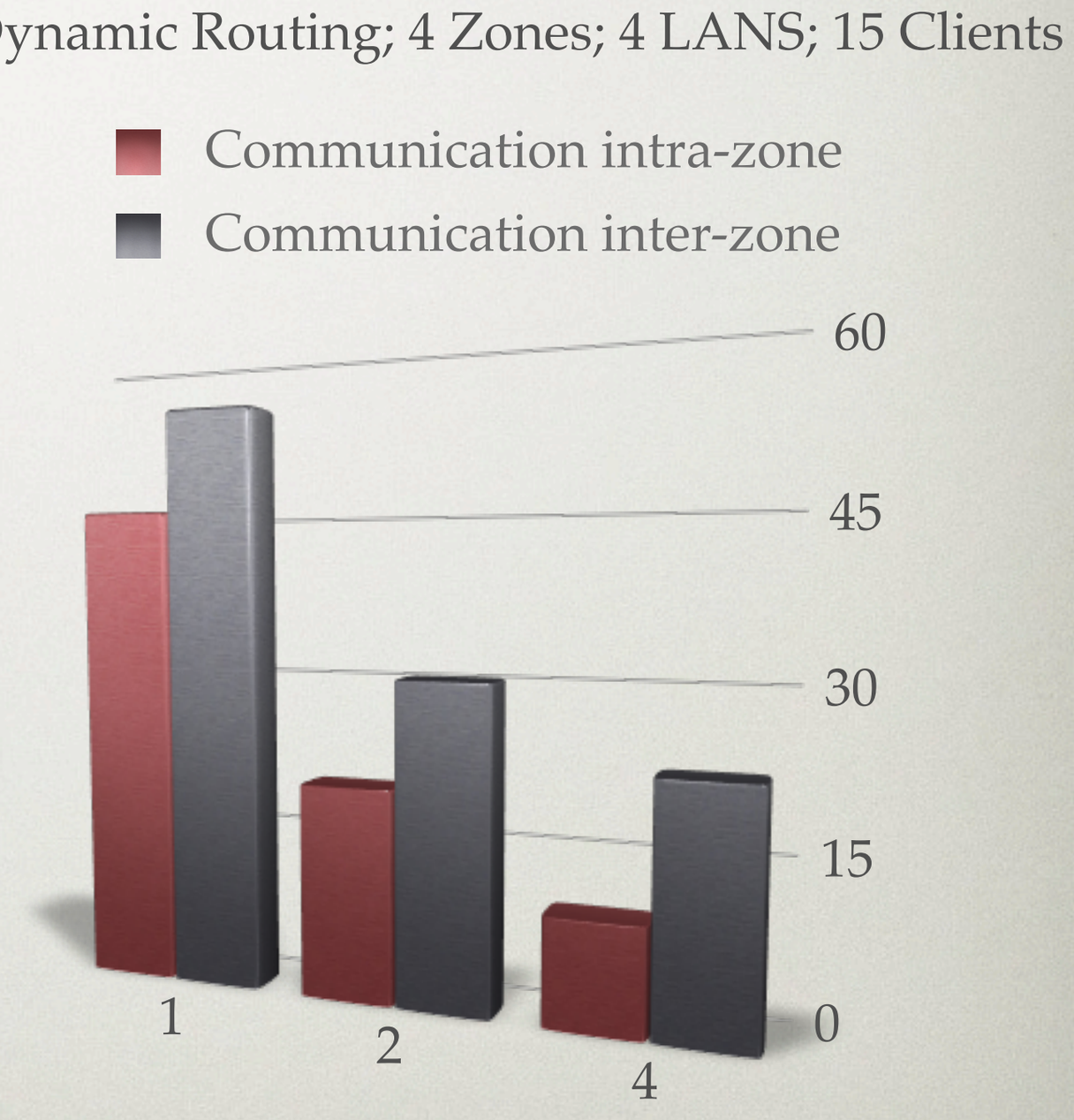
Analysis of the parallel Simulation

- the resolution time in static routing is larger due to the pre-calculation realized to obtain the routing tables of all the nodes in the scenario.



