Ninf-G チュートリアル
初～中級向け）

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Outline

- **What is GridRPC?**
  - Overview
  - v.s. MPI
  - Typical scenarios
- **Overview of Ninf-G and GridRPC API**
  - Ninf-G: Overview and architecture
  - GridRPC API
  - Ninf-G API
- **How to develop Grid applications using Ninf-G**
  - Build remote libraries
  - Develop a client program
  - Run
- **Recent activities/achievements in Ninf project**

What is GridRPC?

Programming model on Grid based on Grid Remote Procedure Call (GridRPC)

Layered Programming Model/Method

Portal / PSE
GridPort, HotPage,
GPDK, Grid PSE Builder,
etc…

Easy but inflexible

High-level Grid Middleware
MPI (MPICH-G2, PACX-MPI, …)
GridRPC (Ninf-G, NetSolve, …)

Ninf

MPI

Low-level Grid Middleware
Globus Toolkit

the globus project™
www.globus.org

Primitives
Socket, system calls, …

Difficult but flexible

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APGrid Asia-Pacific Grid

Ninf

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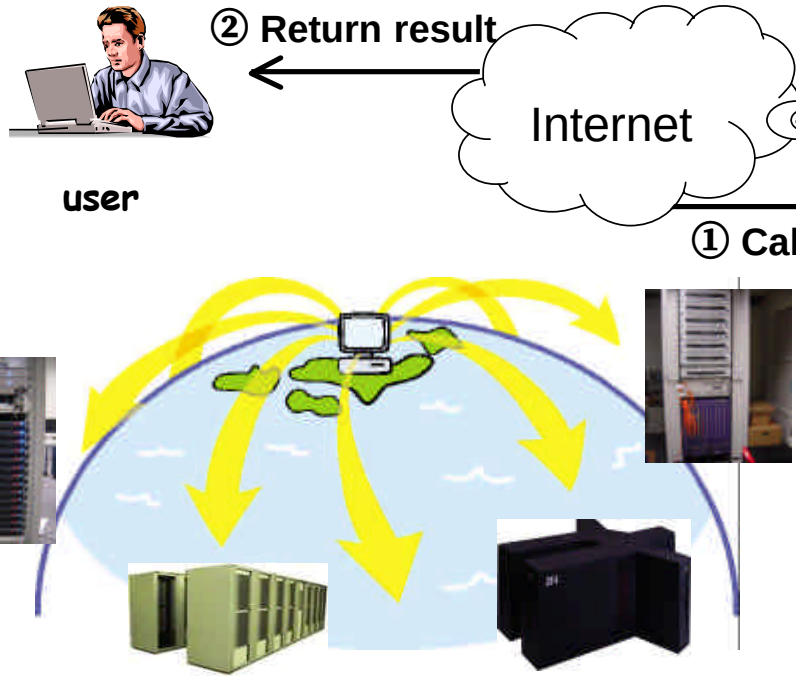
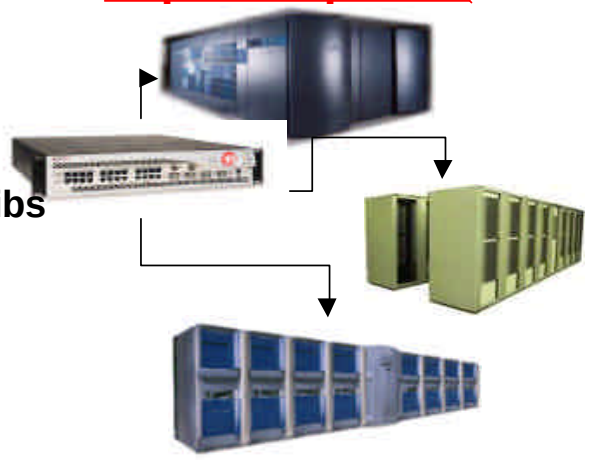
Some Significant Grid Programming Models/Systems

- **Data Parallel**
  - MPI - MPICH-G2, GridMPI, PACX-MPI, ...
- **Task Parallel**
  - GridRPC – Ninf, Netsolve, DIET, OmniRPC, ...
- **Distributed Objects**
  - CORBA, Java/RMI, ...
- **Data Intensive Processing**
  - DataCutter, Gfarm, ...
- **Peer-To-Peer**
  - Various Research and Commercial Systems
    - UD, Entropia, JXTA, P3, ...
- **Others...**

