Backend Systems Architectures in the Age of the Next Generation Network

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Abstract

The services that are projected for the next generation network (NGN) supported ubiquitous society will characteristically develop from the service domain of the individual to include lifestyle and social infrastructure-related services at the community and society levels. The systems for processing the information that is expected to be produced as a result of these changes will need to handle more than ten thousands events per second.

Such gigantic systems processing such a massive volume of events must be provided with a new systems architecture based on innovative processing methods that differ from the conventional methods such as batch and online processing.

Keywords

mass information processing, system architecture, real-time property, memory database, event information

1. Introduction

Conventional network services can be regarded as having developed independently according to the type of network combination (fixed or mobile) or terminal (telephone, cellular phone or PC).

The services of the next generation network (NGN) age to come will evolve into those involving a convergence of networks as well as the convergence/linkage of broadcasting and communications, and will ignore differences that depend on networks. Also, clients will benefit from services that will be more diversified than at present, which will include vehicle-mounted equipment and information oriented home appliances as well as cellular phones, PCs and PDAs. Such a large volume of clients will receive and benefit from similar services independently, regardless of the different type of terminal.

2. Recognition of Issues

It is expected that, in the world of diversified services that will characterize the NGN age, a large amount of information will be generated in relation to the services. This information will include for example the achievement information and billing information generated as a result of network usage. We will call this information “event information.” The event information will increase in geometrical progression according to the combinations of the number of clients and the variety of services, and may be generated irregularly depending on certain conditions such as the service time zone.

In addition, we should not ignore the information that is transmitted by “objects” (such as the status change or position information over time of an “object”) as a result of the utilization of IC tags, etc. In this case, the generated information itself is the event information. When the generation of such information begins, it will become huge floods of information that will circulate on the network.

In this paper, we will discuss the issues related to a large-scale systems architecture that will be capable of processing the large amount of event information that will be generated in the NGN.

3. Requirements of a Mass Information Processing System

At NEC, we have systematized the technology for the construction of a large-scale mission critical (MC) system based on open technology (mission critical systems in enterprises and other systems with highly public characteristics) into the OMCS (Open Mission Critical System/Solution). Also, in the field of systems infrastructures construction technologies, we have designed system architectures and identified system requirements from a systematic viewpoint. In the following, we will consider mass information processing from the viewpoint of an OMCS-based methodology.

The architectures of the systems infrastructures are important in system construction. The OMCS designs the architectures so that they can meet requirements in the following six domains.

1) High availability: Service provision without service downtime.

2) High extendibility: Service extension by simply increasing hardware investments.

3) High performance: Guarantee of a linear increase in performance following an increase in hardware investment.

4) High operability: 24-hour/365-day operation and/or visualization of service situations.

5) High linkage properties: Linkages with other systems including external systems.

6) High security: A security system capable of executing an improvement cycle.

From the perspective of the mass information processing system construction, requirements 2) and 3) are the most important for the architecture design.

High extendibility is important because, when a new service is constructed, it is unusual that a large-scale system is built from the beginning. More often, the service starts on a small scale and needs to be extended shortly after the environment for accepting the service has been arranged and an understanding of its convenience has reached a high level.

High performance should depend on the system architecture presenting a high cost efficiency from the beginning. This is because excessive hardware investments should be avoided when the system is extended. In addition, as the generated events will have relationships with various services, it is also necessary to ensure real-time properties so that the results can be obtained as quickly as possible.

In passing, let us consider the processing scale that may be required in the NGN age. When we look at the conventional mission critical systems, we see that some of the representative systems for processing high traffic volumes can perform online processing of a few thousands of events per second as a maximum.

However, the system discussed in this paper is required to process more than ten times larger amounts of events than the current systems. There is already a cellular phone system that can process a few ten thousands of events per second[1], and such a system should be regarded as the target of the systems in the NGN age. Therefore, the requirements for the design of mass information processing system architecture for the NGN age are as follows.

(1) High Extendibility

Even the amount of data or processing increases by more than 10 times the previous levels (several tens of thousands per second), the system should be capable of extension without modifications to the software. (Extendibility of the processing amount and extendibility of the database configuration)

(2) High Performance

The processing system should be capable of minimizing the processing cost per event without losing the real-time property.

