Business Models, Accounting and Billing Concepts in Grid-Aware Networks

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Abstract. The emerging Grid Economy, shall set new challenges for the network. More and more literature underlines the significance of network - awareness for efficient and effective grid services. Following this path to Grid evolution, this paper identifies some key challenges in the areas of business modeling, accounting and billing and proposes an architecture that addresses them.

Keywords: Accounting, Billing, Model, Grid, Metering, Service, Network.

1 Introduction

Grid technology has emerged over the last few years as a new infrastructure concept which enables the sharing of computational and storage resources among multiple participants across administrative boundaries over the Internet. However, the current Internet is still largely based on its original design. This has been suitable for email and web applications that determined the major part of Internet traffic for many years, however, it has not been designed with large-scale Grid platforms in mind, which hit the limitations of the traditional Internet.

The EU-IST project EC-GIN [13] investigates how the network performance can be improved for Grid applications running on top of the Internet. One of the investigated scenarios in EC-GIN is the fast transfer of large files from one Grid node to another, key service for many grid applications. Under the assumption that between the two nodes there are multiple paths which do not share a common bottleneck, a large file transfer application may benefit from a higher throughput if transporting the file over multiple paths in parallel. In case that the network does not provide any support for source routing or multi-path routing, the only way to achieve a multi-path file transfer is by relaying the data transmission over different intermediate Grid nodes at the edge of the network.

However, a Grid node does only have an incentive to relay traffic if in return it gets some form of compensation which can either be monetary or non-monetary. Non-monetary incentive schemes are based on reciprocity, which uses barter-trade mechanisms [9], such as TFT [7] or PSH [1], can be used to provide incentives to nodes to

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relay services. However, if reciprocity cannot be assumed, due to the heterogeneity of a large-scale Grid system and the different needs of individual Grid users, monetary incentive schemes are required.

This paper proposes a traditional monetary-based incentive approach which follows a traditional accounting and billing architecture. The accounting keeps track of the amount of traffic relayed by each node in a row of relays between any source and destination and forwards that information to an accounting server. This data is used by the billing mechanism to be able to charge the users for the usage of those resources.

The key difference of the proposed accounting and billing architecture for Grid networks compared to other approaches is that it is based on a multi-domain approach supporting multiple virtual organizations and multiple network operators.

2 Large File Transfer Scenario

In the Large File Transfer (LFT) scenario several Grid operators cooperate in order to allow parallel use of existing network paths between two endpoints in the network. Since IP routing determines the best path to a certain destination, it is not possible to exploit several parallel paths by using IP routing mechanisms. Therefore, LFT uses Grid nodes as relays in order to route traffic from the sender to the receiver on multiple paths chosen by the sender.

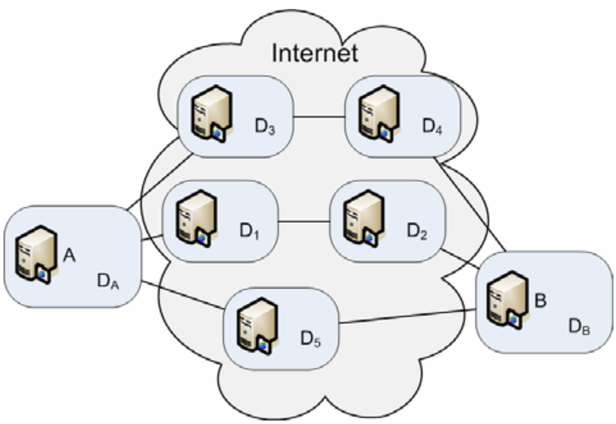

Fig. 1. Large File Transfer Scenario

Figure 1 depicts the LFT scenario, where node A in domain A (D_A) is the sender and node B in domain B (D_B) is the receiver. Due to multi-homing or peering agreements, there are several disjoint paths going through different domains between them. However, due to the way routing protocols work today, all packets sent by A to B will most probably follow the same path (the shortest in routing terminology). The use of an alternative path would only take place if the shortest path becomes unavailable. The use of parallel paths by routing algorithms in order to achieve load balancing is sometimes found within the network of an operator, but almost never on a larger scale, in multi-domain environments. Therefore, Grid nodes along the parallel paths have to act as relays forwarding data to the next hop.

In order to accurately keep track of the consumed resources on each node, appropriate accounting mechanisms need to be deployed. If the LFT transfer has to be paid for, a billing system is required besides accounting.