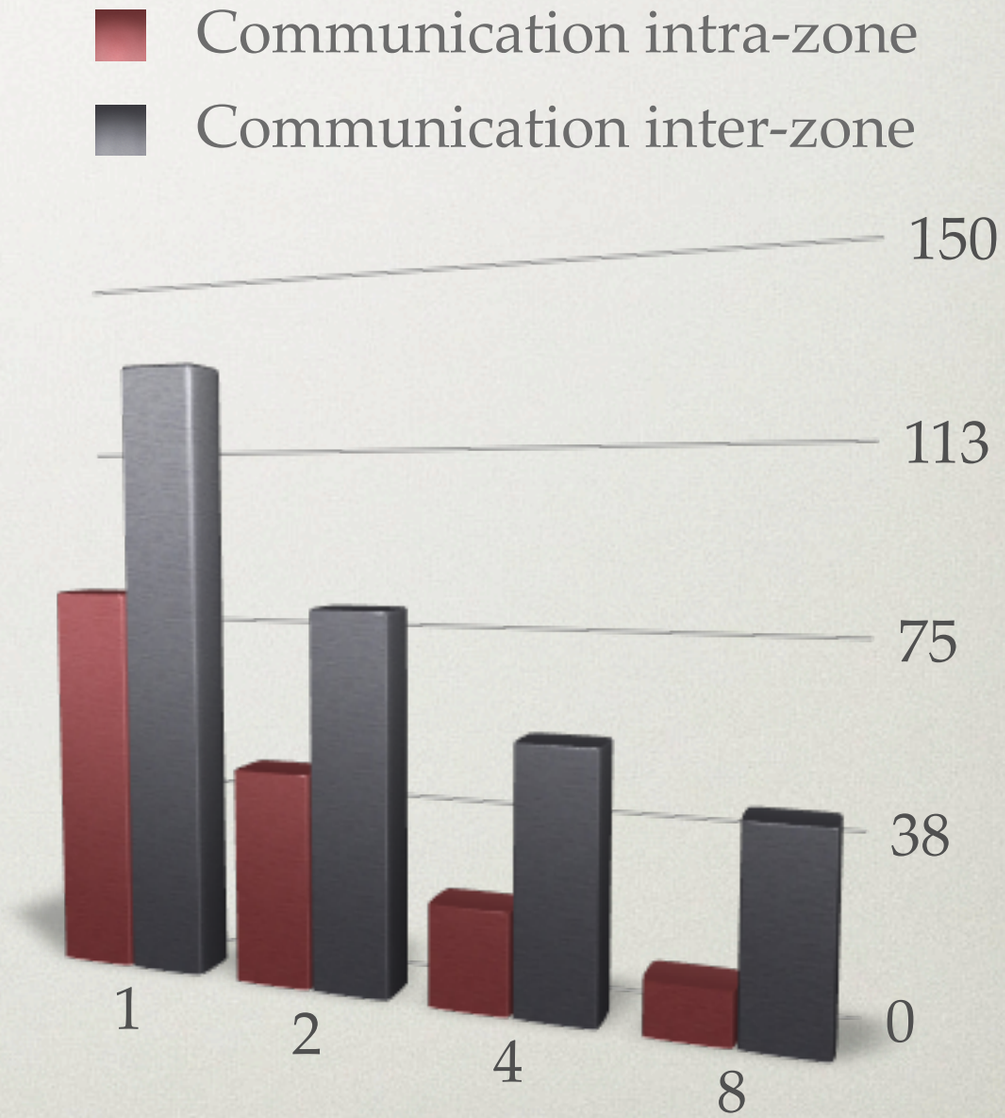
Analysis of the parallel Simulation

- When the scenario grows, the time taken to resolve the simulation in the inter-zone communication grows.



Analysis of the parallel Simulation

- In this Figure the time have been increased due to the increment of inter-zone packets sent.