4. Issues of Systems Construction

Then, let us review the technical issues for the construction of a system that can meet the above system requirements.

The representative processing methods used in the current mass information processing systems are as follows.

(1) Batch Processing

This method stores the information that is generated at times or at a time in a database or in files and processes it at once.

(2) Online Real-time Processing

This method processes information every time it is generated.

These processing methods have the characteristics as shown in **Table 1**, and are selected according to the limitations of the processing time and the available processing cost (business/system requirements).

As shown in Table 1, neither of the current batch or online processing methods may be enough for constructing a large-scale system that can provide high performance while ensuring the real-time property and reduced processing cost. It is therefore necessary to study a new processing method.

Then, let us consider the issues related to the configuration of a database (DB) that defines the extendibility of a large-scale system.

The DB can be configured either in a centralized or in a distributed design.

With the centralized configuration, the DB is configured as a resource that can be accessed commonly by any business application (business AP) so the business APs can have a higher degree of freedom (they can obtain any data on any opportunity). However, when the operation period is long, management is troublesome due to the complexity of the relations between business APs and access data.

With the distributed configuration, the DB that should originally be unique in the system is divided according to a certain rule and each division is configured as a DB. This can distribute the loads of the entire system into multiple DBs and the

Table 1 Comparison of Mass Information Processing Systems

Item	Batch processing method	Superiority*	Online processing method
Real-time property	Low	<	High
	Certain amount of data is stored and later processed simultaneously.		Processing is executed and the result is obtained every time an event is generated.
CPU processing cost per data	Low	>	High
	Batch collection of transaction data for simultaneous processing of a large amount of data.		Processing costs for reception, scheduling and I/O editing are required for every input message.
Operability (Operation with data consistency)	High cost, complicated operation	<	Relatively easy
	With large-scale operation, the startup scheduling/maintenance costs are high and the restart procedure after interruption of processing is complicated.		The "ACID properties**" are guaranteed so no special operation is required. Management of events and schedule destinations are necessary.
Ease of large-scale system construction	Relatively easy	>	Very difficult
	Easy construction except for design in case of concurrence of business applications consuming large part of CPU.		Data model design and performance tuning are particularly difficult.

* With the comparisons of superiority, the method on the right of "<" or on the left of ">" is superior to the other method.
** Atomicity, Consistency, Isolation and Durability.

system extendibility can be higher than the centralized configuration, but is also accompanied with the following problems;

- problem in the consistency between DBs when multiple DBs are updated;
- increase in the complexity of management due to the necessity of handling multiple DBs.

Including the CPU, some of the system resources required by the DB are related to the table lock control for internal sequential controls such as the common control (large-capacity buffer pool management, lock control and disk I/O management). This does not have important effects if the system is of a normal scale, but necessitates huge CPU resources costs if the system handles high traffic.

Also, large system costs are required for the solution of problems due to concurrence of accesses such as deadlocking and processing delays, or for the design/construction/maintenance of a system with optimized performance.

In consequence, the issue regarding construction of a large-scale DB can be summarized on how to build a DB system at as low a cost as possible.

Some recent DB technologies feature the capability of increasing the processing speed, and they are commercialized as memory DB products. These products are superior to the disk-based DB products in that they can reduce the CPU cost per event by 1/10th, but they are still hard to use when the guarantee of the permanency of data is in question.

5. Features of New System Architecture for Mass Information Processing

In order to apply the system foundation construction technology of the OMCS in the mass information processing system of the NGN age, we have developed new systems infrastructure architectures with the following features (see **Table 2**).

(1) Scheduling Method Guaranteeing Real-time Properties

The event-driven batch scheduling method is adopted to schedule the input events after grouping them in certain batch volumes. Since the amount of input events is so large, a sufficient amount of scheduling can be processed in batch form even if the processing interval is short, so that the real-time property can be guaranteed and the scheduling cost can be reduced.

(2) Memory DB Reducing the Data Access Costs of CPU

The memory DB can reduce the CPU cost for data access by 1/10th compared to the disk-based DB as described above.

Table 2 Features of the new architecture.