GridRPC



Utilization of remote Supercomputers



Call remote (special) libraries

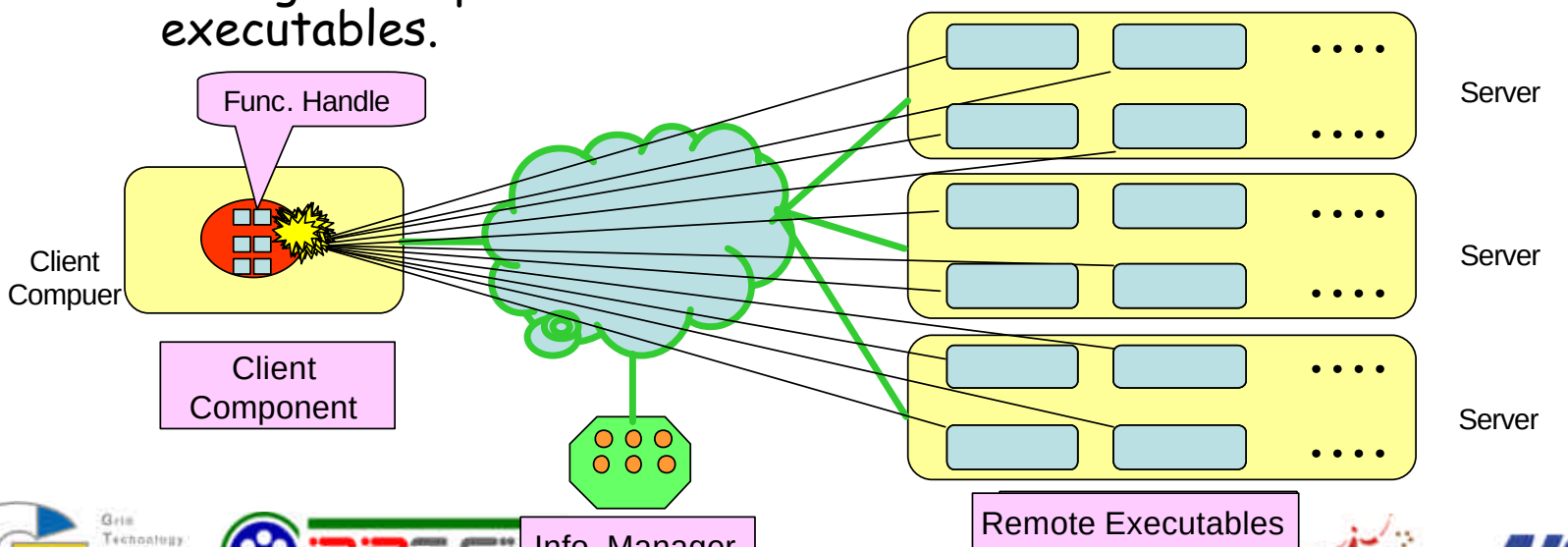
Use as backend of portals / ASPs

Large-scale distributed computing using multiple computing resources on Grids

Suitable for implementing task-parallel applications (compute independent tasks on distributed resources)

GridRPC Model

- **Client Component**
  - Caller of GridRPC.
  - Manages remote executables via function handles
- **Remote Executables**
  - Callee of GridRPC.
  - Dynamically generated on remote servers.
- **Information Manager**
  - Manages and provides interface information for remote executables.



GridRPC: RPC "tailored" for the Grid

- Medium to Coarse-grained calls
  - Call Duration < 1 sec to > week
- Task-Parallel Programming on the Grid
  - Asynchronous calls, 1000s of scalable parallel calls
- Large Matrix Data & File Transfer
  - Call-by-reference, shared-memory matrix arguments
- Grid-level Security (e.g., Ninf-G with GSI)
- Simple Client-side Programming & Management
  - No client-side stub programming or IDL management
- Other features…

GridRPC v.s. MPI

	GridRPC	MPI
parallelism	task parallel	data parallel
model	client/server	SPMD
API	GridRPC API	MPI
co-allocation	dispensable	indispensable
fault tolerance	good	poor (fatal)
private IP nodes	available	unavailable
resources	can be dynamic	static*
others	easy to gridify existing apps.	well known seamlessly move to Grid