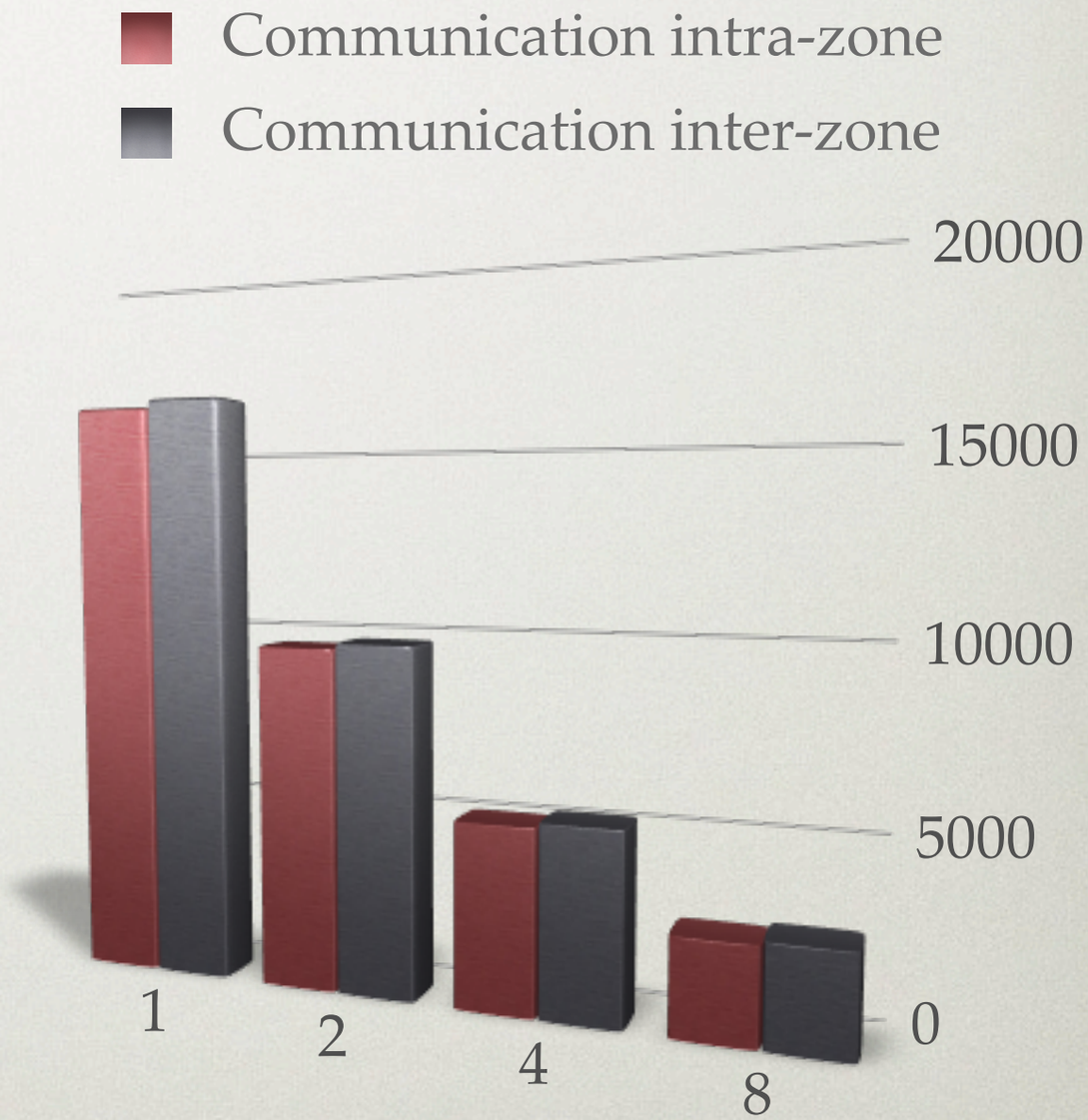
Analysis of the parallel Simulation

Performance at inter-zone communication

	1 Proc	2 Proc	3 Proc	4 Proc
Impact of the communication	0%	6,49%	22,12%	27,02%

Analysis of the parallel Simulation

- In static routing method, the inter-zone and intra-zone communication are similar due to the penalty introduced by the calculation of the routes in the loading phase