Item	Processing method
Real-time property	High
	Similar to online processing: Processing in near synchronization with the event arrival.
CPU processing cost per data	Low
	Similar to batch processing: Simultaneous processing.
Operability (Operation with data consistency)	Relatively easy
	Data consistency is guaranteed, but the routes for the transfer of messages between business APs should be defined.
Ease of large-scale system construction	Relatively easy
	Extendibility is high, but considerations for data division and installation design are required for distributing the processing loads.

To guarantee the permanency of stored data and continuity of services even in the case of a server fault, the data is also saved in the standby server.

(3) Distributed DB Configuration Guaranteeing the System Extendibility

The memory DB as described in (2) above is placed in each of the servers of distributed configuration. This process provides the system with a high extendibility that makes it possible to extend server capability according to the division of data.

This configuration leads to the restriction that the DB becomes a local resource of the distribution server, but data can be handed to other business APs by means of a container transfer mechanism that enables handling of permanent data between servers.

Fig. 1 shows the positioning of the system architecture targeted by the new architecture, from the perspective of real-time property and processing costs.

6. Application Domains of New System Architecture

The new architecture can be applied to systems that are needed to process a large amount of event information in real time.

6.1 Application in the Domain of Broadcasting-Communications Convergence/Linkage

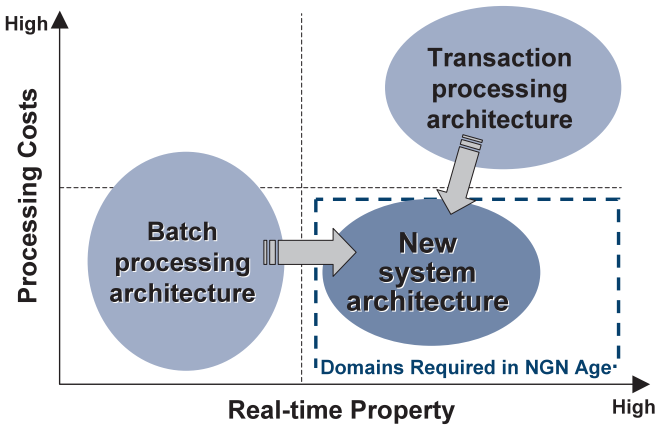

Fig. 1 Positioning of new system architecture.

Digital broadcasting features the simultaneous transmission of video content and metadata. The viewers can access various kinds of Internet information by referring to the metadata. This feature is applicable for example to quiz answering, questionnaire answering or voting in live-interlocked programs, with which information may be generated intermittently and should be collected in real-time because of the live nature of the programs.

Results of test calculations of traffic are:

20,000 events/sec. (TV traffic only) to 100.000 or more events/sec. (including cellular phone traffic)

(Assuming the year 2010 with 45 million households, 70% digital TV saturation level and 20% audience rating, so 6.3 million households voting in 5 minutes.)

6.2 Application in Next-Generation SCEM Systems

With the SCEM (Supply Chain Event Management) system, events associated with production are exchanged between enterprises in real time with the aim of just-in-time production and sales. This system is expected to use the IC tag in the future.

The use of the IC tag is being attempted in the fields of inventory management, asset management, manufacturing process management and logistics management. When the materials and assets are distributed in the fields outside the boundaries of enterprises, it becomes necessary to collect a huge amount of event information as the tracking information. In doing this, it will also be necessary to prepare a system for use in the centralized management of events information, such as an integrated event platform.

7. Middleware for the Implementation of New System Architectures

To allow the new system architectures to be used in new system fields as described above, we provide the following middleware.

(1) Event Schedule Management

- Event transport control function (event transfer, container control, etc.)
- Operation support functions (configuration information management, availability of statistics collection, etc.)

(2) Memory Database Access Management

- Access techniques (library, memory backup, etc.)
- Operation support functions (fault countermeasures, statistical information collection tool, etc.)

8. Conclusion

It is expected that the Ubiquitous society that will be realized based on the next generation network (NGN) will involve much richer and more diversified systems than those now available. However, although at the present time the shape remains unpredictable, we believe that systems based on architectures as described in this paper will be required to implement these services.

This paper discusses these new architectures by considering the mass processing requirements and we express our intention to continue to challenge systems developments so that we can meet the requirements of our customers by developing inspirational new business models.

Reference

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