WORKSHOP WHITE PAPER
Information Dominance Via
Global Virtual Databases

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1 Extended Abstract

The Next Generation Internet (NGI) will provide an order of magnitude improvement in the computer/communication infrastructure. What is needed is a corresponding order of magnitude improvement at the application level. I believe that this will come in the form of global virtual databases. Such databases will be enterprise specific and offer features along real-time, fault tolerance, quality of service for audio and video, and security dimensions. Support of all these features and tradeoffs between them will provide an order of magnitude improvement over browsers, browsers connected to databases, and, in general, today's distributed databases. Such global virtual databases will not ONLY be enterprise specific, but also interact (given proper protections) with the worldwide information base via wrappers. Such wrappers may be based on Java and Java Data Base Connectivity standards.

Different global virtual databases with their own real-time, fault tolerant, QoS, and security requirements might exist for scientific research, national security, distance education, environmental modeling, and health care, to name a few. For example, the intelligence community would have worldwide databases connected over the NGI to form its intelligence enterprise. This application has very strict security requirements, various real-time constraints especially under crisis, needs to see images, video, and text, at different levels of quality, and must continue to operate even in the presence of faults (which are very likely to occur given the large and worldwide nature of the system). This system must also be able to access vast repositories of public information such as news services, weather databases, etc.

These global virtual databases will impart significant requirements on the OS and networking infrastructure. For example, user applications (including transactions) will have real-time, fault tolerance, QoS and security requirements. System level mapping layers will translate these into lower level CPU, I/O, and network requirements. This mapping is a key research issue. It is imperative to understand the applications and identify how these applications will impart requirements on the NGI.

To implement a real-time global virtual database, new protocols and algorithms are needed that embody (i) a new notion of data deadlines [2] (rather than only transaction deadlines commonly found in real-time database work), (ii) parallel and real-time recovery, (iii) use of reflective information [4] to support flexibility and adaptivity, (iv) a specification language to support security, (v) composable and tailorable fault tolerant entities that synergistically operate with the transaction properties of databases and with the real-time logging and recovery, (vi) a new architecture and model of interaction between multimedia and transaction processing, (vii) a uniform task model that permits hard and multimedia tasks to be treated together in one virtual system, (viii) new scheduling, resource management and renegotiation algorithms to support various types of end-to-end QoS, and (ix) support for global execution platforms [1] where outputs of database queries could be analyzed (in parallel).

Consider the real-time issue in more depth. Transactions may have deadlines and operate on data whose validity expires with time. Transactions that process data with time validity intervals must use timely and relatively consistent data in order to achieve correct results. New and effective scheduling algorithms have been developed which modify transaction priorities based on data deadlines and forcing transactions to delay processing if data is about to become invalid [2]. These ideas have also been combined with similarity notions which says that as long as the data value is not too different from the value used in the processing, then the transaction can be committed. This enables much more efficient and time cognizant transaction processing especially in overload or crisis situations. Such work must be expanded to consider virtual distributed systems and the NGI infrastructure.

In these virtual database systems, real-time aspects will undoubtably become increasingly more pervasive [3] especially as audio and video become commonplace database outputs. The real-time solutions will need to support an increasingly broader spectrum of applications. These solutions will support admission control, resource reservations, synchronization, and renegotiation of QoS. Many applications have widely varying time and resource demands and must deliver dependable and adaptable services with guaranteed temporal qualities. This will be a key challenge. It will also be necessary to trade off real-time performance, fault tolerance, quality of service, and possibly even security, dynamically (at run time) in order for these systems to operate effectively. This is another key challenge.

In summary, we must consider the next generation applications that will utilize the NGI and identify the requirements that they will impose on the NGI. In this regard, a global virtual database is one of these application classes. Many key research challenges must be met before this vision becomes a reality. We are working on these problems and are currently designing a prototype system of this type called BeeHive [5].

2 References

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