Analysis of the parallel Simulation

Improvement at intra-zone communication

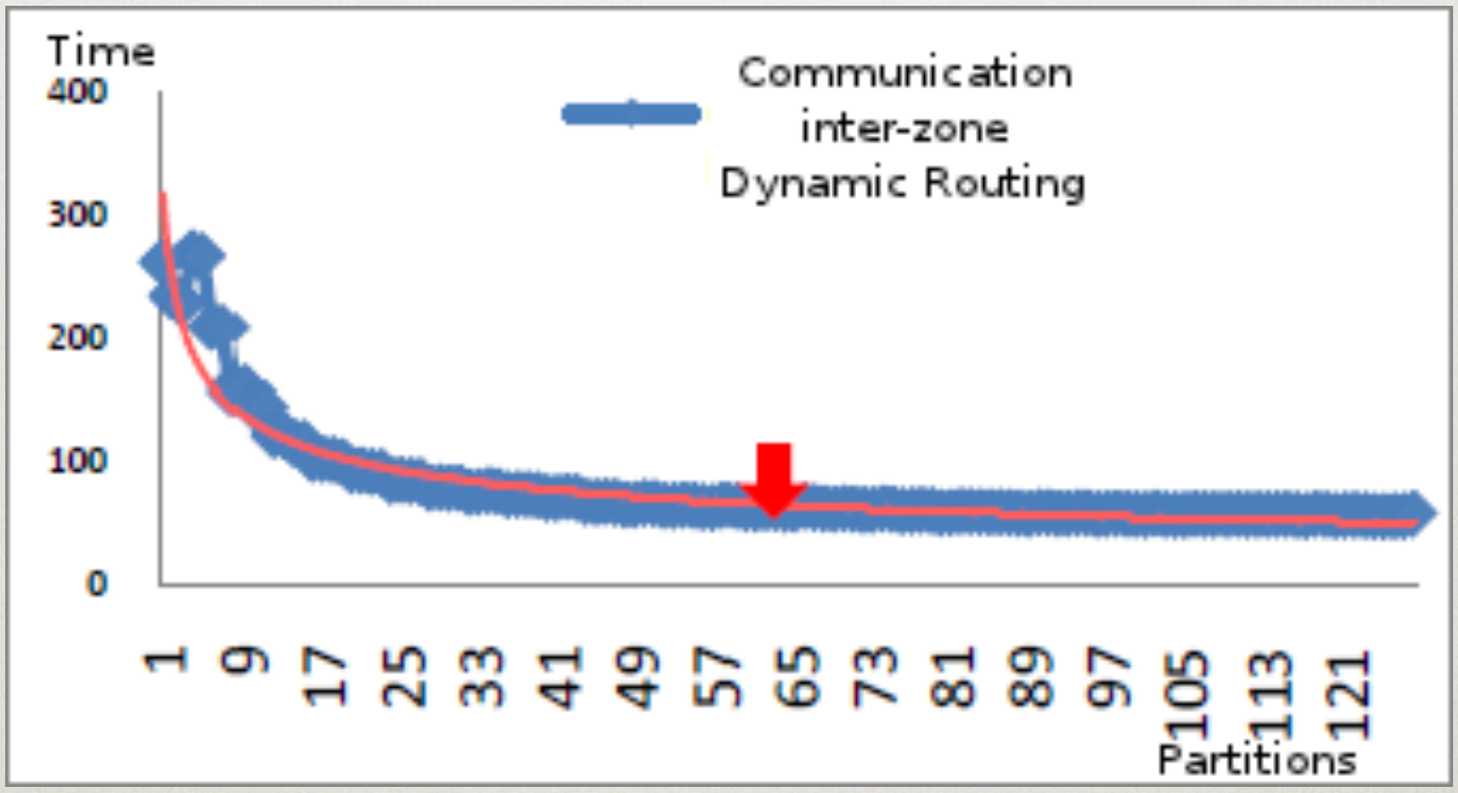
Zone	1 Proc	2 Proc	4 Proc	8 Proc	15 Proc
2	0%	50,89%	-	-	-
4	0%	51,16%	74,94%	-	-
8	0%	51,49%	75,12%	86,91%	-
15	0%	48,57%	73,79%	85,99%	92,64%

Analysis of the parallel Simulation

Improvement at inter-zone communication

Zone	1 Proc	2 Proc	4 Proc	8 Proc
2	0%	44,89%	-	-
4	0%	42,59%	58,02%	-
8	0%	44,53%	53,56%	65,49%

Analysis of the parallel Simulation



Conclusions and Future Works

- Traditionally, the researchers use the simulation as a method to validate their new protocols and proposals.
- With the parallel and distributed approach the simulation of a network scenario resolve the complexity of the problem.
- We have adapted and deployed NS-2, NS-3 and Omnet ++ in the Lusitania Supercomputer to make complex simulations.
- With the simulation platform deployed in the supercomputer, we want to develop a framework to predict the network usage in the future using the supercomputer and establish the technical and the investments needed to afford the requirements in the future Internet.

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Thanks for your attention

Questions?