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# SCTP, XTP and TCP as Transport Protocols for High Performance Computing on Multi-Cluster Grid Environments

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## Agenda

- Motivation
- Introduction
- SCTP and XTP Characteristics
- Related Work
- Experimental Environment and Results
- Conclusions and Future Work

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## Motivation

- *Multi-cores* and *multi-processors loosely coupled architectures* are being considered interesting commodity-off-shelf architectures *to build multi-cluster configurations* as *grid environments*.
- These grid environments have some *challenges to be circumvented*, examples of some obstacles are:
  - *Heterogeneity* of computational resources (e.g. *operating systems, processors*);
  - Different *programming paradigms*; and
  - *Network protocols*.

## Motivation

- *Transport protocols* are especially important, because those have a

*direct impact*

on the *execution of distributed* engineering and scientific *applications*.

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## Introduction

- In the literature, it is possible to find *two different research groups* attempting to solve the network protocols previous commented:
  - The *first group* is characterized by a *general research* on how to *improve* the *efficiency* on *existing* protocols or even *new proposed protocols*.
  - The *other research group* is characterized by their focus in a *more specific aspects* related to *high performance computing*.

## Introduction

- In this research work it is presented *an experimental study* in the utilization of the *SCTP, XTP and TCP* as transport protocols to *support applications over multi-cluster* configurations.
- Our experimental environment, *different from previous works, does not* have a *laboratory boundary*.
- In other words, *our experiments* were realized in *a large organization* considering a *day-to-day basis* of routers, switches, and firewalls with *unpredictable workloads* and *latencies*.
- Therefore, the *idea was* to evaluate some transport protocols for HPC that could *gather computational resources* on a *real environment* to execute distributed and parallel applications.

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## SCTP and XTP Characteristics

- The *Stream Control Transmission Protocol* (SCTP) is a *message-oriented reliable* transport protocol that *operates on the top of an unreliable connectionless packet* service such as IP.
- The SCTP is a *session-oriented protocol* that creates *n multiple independent logical* streams endpoints.
- The *protocol enhances the throughput* allowing *parallel connection* without the necessary use of multiple sockets connections.

## SCTP and XTP Characteristics

- The *Xpress Transport Protocol* (XTP) is a *transport layer* protocol which brings new features, when compared to conventional transport protocols such as TCP and UDP, such as:
  - Multicast and management of multicast group;
  - Support to priority;
  - Transmission control rate;
  - Selective retransmission.
- *This protocol* was primarily *conceived* to be employed *in specialized high performance networks*.

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## Related Work

- Several ongoing investigations focus on the efficient utilization of *computer* and *communication networks*.
- There are *broadly two different schools* researching this problem:
  - One group considers a more general use of the network .
- In other words, *this school does not have a specific application focus*. As a result, the objective of this group is to provide:
  - A *better throughput* with a *low latency* for different applications.

This could be a *serious drawback* for a *distributed and parallel application* if no *QoS* (Quality of Service) policy *is adopted*.

## Related Work

- In contrast, the *second group* is concerned with *distributed and/or parallel applications*.
- These efforts are *interesting for scientific and engineering applications* which rely on local clusters to be executed.
- However, *proposals are in initial stages* and *proposed solutions are for specific infrastructures*.
- Therefore, when *considering multi-cluster configurations* as grid environments to execute distributed applications *it would be better to have a hybrid investigation:*
  - *The use of a general proposal new protocol on a commodity distributed configuration for the execution of distributed applications*

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## Experimental Environment and Results

- Considering fig. 1. as an *ideal multi-cluster* as a grid configuration, it would be desirable that this multi-streaming application could be supported for transport protocol which could prove this facility.
- In addition, it would be also desirable the same service when any congestion occurs in the network.