* May be dynamic using process spawning

Typical scenario 1: desktop supercomputing

- **Utilize remote supercomputers from your desktop computer**
- **Reduce cost for maintenance of libraries**
- **ASP-like approach**

server

client

arguments

results

Numerical Libraries
Applications

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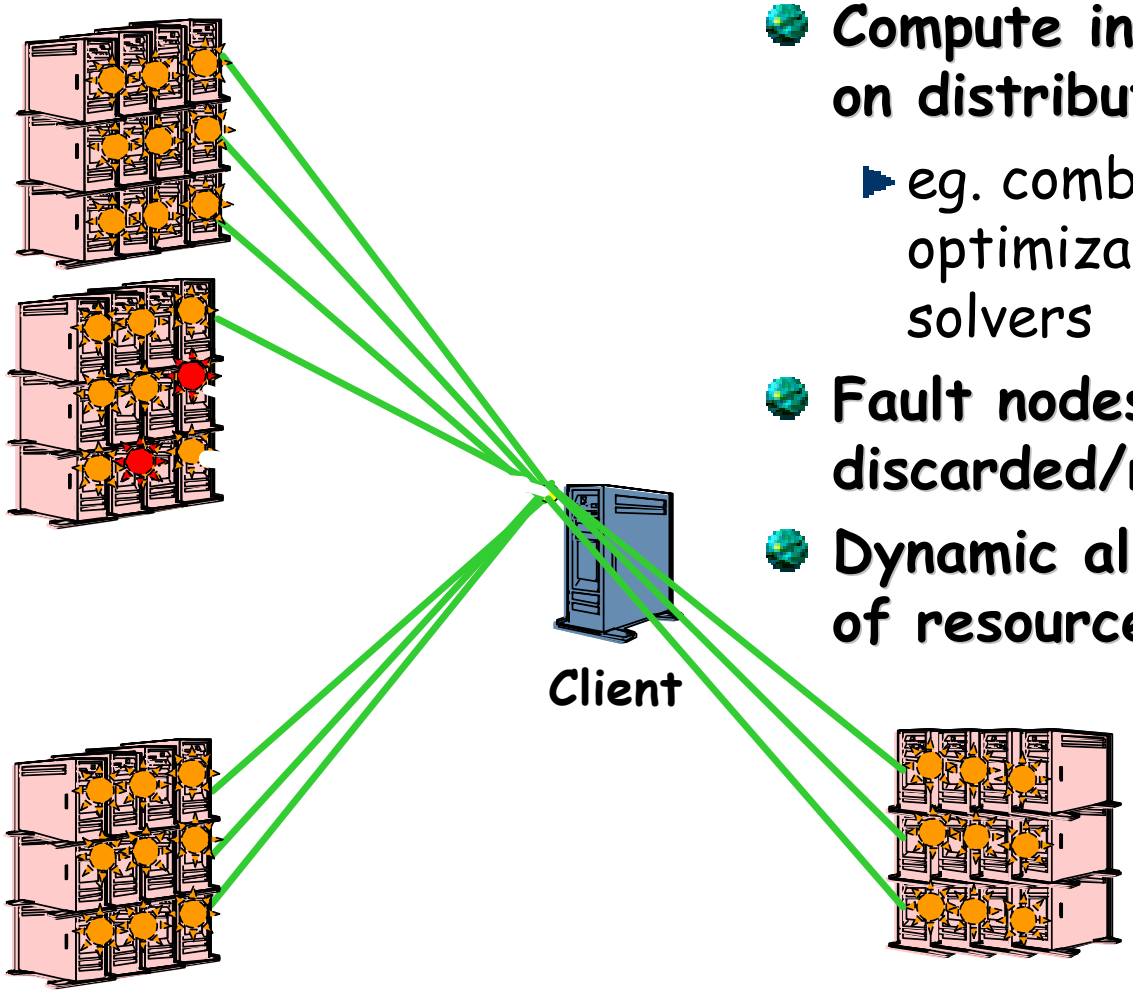
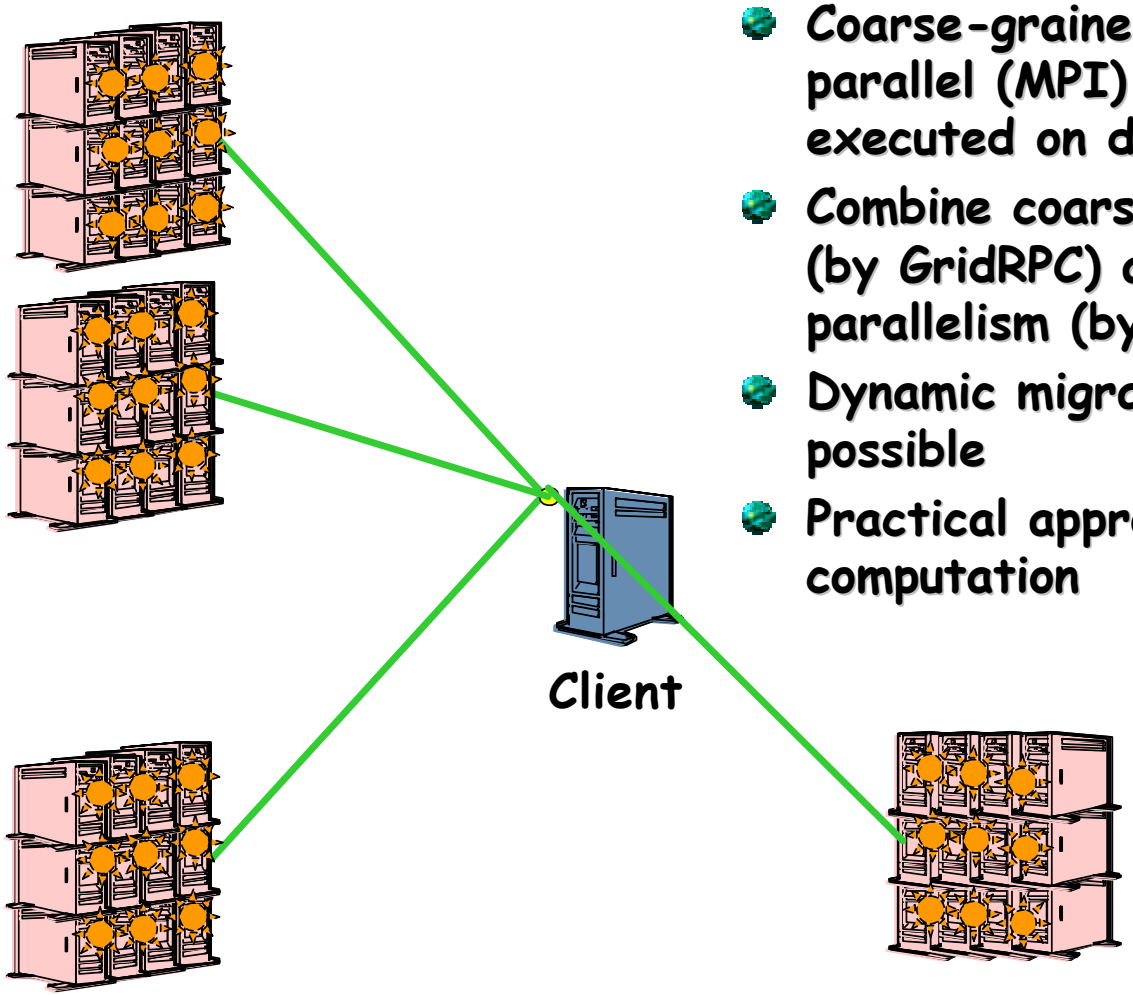
Typical scenario 2: parameter surevey



