Efficient Management of Network Resources Using Autonomous Agents in Grid

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Summary

The knowledge of existing grid resources and their characteristics is important for grid schedulers and resource brokers. In our work, we have proposed a network management system for heterogeneous networks using autonomous, static and mobile agents. Stationary and mobile agents co-operate to form a swarm intelligence based network management system. Stationary agents perform network measurements on the particular node of a particular cluster. Mobile agents are used to initiate measurements collect data and perform recovery mechanisms. Both, stationary and mobile agents are managed by the Mobile Agent Generator (MAG). MAG plays a key role in management related activities like creating mobile agents, estimating cost functions. The predicted and the measured values prove the accuracy of our management system.

Key words:

Grid, Network Management, Mobile Agents, Cost Function.

1. Introduction

A grid is a type of parallel and distributed system that enables sharing, selection, and aggregation of resources distributed across 'multiple' administrative domains based on their (resources) availability, capacity, performance, cost and users' quality-of-service requirements [1, 20]. Grid computing involves the combined effective utilization of the grid resources to achieve high performance. But locating the resourceful sites in the grid needs continuous monitoring. Irrespective of the nature and type of grid used, creation of resource pools should fulfill certain requirements like quality of service, service level agreements.

Effective performance realized in a network that consists of many heterogeneous links and subject to congestion can vary dramatically over time. Due to the heterogeneity and constantly varying nature of grid, estimation of network performance is indispensable. If the status of the network path can be predicted, it is possible to use that information in grid applications. For example, the network status can be used to adapt the traffic load in order to avoid congestion on a network path. Scheduling of large data flows for data intensive applications is highly dependent on network path characteristics. For computationally intensive applications, resource broker or scheduler needs to have comprehensive and accurate knowledge of network properties to fulfill service level agreements, ensure QOS, and to make clean choices for advance reservation.

Although, many ideas had been presented in the field of network management for grid environment in literature, most techniques do suffer from scalability related issues [2]. Any measurement technique should not be intrusive, i.e., flood the network with innumerable packets making it useless for grid application. One such system is the widely used Network Weather Service (NWS) [27]. NWS is used for network performance measurement and prediction system in grid computing. However, NWS suffer from the above problems: intrusiveness and scalability problem[7].

Mobile agent based network management equip agents with network management capabilities and allow them to issue requests to managed devices (or nodes) after migrating to those nodes [2]. Mobile agents give the flexibility of analyzing the managed node locally. Instead of querying the managed node for every fixed interval and analyzing the performance from management station, mobile agent can be dispatched to analyze the node locally. Due to its robustness, fault detection capabilities, less network usage, mobile agents are used for network management tasks.

Calibration of resources, prediction, fault detection and recovery mechanisms are key features in network management. Most proposed schemes suggest ideas for only a subset of this operation. In this paper, we present a holistic approach in the field of network management. The proposed design consists of agents which are categorized as process agents, autonomous intelligent agents, forecast agents, persistent agents and mobile agents which co-operate together to perform network management operations.

2. Related Work

Network Monitoring in Grid has seen vast research and different architectures have been proposed as in [4, 5, 8, 22]. NWS[6] prediction methods do not capture the complicated short and long range temporal dependence characteristics of heterogeneous network traffic. NetLogger[5] provides an overall view of the performance bottlenecks with considerable intrusiveness because of activation nodes periodically polling the activation manager, and applications to periodically check their configuration file.

JAMM's[4] sensors filter incoming events according to consumer queries but replication is not supported. Relational Monitoring in Grid Environment, RGMON [9] which is based on Producer-Consumer model suffers from scalability issues. Mobile agents play a major role in resource monitoring [2].In this paper, we present a distributed agent architecture for Network Management and Monitoring in Grid.

3. Design of mobile agent based network management system

The mobile agent based network management system consists of three types of static agents namely Mobile Agent Generator, process agent and forecast agent. The proposed model within a single cluster is shown in Figure 1.