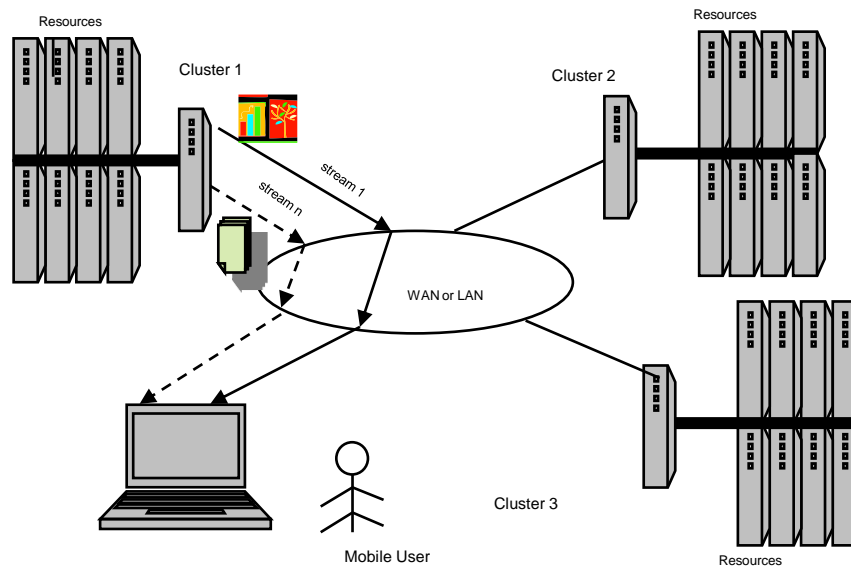


Fig. 1: A multi-cluster grid configuration example

## Experimental Environment and Results

- *Figure 2* illustrates the *testbed* with all available resources. The VO of our grid was formed by four multi-cluster configurations (i.e. *Alfa*, *Beta*, *Gama* and *Delta*).
- The multi-cluster configurations shown in *figure 2* have a *similar function* to those *from fig. 1*. However, *a differential aspect* is related to *unpredictable workload* and *latency* from the networking.

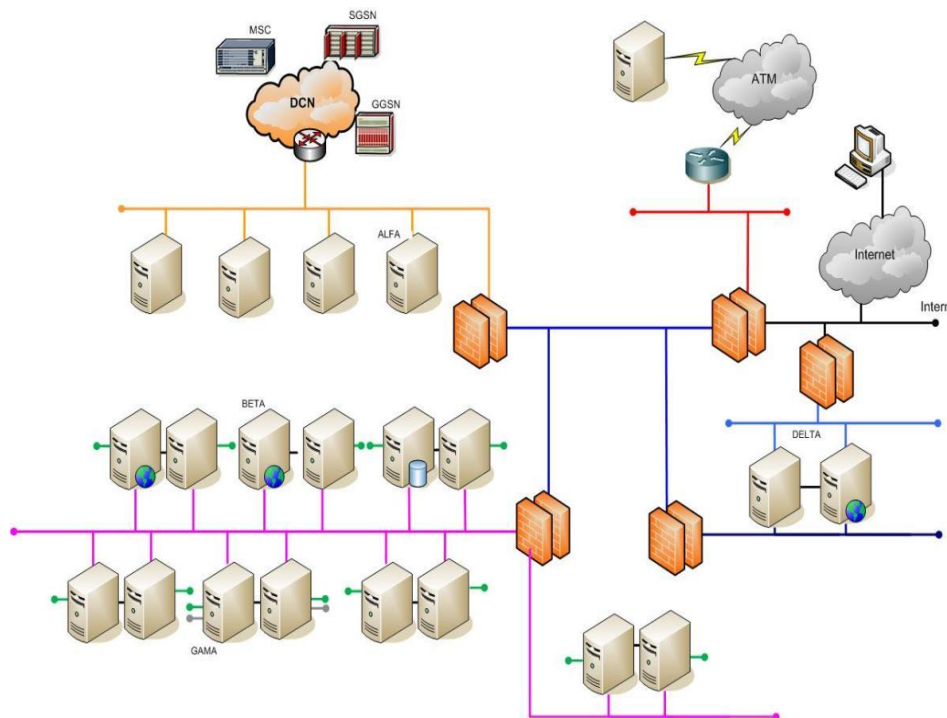


Fig. 2: Real multi-cluster environment

## Experimental Environment and Results

- All results present in the following figures *represent measurements* from the *inter-communication* between machines within the *Alfa* and *Delta clusters*.
- This *inter-communication* is *representative* in the *multi-cluster configuration* presented in *figure 2*.

## Experimental Environment and Results

- Figure 3 shows the *throughput* and *flow performance* of the *three tested protocols*.
- In theory, it was expected that *SCTP perform better*, since *multiple flows* are an inherent characteristic of SCTP. *However*, the *security facility* has a *drawback effect on this protocol* in these experiments *especially because two firewalls* exist between the two clusters.
- We discovered that the *CRC-32c checksum calculation* and *package splitting penalized* the *SCTP* and *XTP* protocols.

