The Bio-Networking Architecture
Bi-weekly report #6 (August 18, 2002): Bio-Networking Platform

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Introduction

The Bio-Networking platform is a middleware that provides reusable software components for deploying and executing cyber-entities (CEs), service components in the Bio-Networking Architecture.

As described in the bi-weekly report #3 submitted on July 8, '02, the Bio-Networking platform runs on a Java virtual machine on a network node. The Bio-Networking platform consists of three components; Bionet services, Bionet message transport, and Bionet container (see Figure 1). The Bionet services provide a set of runtime services that cyber-entities frequently use. Examples of the Bionet services include the Bionet relationship management service, Bionet energy management service and Bionet discovery service. For a complete list of Bionet services, please see the bi-weekly report #3 (submitted on July 8, '02). The Bionet message transport abstract low-level networking and operating details such as network I/O, concurrency, messaging, and network connection management. The Bionet container dispatches incoming messages to cyber-entities running on a local Bio-Networking platform.

Cyber-entities run on a Bio-Networking platform and use services provided by the Bio-Networking platform for performing its services and invoking its behaviors (e.g. discovery, replication and migration). The CE context is an entry point for a cyber-entity to access Bionet services. It examines if a Bionet service requested by a cyber-entity is available on the Bio-Networking platform, and if it is, it obtains a reference to the requested Bionet service. The CE context is created and associated with each cyber-entity implicitly (automatically), when a cyber-entity is created, replicated, reproduced or migrated from another host.

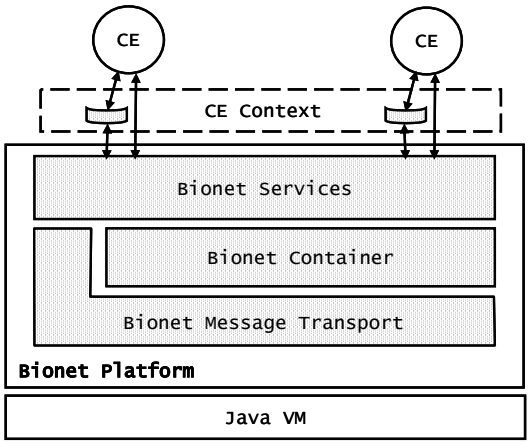

Figure 1. Architectural Components in the Bio-Networking Platform

New Accomplishments

In the bi-weekly report #3 (submitted on July 8, '02), the PI reported some of the preliminary performance measurement of the current implementation of the Bio-Networking platform. Since then, the PI has made a progress in the design, implementation and measurement

of the Bio-Networking platform. The PI's recent accomplishments include (1) refinement of design and implementation of cyber-entities, relationship between cyber-entities, and the CE context, and (2) additional preliminary measurements of the Bio-Networking platform to examine its efficiency and scalability.

Refinement of design and implementation

As described in the bi-weekly report #3, we have proposed our design of the Bio-Networking platform [SFS02] to the Object Management Group (OMG), the largest standard making body for object oriented software technologies, as a reference architecture for Super Distributed Objects (SDO) specifications [SFS02, SAS01, SSS02]. Through extensive discussions at SDO group meetings, the PI successfully built a consensus regarding the design of SDO resource data model [SSS02] that closely aligns to our Bio-Networking platform design [SFS02]. In order to accommodate minor design differences between our original Bio-Networking platform design and the SDO resource data model, the PI has refined the design and implementation of the cyber-entities, relationship and CE context. The OMG SDO group is currently using the Bio-Networking platform as a proof-of-concept implementation of the SDO specifications.

Figure 2 shows the refined design of the Bio-Networking platform (i.e., the SDO resource data model) and how key components in the Bio-Networking Architecture (i.e. cyber-entities, relationship and CE context) are designed based on the SDO resource data model. Each cyber-entity is designed as a subclass of `CyberEntityImpl` (i.e. a specialization of `SDO`). We have successfully implement the design shown in Figure 2 on the Bio-Networking platform, and confirmed its extensibility and reusability.