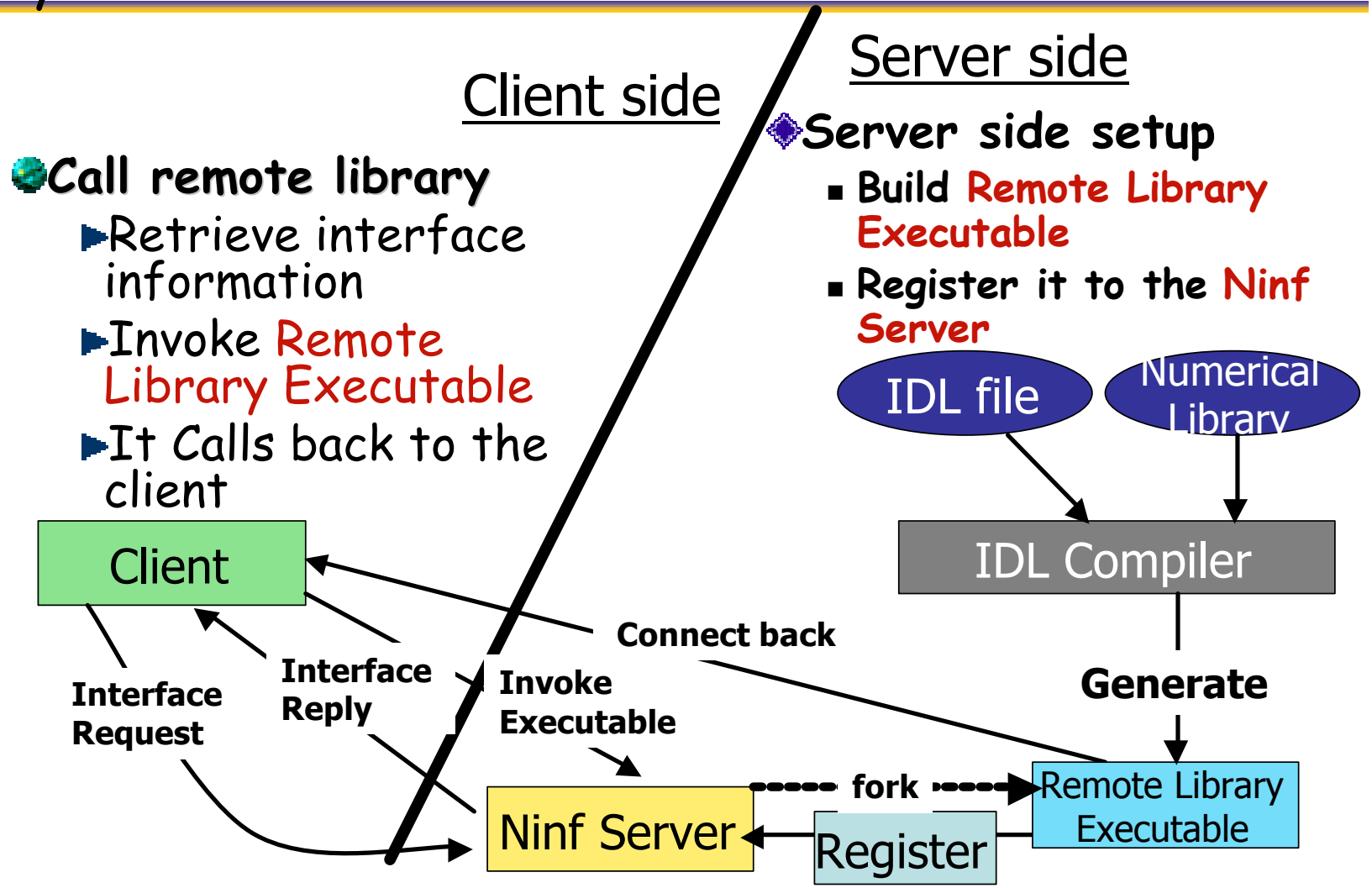
- **Compute independent tasks on distributed resources**
  - eg. combinatorial optimization problem solvers
- **Fault nodes can be discarded/retried**
- **Dynamic allocation / release of resources is possible**