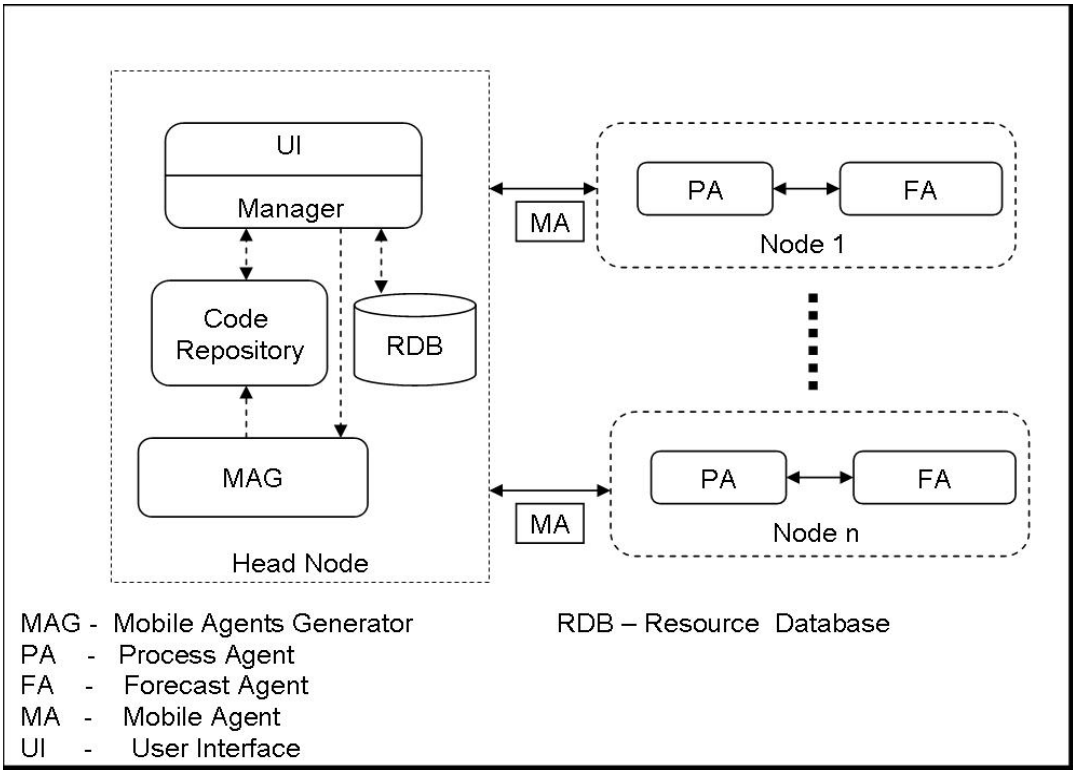

Fig 1. Proposed agent based model in a cluster

Every cluster contains a head node, also termed the resource provider which performs the main part of network monitoring activities. The user initiates measurements or forecasts on a remote node as required by the job at hand. The UI manager responds to the user by checking in the code repository for the required code format if available it makes use of it else it creates a mobile agent using mobile agent generator and stores the new code in code repository and makes use of it. the generated mobile agent is moved on to the appropriate

The process agent runs in each Computational

node and it performs the required operation as stated by the user. The mobile agent then returns the output to the head node and the output is displayed to the user graphically. The measured values of a particular node are stored in their respective memory and values that should be analyzed further by the head node are stored in a special storage unit known as the resource database.

3.1 Process Agent

Element (CE) and is responsible for measuring a particular aspect of them. The measurement of traffic is initiated based on request from the head node. To determine a network metric like for example, available bandwidth for a particular time interval, a mobile agent specifying details like algorithm used, CEs involved in the measurement process are sent by the head node. Process agents infer these details and perform the required tasks. The measured values are sent to the head node for further performance analysis. Latency, available bandwidth [15] are the network characteristics measured using process agents.

3.2 Forecast Agent

Forecast agents are initiated by head node through mobile agent. The forecast agent can be configured in certain CEs to provide an efficient prediction of network resources in the near future. Prediction based models can be used to forecast any metric of interest. One such method based on non linear model adopted is using artificial neural networks which have the capability to extract patterns and detect trends of network traffic. Multilayer perceptron with back propagation training feature is used to make the predictions [10].