3 Business Models

Commercial cloud services as the ones released by Amazon in 2006 directly tap into the idea of utility computing [8]. The wide adoption of these services with pay-as-you-go schemes enable significant savings. Amazon Web Services have become already in 2008 the most successful "utility computing" realization. The 'Cloud' seems to be a business reality of the 'Grid' vision.

As clearly described in [12], the commercial use of Grid stimulates new business models, fitting the market demand of this new era. Moreover, in [11], the Grid economy is envisaged as a monetary model that will facilitate the sharing of resources between co-operating business partners.

In [2] and [3], a Grid business model and the term of computational economy framework are discussed. By adding grid - awareness to the equation, we come to a complete new picture of a new non-zero-sum market, where resource sharing and incentive - based economy increases productivity and efficiency for all parties.

A --> B	Resource Providers	Backbone Operators	Access Providers	Service Providers	Grid Operators	Content Providers	End Users
Resource Providers	X	X	V	X	V	X	X
Backbone Operators		V	V	X	X	X	X
Access Providers			X	V	X	X	V
Service Providers				V	V	V	V
Grid Operators					V	X	X
Content Providers						X	X
End Users							V

Fig. 2. A vision to Revenue sharing cases between Grid Economy parties

Up to cloud computing, business development has occurred only in the area of storage and computational resource sharing. This business is based on the traditional provider – consumer model. The addition of multi-path relay in the business shall dramatically alter this model, in a way similar the one Web 2.0 changed the content business! In the era of grid nodes providing multi-path relays, participating entities are constantly providers and consumers, the so called *prosumers*. Grid computing becomes an issue of many more organizations rather than cloud service providers.

The different types of business entities that are expected to play a role in the new business model are analyzed in the table of Figure 2. Checked cross-tabs illustrate an expected business relation. The revenue sharing agreements of the related entities define the requirements for the billing framework.

Having LFT scenario in mind, we analyze in the following paragraphs an architecture that materializes this vision into a usable infrastructure.

4 Architecture

Figure 3 depicts the overall Grid Economic architecture which includes besides the respective AAA and Billing components, a Pricing element that is responsible to determine the price for the service to be charged for, a Metering element that measures the amount of traffic forwarded by a node, and a Security element that maintains certificates for each relay node.

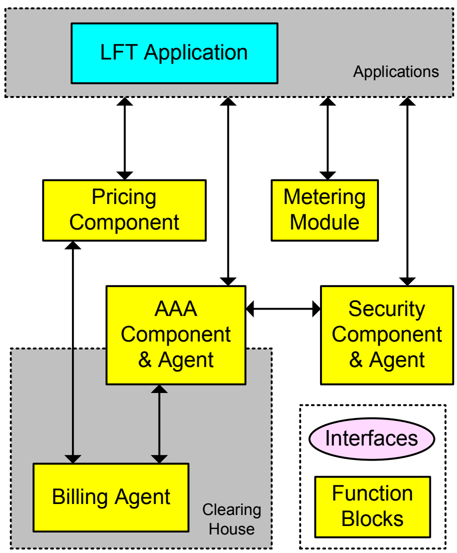

Fig. 3. Overall Grid Economics Architecture

4.1 Accounting

The accounting architecture is depicted in Figure 4. In order to assure interoperability, it is based on the IETF generic AAA (Authentication, Authorization, and Accounting) architecture [6]. The main components of the accounting architecture are the accounting server and the accounting client. Accounting servers (herein also referred as 'Clearing houses') consist of a distributed infrastructure responsible to collect accounting records from accounting clients and store them. Each operator domain has one or more accounting servers. The accounting client resides on the Grid node and it sends accounting records about resource usage and service consumption to the accounting server. The accounting client sends the accounting records to the server in its domain. Accounting data exchange between domains can only happen via the accounting servers. The accounting record transfer is based on the Diameter protocol [4]. Accounting records are routed to the corresponding accounting server (clearing house) based on the domain where the user is registered. Each server maintains a realm-based routing table that contains the next hop accounting server for each domain as well as a default route. The routing of accounting records fully complies with the Diameter routing specification [4] and allows multi-domain message routing.

