Short paper

Towards Interplanetary Grids

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This short paper presents how to integrate the Disruption Tolerant Networking with Active Grids in order to design Delay Tolerant Grids. These Grids will provide the basic set for the future deployment of interplanetary Grids.

1. Introduction

The idea to extend the computer network protocols in order to tremendously extend the range of Internet through space was born and supported by the same persons who design TCP/IP 30 years ago, like Vint Cerf, aka. the father of Internet[4].

Due to some constraints, transport protocols, among other (ex: routing, name space) must be radically changed to fit the requirement of this unusual environment, namely space!

In the same time, the Delay Tolerant Networking (DTN) community[2], work on networks which must deal with high latencies, frequent disconnections, no end-to-end path and power saving constraints.

The solution provided by the DTN community is to add a protocol layer, called the *bundle layer*, located between the application layer and all the sub-layers of the network stack for the end hosts, and above the network stack for all the intermediate nodes (gateway, router, relay). This bundle layer provides intermediate storage and adaptation capabilities to all kinds of network.

The new proposed protocols are designed to support high latencies and long disconnection (i.e more than few milliseconds like current TCP/IP implementations). They also should resist to planned or unplanned disconnection.

We consider that the concept of Interplanetary Networks based on Disruption Tolerant Network [1] solutions can be applied on Grid infrastructures.

Grid computing facilities are generally composed of several high-performance, permanently connected, clusters of computer. But these clusters can be connected together through unreliable public links, like Internet, providing absolutely no guaranty. Moreover, the owner of a cluster may decide to temporarily disconnect his cluster from the public access for its own usage (management, upgrading...). Other clusters running the massively parallel application should not stop because this cluster disappear for probably just few hours.

We can imagine that next generation space transport will be able to embed some computing and storage facilities (clusters) to remote planets. But, most of computing resources will remain on earth, due to weight limits and the cost for sending large equipments (Fig. 1). Thus, an interplanetary Grid between computing centers on earth and on remote planets must be designed to support computing requirements of space exploration.

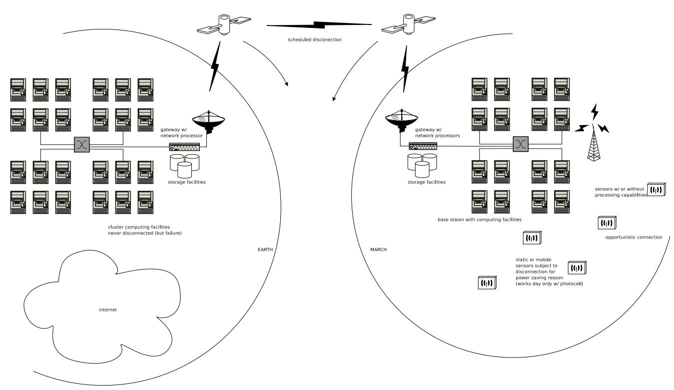

Figure 1. Interplanetary Grid between Mars and Earth

In this short paper, we expose our ideas to provide a complete environment to transparently help grid applications to work over such a disruptive network: the Interplanetary

Grid (IPG) !

2 Integrating Disruption Tolerant Protocols within Active Grids for High Delay Tolerant Active Grids

Programmable and active networks allow specified classes of users to deploy dynamic network services adapted to data streams requirements. In the past, we have proposed solutions to merge Programmable Networking and Grid fields by designing the Active Grid Architecture (A-Grid) which focuses on active network adaptation for supporting Grid environments and applications. This Active Grid architecture proposes solutions to support multi-cluster infrastructures. This architecture is based on programmable network nodes distributed on network path used as gateways of clusters. In this architecture the network will takes part in the Grid computing session by providing efficient and intelligent services dedicated to Grid data streams transport [5].

Currently, highly communicating Grid applications have to be re-designed in order to support high latency in networks Grids (like Batching Pivot [3]). This tolerant design expects that applications remain efficient even if networks generate high latencies for communications.

This approach focused on latency can be generalized to disrupted infrastructures. But, we want to propose global solutions as transparent as possible for users, applications and Grid middleware.

Our approach allows us to modify only the system used as programmable network gateway (PNG) located between clusters and the external network (i.e Internet)(Fig. 1).

If receiving nodes of the IPG are out of reach (disconnected, non-line-of-sight, ...), the programmable network gateway will be able to store or redirect message from senders until the receivers come back. Sending applications should not pay attention if the receiver has effectively received messages. A stub (the gateway) take care of them, and will transmit them to the receiver as soon as possible (Fig. 2).

During disconnection, if a computing node needs to receive a message from other node to continue its tasks, the application should be able to wait until the message is received (no timeout, just wait). So the PNG, must be able to launch remote distributed check-pointing operations for properly stopping applications running on cluster while the network is disconnected.

When a cluster is disconnected from the wide area network, the gateway should be able to store data sent by the cluster's node in a local storage capacity and send a special acknowledgment called a TACK which stands for *Temporary ACK*.

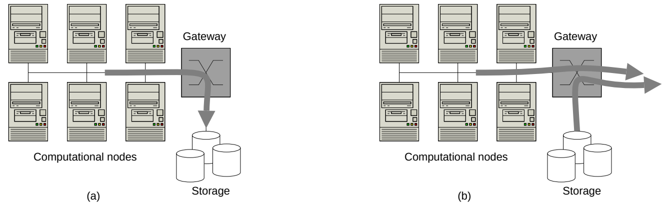

Figure 2. (a) No connection for the next hop is available but cluster still computes and sends data. (b) The link is now available, delayed stored and computed data are forwarded.

The application running on the earth cluster's node, then, can decide to stop or follow data transmission but knows that transmitted data are still "on the wire" and didn't reach the receiver yet. A real ACK can be sent by the recipient once data have effectively reach their destination.

3. On-going work

Today, given the available technologies, we think that the concept of Interplanetary Grid is far from science-fiction and it can be seriously designed. The proposed architecture of an Interplanetary Grid can also be applied to Grid infrastructures dealing with unreliable long distance network connections.

In the next months, we plan to implement the model exposed in the previous section and to emulate first experimentations and evaluations of this approach.

To face performance concerns, we will design and deploy the new services of the Programmable Network Gateway on high performance network interface cards embedding programmable Network Processors.

Next, we will test our prototype on a very large scale basis, thanks to the Grid 5000 project, which allows us to emulate a real grid environment.

References

[1] S. Burleigh, A. Hooke, L. Torgerson, K. Fall, V. Cerf, B. Durst, K. Scott, and H. Weiss. Delay tolerant networking: an approach to interplanetary internet. *IEEE Communications Magazine*, pages 128–136, June 2003.

[2] DTN : Delay tolerant research group. www.dtnrg.org.

[3] T. Endo and K. Taura. Highly latency tolerant gaussian elimination. In *Grid 2005 - 6th IEEE/ACM International Workshop on Grid Computing*, Seattle, Washington, USA, Nov. 2005.

[4] IPN : Interplanetary internet project. www.ipnsig.org.

[5] L. Lefèvre and P. Roe. Improving the flexibility of active grids through web services. In *4th Australasian Symposium on Grid Computing and e-Research*, Hobart, Australia, Jan. 2006.