3.3 Mobile Agent Generator

It resides on the head node of a particular cluster. Mobile Agent Generator forms the core of the management system. Most of the decision making tasks are automated by them. MAG exhibits autonomy and learning capabilities. They are used to perform a system level diagnosis check on the particular CE for fault detection involving network resources. For example, information about latency, available bandwidth in an end-to-end path can be used to compute cost functions for a particular grid application. MAG can be tuned according to traffic variations, in order to gather more detailed information during congestion periods and reducing amount of less meaningful information under normal traffic conditions [17]. In this way, Mobile agent generator systematically monitors a particular cluster.

3.4 Mobile Agent

Mobile agents are used to initiate measurement, prediction and recovery mechanisms. Instead of remotely polling CEs, a mobile agent can be dispatched to perform an analysis of the concerned CE. Mobile Agents are provided with itinerary table, a data state where collected information is stored and methods to control interaction with the network resource. Grasshopper platform, which has been developed by GMD FOKUS and IKV++ GmbH, is a mobile agent development platform implemented in Java, based on the Java 2 specification. Grasshopper is also compliant with the specifications of the Foundation for Autonomous intelligent Physical Agents (FIPA) [18,19,23]. Hot – swapping technologies can be adopted using mobile agents. However, this decision is based on autonomous intelligent analysis of factors like network load, system crash, and failure rates.

3.5 Resource Database

RDB is the actual database which contains aggregated information about resource metrics of all the CEs, retrieved by the head node of each cluster. The location of the resource database is known only to the head node. All the performance metrics present in the RDB are accessed by the mobile agent generator for future needs such as performance tuning and recovery mechanisms.

4. Cost Function Evaluation

Measuring network characteristics like latency, throughputs are frequent operations in a network management system. However, situations occur when a single network characteristic does not provide decent information about the network resources. Hence an aggregation of multiple parameters known as Cost Function (CF) is used. In this case, we define function associating available bandwidth and latency between two nodes.

It is defined as follows

$CF_{ij} = (BW_{ij} / BW_{max}) * \mu \wedge (L_{ij} / L_{max})$

where ,

BW_{ij} = Minimum available bandwidth between the path involving Nodes N_i and N_j,

BW_{max}= Maximum available bandwidth between Nodes N_i and N_j,

μ = varies in the interval [0,1] and tuned to balance the dependency on latency or available bandwidth,

L_{ij} = Minimum Latency between the path involving Node N_i and N_j,

L_{max} = Maximum Latency Time between Node N_i and N_j.

5. Implementation

The above model is implemented in a grid environment with a set of 2 clusters. The different components interact with each other as shown in Fig. 2. Implementation of our model involves setting up of process agents and forecast agents in grasshopper platform followed by the implementation of autonomous intelligent agents. Training data sequence acquired over a period of time is used for prediction.

The grasshopper tool is used to code and deploy the process and forecast agent. The process agents are deployed in each cluster to measure network resources in the nodes of the cluster .The measured values are stored in respective nodes in this phase. The monitoring is done at periodic intervals, so as to obtain the resource metric values. Forecast agent is used to predict the resource state for the near future. A multilayer perceptron with back propagation algorithm is implemented. The output of the neural network is the bandwidth data predicted at the next n, n+m, n+2m and so on up to n + i * m second. The values of n, m and i depends on whether the traffic exhibits a high variability or not. If the variability is high the values of n, m and i are set for a small values; otherwise they are large. In our implementation work, values of n, m are 100, 1 respectively. The Mobile agent generator is coded and configured in the head node. It acts as a managing entity capable of directing, coordinating, monitoring and management actions. Resource database is used to store all the measurements made by process and forecast agents. This database is used to identify the root causes of anomalies and decide on reparative actions. The main issues faced in case of mobile agent based system pertains to security and network intrusiveness. For instance, if all the nodes in a cluster inject mobile agent then the network may be flooded. To rectify this situation partially, only those with administrative privileges should be allowed to initialize mobile agents based functionalities.

The current model being used adapts client server approach, which increases the network load which in turn affects the measurement of the required metric. Thus it affects the overall performance of the system, this means forecasting done is also prone to error. The use of mobile agents thereby solves the above stated problem. It increases the accuracy and performance of the system and provides an option for concurrent execution.