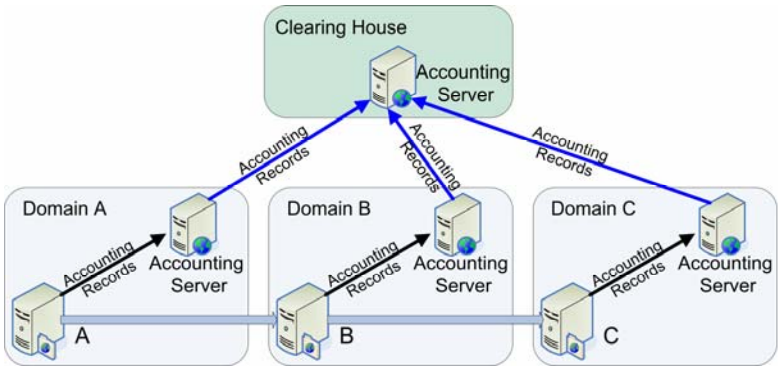

Fig. 4. Accounting Infrastructure

As Figure 4 shows, node A sends data to node C via node B. In order to enable billing across several domains, the accounting servers send accounting data to a clearing house. Clearing houses of our architectures are assumed as trusted organizations similar to the ones that clear up roaming charges among mobile telephony operators. They collect accounting records, compute service charges and bill end-users and domains. A clearing house's profit is derived by a commission on the transactions volume processed.

Each accounting record includes the origin and the destination of the record, the unique session identifier, the record number, a timestamp, the username, the identification of the data flow (src/dst addresses and ports), and usage statistics about the network usage (number of bytes and packets). The accounting records are transferred via the Diameter Accounting Request message and are acknowledged by the server via the Diameter Accounting Answer message.

4.2 Billing

The effort towards the realization of a realistic grid-aware network billing concept came across a key challenge: the goal to keep everything decentralized enabled the emerge of some conflicts of interest:

- A relay or a service domain might have reason to provide false accounting and / or billing data,
- A relay or a service domain might have reason to reduce quality or cancel service without documenting it,
- A client might question the service delivery or accounting / billing data collected by the relays and / or service domains.

For this reason we have introduced "clearing house" node hierarchy mentioned above. These nodes are considered as 3rd party trusted organizations that maintain balances for participating domains / hosts, host potential auction components of pricing, and correlate all accounting information in order to objectively clear-up transactions and balance updates, identify malicious behaviours and potentially set the penalties.

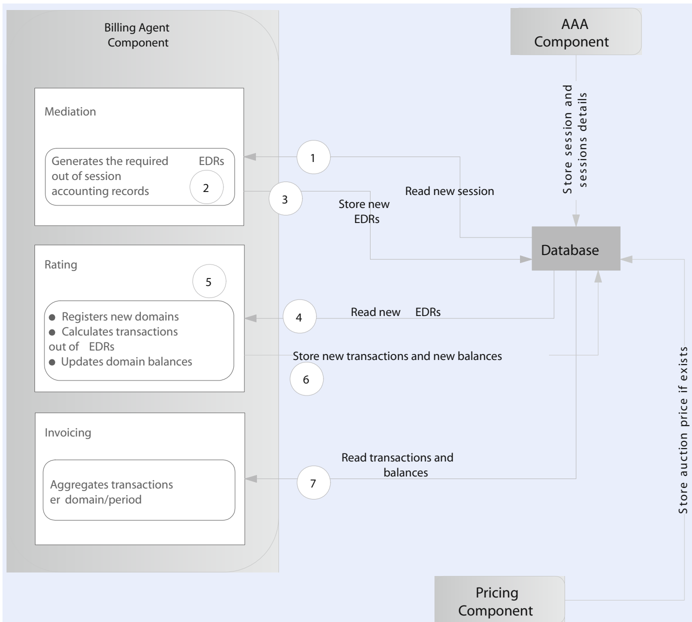

Fig. 5. Billing component structure and related interfaces

An additional design decision that has been made is that the client node considers that it receives the total service by the grid node that is price-wise or trust-wise selected. This node is considered as the total supplier for the session and encapsulates the cost and service of additional nodes, if it happens that the total supplier is actually a relay and not the end service node (service cascading). This assumption simplifies the rest of our analysis in defining the behaviour of the billing component between the client node and the supplier node.

The Billing component retrieves the respective information and executes the following operations in order to bill each service session: Mediation, Rating and Invoicing in a post-paid concept.

These operations refer to standard billing processes which have been here adjusted to the Grid Economy model and the LFT scenario.

Figure 5 depicts the design of the billing agent of the proposed architecture. The subcomponents included are:

Mediation: As soon as the AAA component stores completed session information in the database, the mediator reads it and creates a new Event Data Record (EDR).