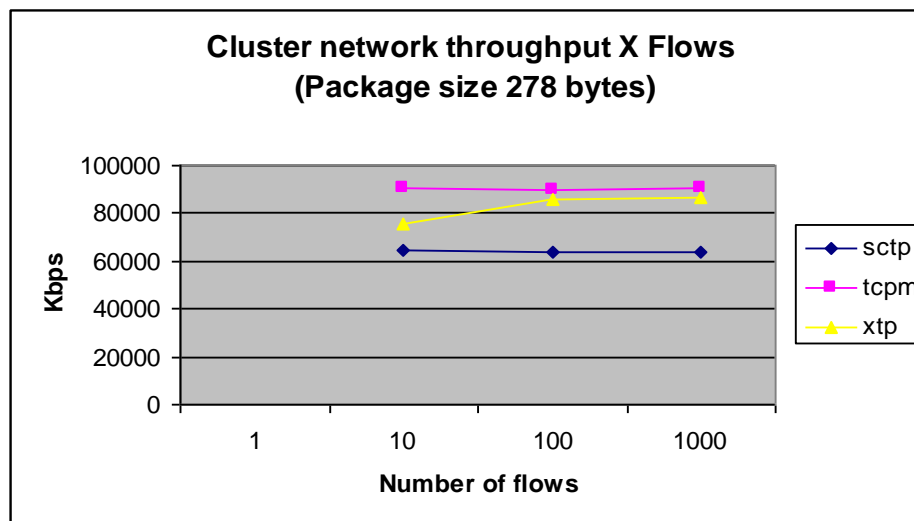


Fig. 3: Cluster network *throughput x flow 278 bytes*

## Experimental Environment and Results

- As plotted in Figure 4, as the *number of flows increases*, the *latency of the SCTP decreases*.
- On the other hand, the *XTP* and *TCPM* had the *same latency performance* as the *number of flows increased*.

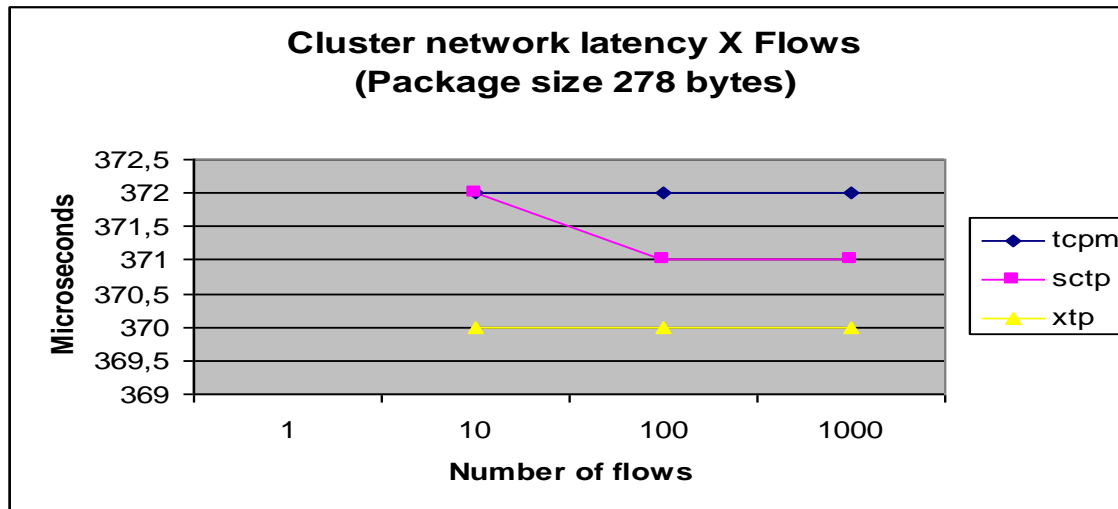


Fig. 4: Cluster network *latency x flow 278 bytes*

## Experimental Environment and Results

- The *throughput* of TCPM *decreases* when the *number of concurrent flows increases*, as illustrates in Figure 5.
- On the other hand, *XTP* and *SCTP* *maintained their performance pattern*.