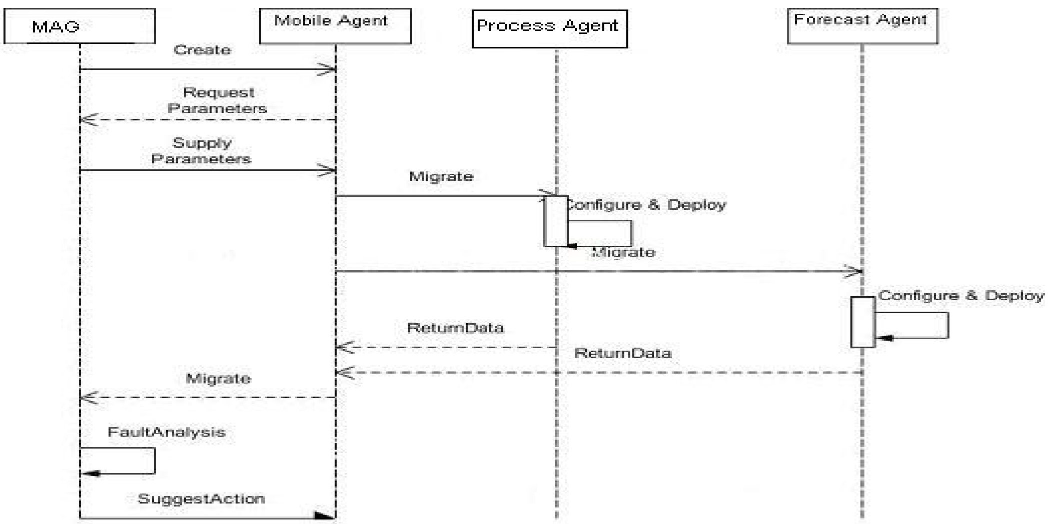

Fig.2.Interaction between different Agents

6. Results

A comparative study of prediction models used by Network Weather Service and our proposed forecast agent is made. The process agents are deployed between the two nodes of interest and Available Bandwidth metric is measured. These measured values acts as input to the forecast agent and NWS. NWS forecaster is deployed in a particular host and predicted values are stored in the database. Simultaneously, forecast agent is deployed and prediction based model is executed. The output values are stored separately. At the time instance pertaining to predicted values, process agents are deployed again to measure available bandwidth. These values are stored in the database. Comparisons between the two models are made as follows. Measured vs. predicted values using NWS and forecast agent are plotted as shown in Fig.3, and Fig.4. The results show that our agent based model accurately captures the changes in network traffic than NWS.