Rating: The rating daemon is constantly polling the database in order to identify newly mediated EDRs and start processing them. Its functions include calculation of charges per EDR and updates of supplier/consumer balances.

Invoicing: The invoicing module is responsible for the aggregation of transaction information and the presentation of the results of the previous phases.

5 Architecture Advantages

In brief the proposed architecture is characterized by the following advantages:

- Support of accounting and charging across **multiple domains.**
- **Robustness** and scalability through the support of multiple parallel sessions to different accounting servers.
- **Security,** using IPSec and Transport Layer Security (TLS) over OpenDiameter library.
- **Simplicity** by applying *the* 'Service Cascading' concept and following the main structural blocks of state-of-the-art commercial billing infrastructures (mediation, rating, invoicing).
- **Flexibility,** since it does not limit the applicability in a specific pricing / discounting policy, services, business relationships or network infrastructure.
- **Feasibility**, since no complex pricing algorithms or metrics have been used however all complexity that the business relations are expected to have is supported.
- **Trust,** due to the existence of clearing house entities among the business parties, an approach pragmatic in network economies as the one of wireless telephony.

6 Conclusions

The business models, accounting and billing techniques analyzed in this paper provide a framework for realistic incentive - based networks that provide explicit support for grid applications. The experiments conducted so far with the generic problem of Large File Transfer service have verified that this architecture is scalable, efficient and feasible over the standard internet, with limited implications. Further experiments and evaluations are in progress with an immediate goal the integration and evaluation of this architecture with real-time streaming services (e.g. VoD, IPTV) provided by multiple different alternative hosts / domains.

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References

1. Bocek, T., Kun, W., Hecht, F.V., Hausheer, D., Stiller, B.: PSH: A Private and Shared History-based Incentive Mechanism. In: Hausheer, D., Schönwälder, J. (eds.) AIMS 2008. LNCS, vol. 5127, pp. 15–27. Springer, Heidelberg (2008)
2. Buyya, R., Stockingerz, H., Giddy, J., Abramson, D.: Abramson: Economic Models for Management of Resources in Grid Computing (2001)
3. Buyya, R., Abramson, D., Giddy, J.: A Case for Economy Grid Architecture for Service Oriented Grid Computing. In: 15th International Parallel and Distributed Processing Symposium, pp. 776–790 (2001)
4. Calhoun, P., Loughney, J., Guttman, E., Zorn, G., Arkko, J.: Diameter Base Protocol. IETF RFC 3588 (September 2003)
5. Hausheer, D., Stiller, B. (eds.): Implementation of Economic Grid Traffic Management and Security Mechanisms. Deliverable D4.1 of the EC-GIN Project (May 2009)
6. de Laat, C., Gross, G., Gommans, L., Vollbrecht, J., Spence, D.: Generic AAA Architecture. IETF RFC 2903 (August 2000)
7. Lian, Q., Peng, Y., Yang, M., Zhang, Z., Dai, Y., Li, X.: Robust Incentives via Multi-level Tit-for-tat. In: 5th International Workshop on Peer-to-Peer Systems (IPTPS 2006), Santa Barbara, CA, USA (February 2006)
8. LaMonica, M.: Amazon: Utility computing power broker, CNET News.com (November 2006), http://news.cnet.com/2100-7345_3-6135977.html
9. Obreiter, P., Nimis, J.: A Taxonomy of Incentive Patterns - The Design Space of Incentives for Cooperation. In: Moro, G., Sartori, C., Singh, M.P. (eds.) AP2PC 2003. LNCS (LNAI), vol. 2872, pp. 89–100. Springer, Heidelberg (2004)
10. Stiller, B., Hausheer, D. (eds.): Design of Economic Grid Traffic Management and Security Mechanisms. Deliverable D4.0 of the EC-GIN Project (May 2008)
11. Weishaupl, T.: Business and the Grid, Economic and Transparent Utilization of Virtual Resources; Dissertation, Universitaet Wien (October 2005)
12. IST Workshop: Grid Economy and Business Models; part of 2003 Grid related Conference in Milan, titled Harnessing computing and knowledge resources, http://cordis.europa.eu/ist/grids/grid_economy_and_business_models.htm (accessed: 04 September 2007)
13. The EC-GIN Consortium: Europe-China Grid InterNetworking (EC-GIN), Specific Targeted Research Project (STREP), http://www.ec-gin.eu/ (last access June 2009)