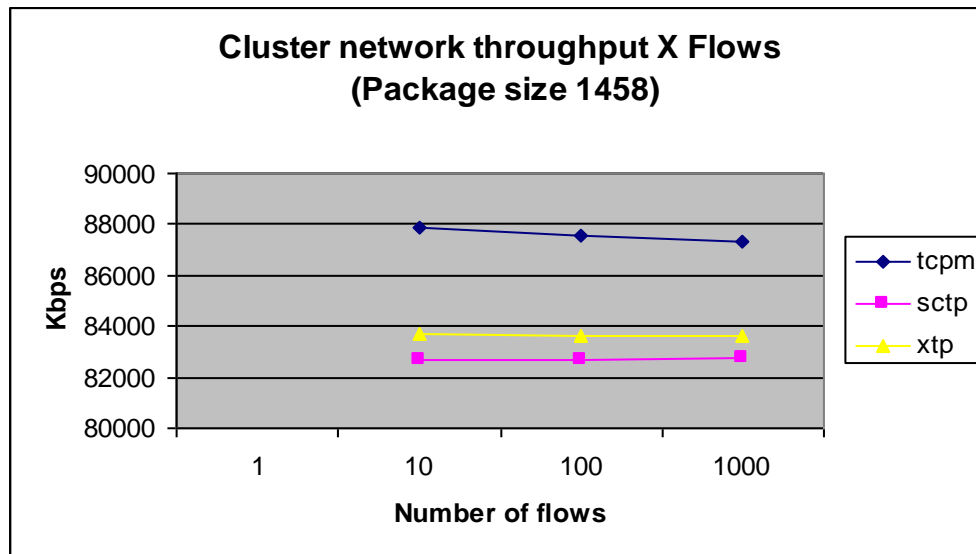


Fig. 5: Cluster network *throughput x flow 1458 bytes*

## Experimental Environment and Results

- The graph of *latency in Figure 6* shows that *XTP had lower performance for all flows*, whereas the *TCPM and SCTP had the same continuous latency for the threshold between ten and a thousand flows* (because of that the SCTP is shadowing the TCPM line)

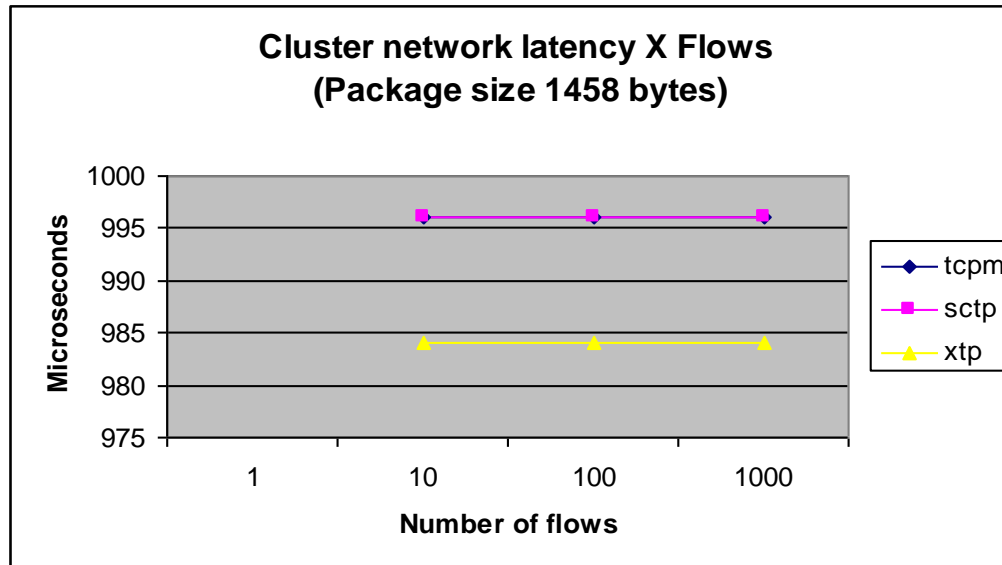


Fig. 6: Cluster network *latency x flow 1458 bytes*

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## Conclusions and Future Work

- In this paper we have presented *a study comparison between the SCTP, XTP and TCP transport protocols. Different from other studies, we considered a real VO scenario form by four multi-cluster configurations.*
- Our *experiments indicate* that the *SCTP* has the *drawback of security* aspects *in terms of throughput against number of flows.*
- *However, the latency decreases while the communication links increase.*
- These characteristics *are* interesting, because *it is possible to consider less security* in connections *to achieve more throughput levels.*

## Conclusions and Future Work

- On the other hand, *XTP* and *TCP* represent *interesting options in terms of throughput and latency* for environment where *applications do not require multi-homing, fail-over or deny-of service protection*.

## Conclusions and Future Work

- As a future work, we are planning to apply this research to *a large number of different applications*.
- The *objective* is to understand the *performance of these transport protocols executing different engineering and scientific applications* and *how to enhance the utilization* of these application *in multi-clusters as grid environments*.

Thank you !

Questions ?

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