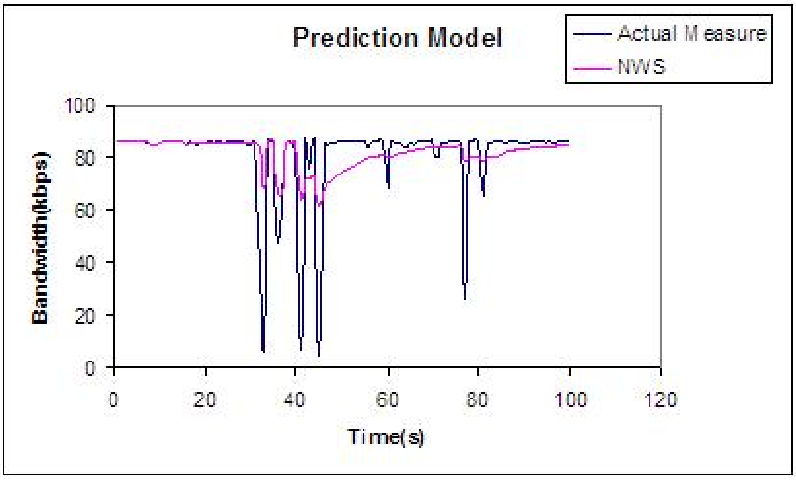

Fig. 3. Bandwidth Prediction using NWS

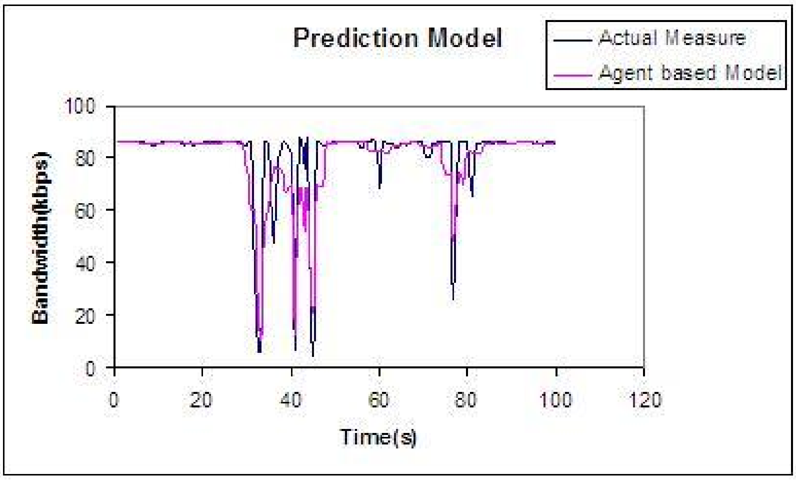

Fig. 4. Bandwidth Prediction using Agent based system

7. Conclusion and Future work

Network monitoring in grid using mobile agent technology has already been proved efficient. Further, with the introduction of autonomous agents in a grid environment, network management tasks are automated and high fault tolerance is achieved. The performance of the proposed monitoring framework can be enhanced to improve the availability and it can be extended to support with GGF and other standards and testing of this architecture in significant test beds. Future work includes extending the above management system to support more network characteristics like jitter, bulk transfer capacity with some changes in the process agent. A feasibility study of the number of mobile agents required for a particular grid with given nodes can also be considered. Issues like intercommunication between two mobile agents and delegation of tasks by one agent to another in case of agent's failure can also be addressed.

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References

[1] I.Foster and C.Kesselman, "Globus: A metacomputing infrastructure toolkit", *International journal of supercomputer applications*, pp.115-128, 1997.

[2] Andrez Bieszczad, Bernard Pagurek And Tony White, "Mobile agents for network management", IEEE Communications Surveys, 1998.

[3] Kameshwari S, Valliyammai C, Divya S, Sharmila R, "Dynamic Updating and Management of Virtual Resource Database in Grids Using Mobile Agents" IJCSNS International Journal of Computer Science and Network Security, VOL.7 No.5, May 2007.

[4] B. Tierney, B. Crowley, D. Gunter, and et al. "A monitoring sensor management system for grid environments." *Cluster Computing Journal*, 4, 2001.

[5] D. Gunter, B. L. Tierney, C. E. Tull, and et al. "On-demand grid application tuning and debugging with the netlogger," *Cluster Computing Journal,* 2003.

[6] Yousry El-Gamal, Khalid El-Gazzar, and Magdy Saeb. "A Comparative Performance Evaluation Model of Mobile Agent Versus Remote Method Invocation for Information Retrieval", International Journal of computer Science and Engineering, 2007.

[7] Muhammad Murtaza Yousaf et al. "Fog in the Network Weather Service: A Case for Novel Approaches", University of Innsbruck, Austria, 2007.

[8] L. Donghua, X. Zhiwei, and L. Wei. "A dag based two layer grid monitoring system" *.Journal of Computer Research and Development*.

[9] Mark Baker and Garry Smith, "GridRM: An Extensible Resource Monitoring System", Proceedings of the IEEE International Conference on Cluster Computing, 2003.

[10] Alaknantha Eswaradass, Xian-He Sun, MingWu "A Neural Network Based Predictive Mechanism for Available Bandwidth " Proc. of 19th International Parallel and Distributed Processing" (IPDPS05), Denver, Colorado, April., 2005.

[11] Alaknantha Eswaradass, Xian-He Sun, Ming Wu " Network Bandwidth Predictor (NBP): A System for Online Network performance Forecasting" Proc. of 19th International Parallel and Distributed Processing Symposium (IPDPS05), Denver, Colorado, 2005.

[12] Martin Swany and Rich Wolski, "Representing Dynamic Performance Information in Grid environments with the Network Weather Service" Future Generation Computer Systems, 1999.

[13] X.H. Sun and M. Wu, "GridHarvest Service: A System for Long-Term, Application- Level Task Scheduling," in the Proc. of 2003 IEEE International Parallel and Distributed Processing Symposium (IPDPS 2003), Nice, France, Apr., 2003.