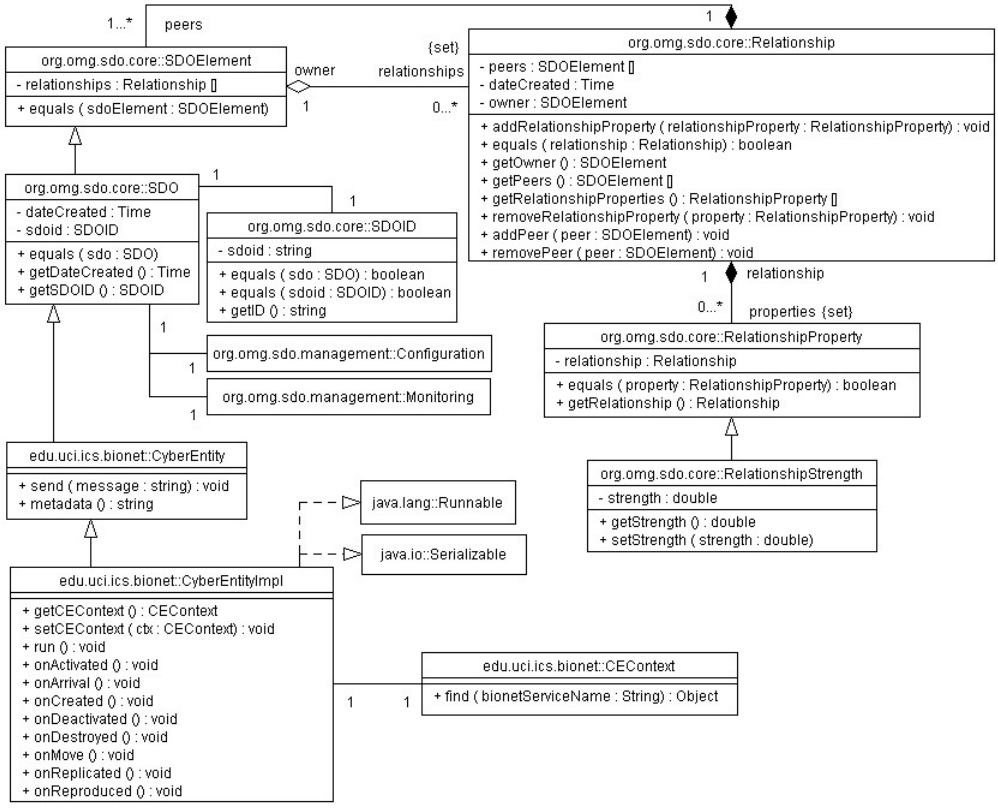

Figure 2. SDO Resource Data Model and Key Bio-Networking Architecture Components

Measurement Results

Figure 3 and Table 1 show preliminary measurements of the Bio-Networking platform that the PI implemented.

Figure 3 shows the throughput of the Bio-Networking platform per cyber-entity (i.e. how many messages a cyber-entity can receive and process in a second). In this measurement, a cyber-entity randomly chooses a remote cyber-entity and sends messages. The Bio-Networking platform runs on a Java 2 virtual machine (version 1.4) atop a Windows XP with an Intel Pentium 3 processor (1 GHz) and 256 MB RAM. Figure 3 shows that the throughput of the Bio-Networking platform is competitive with existing distributed object platforms (JacORB, Java IDL and Zen). Figure 3 also shows that the throughput remains relatively constant as the number of cyber-entities grows (2309 messages/sec on the average), indicating that the Bio-Networking platform scales.

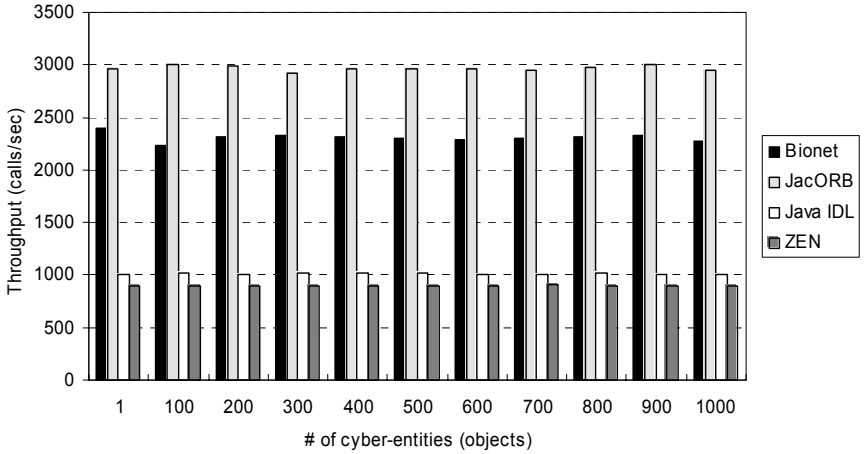

Figure 3. Throughput of Cyber-entity

Table 1 shows the bootstrap overhead and memory footprint of the Bionet message transport and the Bionet container. The bootstrap overhead measures the time for the Bio-Networking platform to initialize platform components, and the memory footprint measures the amount of memory space the platform components utilize when the Bio-Networking platform is initialized. The measurement results show that the bootstrap overhead and memory footprint of the Bio-Networking platform are fairly small.

Measure	Platform component	Measurement result
Bootstrap overhead	Bionet message transport	18 msec
	Bionet container	102 msec
Memory footprint	Bionet message transport	4.65 KB
	Bionet container	6.88 KB

Table 1. Bootstrap Overhead and Memory Footprint of the Bionet Transport and Bionet Container

Reference

[SFS02] J. Suzuki, K. Fujii and T. Suda, "The UCI Initial Proposal to SDO PIM," Super Distributed Objects Domain SIG, Object Management Group, OMG document number: sdo/2002-06-01, presented at the OMG TC meeting at Orlando, June 2002.

[SSS02] S. Sameshima, S. Steglich and J. Suzuki (ed.), “PIM and PSM for Super Distributed Objects,” Request for Proposal, Super Distributed Objects Domain SIG, Object Management Group, January 2002.
[SAS01] S. Sameshima, S. Arbanowski and J. Suzuki, “OMG Super Distributed Objects White Paper,” Super Distributed Objects Domain SIG, Object Management Group, July 2001.