[14] Orazio Tomarchio, Lorenzo Vita, Antonio Puliafito, "Active monitoring in Grid environments using mobile agent technology", DATAGRIDworkshop, 2000.

[15] V. Ribeiro et al., "pathChirp: Efficient Available Bandwidth Estimation for Network Paths," *Proc.* Passive and Active Measurement Workshop, 2003, http://moat.nlanr.net/ PAM2003/PAM2003papers/3824.pdf.

[16] Manoj Kumar Kona and Cheng-Zhong Xu, "A Framework for Network Management using Mobile Agents" ,Wayne State University, in the Proc. of 2004 IEEE International Parallel and Distributed Processing Symposium (IPDPS 2004).

[17] A. De Paola et al, " Rule based Reasoning for Network Management", Proceedings of Seventh International Workshop, IEEE, 2005.

[18] *Object Management Group, Mobile Agent System Interoperability facilities Specification*, orbs/97-10-05, [Online] Available: ftp:// ftp.omg.org/pub/docs/orbos/97-10-05.pdf, 1997.

[19] *Foundation for Autonomous intelligent Physical Agents*, [Online] Available: http://www.fipa/org

[20] I.Foster, C.Kesselman, "*The Grid: Blueprint for a New Computing Infrastructure*", Morgan Kaufmann, USA, pp. 259-278, 1999.

[21] Maozhen Li, Mark Baker, "The Grid Core Technologies", John wiley & Sons Ltd, pp.154-240, 2005.

[22] Serafeim Zanikolas, Rizos Sakellariou, "A taxonomy of grid monitoring systems," *Future Generation Systems*, pp. 163-188, 2005.

[23] Thomas Magedanz, IKV++ GmbH Germany, Grasshopper-Agent platform: A Universal Agent Platform Based on OMG MASIF and FIPA Standards, 1999. [Online] Available http://www.ikv.de/products// grasshopper/index.html

[24] B.Tierney R. Aydt, D.Gunter, M.Swany, R.Wolski, GWD-I(Informational), GGF Perfromance Working Group, "A Grid Monitoring Architecture", January 2002.

[25] Bruce Lowekamp, Brian Tierney. Les Cottrell, Richard Hughes-Jones, Thilo Kielmann, Martin Swany, GFD-R-P.023 (Proposed Recommendation), GGF Network Measurements Working Group, "A hierarchy of Network Performance characteristics for Grid Applications and Services", May 2004,

[26] Globus. [Online]. Available: http://www.globus.org

[27] *Object Management Group, Mobile Agent System Interoperability facilities Specification*, orbs/97-10-05, [Online] Available: ftp:// ftp.omg.org/pub/docs/orbos/97-10-05.pdf, 1997.
[28] *Foundation for Autonomous intelligent Physical Agents*, [Online] Available: http://www.fipa/org
[29] I.Foster, C.Kesselman, "*The Grid: Blueprint for a New Computing Infrastructure*", Morgan Kaufmann, USA, pp. 259-278, 1999.
[30] Maozhen Li, Mark Baker, "The Grid Core Technologies", John wiley & Sons Ltd, pp.154-240, 2005.
[31] Serafeim Zanikolas, Rizos Sakellariou, "A taxonomy of grid monitoring systems,"
Future Generation Systems, pp. 163-188, 2005.
[32] Thomas Magedanz, IKV++ GmbH Germany, Grasshopper-Agent platform: A Universal Agent Platform Based on OMG MASIF and FIPA Standards, 1999. [Online] Available http://www.ikv.de/products// grasshopper/index.html
[33] B.Tierney R. Aydt, D.Gunter, M.Swany, R.Wolski, GWD-I(Informational), GGF Perfromance Working Group, "A Grid Monitoring Architecture", January 2002.
[34] Bruce Lowekamp, Brian Tierney. Les Cottrell, Richard Hughes-Jones, Thilo Kielmann, Martin Swany, GFD-R-P.023 (Proposed Recommendation), GGF Network Measurements Working Group, "A hierarchy of Network Performance characteristics for Grid Applications and Services", May 2004,
[35] Globus. [Online]. Available: http://www.globus.org
[36] The Network Weather service, [Online]. Available : http://nws.cs.uscb.edu

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