Typical scenario 3: GridRPC + MPI



- Coarse-grained independent parallel (MPI) programs are executed on distributed clusters
- Combine coarse-grained parallelism (by GridRPC) and fine-grained parallelism (by MPI)
- Dynamic migration of MPI jobs is possible
- Practical approach for large-scale computation

Sample Architecture and Protocol of GridRPC System – Ninf -



GridRPC: based on Client/Server model

- **Server-side setup**
  - Remote libraries must be installed in advance
    - Write IDL files to describe interface to the library
    - Build remote libraries
  - Syntax of IDL depends on GridRPC systems
    - e.g. Ninf-G and NetSolve have different IDL
- **Client-side setup**
  - Write a client program using GridRPC API
  - Write a client configuration file
  - Run the program

Ninf-G

Overview and Architecture

What is Ninf-G?

- **A software package which supports programming and execution of Grid applications using GridRPC.**
- **The latest version is 2.4.0.**
  - The version 4.0 beta based on WS-components of Globus is also available.
- **Ninf-G is developed using Globus C and Java APIs.**
  - Uses GSI, GRAM, MDS, (GASS), and Globus-IO
- **Ninf-G includes**
  - C/C++, Java APIs, libraries for software development
  - IDL compiler for stub generation
  - Shell scripts to
    - compile client program
    - build and publish remote libraries
  - sample programs and manual documents

Globus Toolkit

Defacto standard as low-level Grid middleware

Requirements for Grid

- **Security**
  - authentication, authorization, message protection, etc.
- **Information services**
  - Provides various information
    - available resources (hw/sw), status, etc.
- **resource management**
  - process spawning on remote computers
- **scheduling**
- **data management, data transfer**
- **usability**
  - Single Sign On, etc.
- **others**
  - accounting, etc…

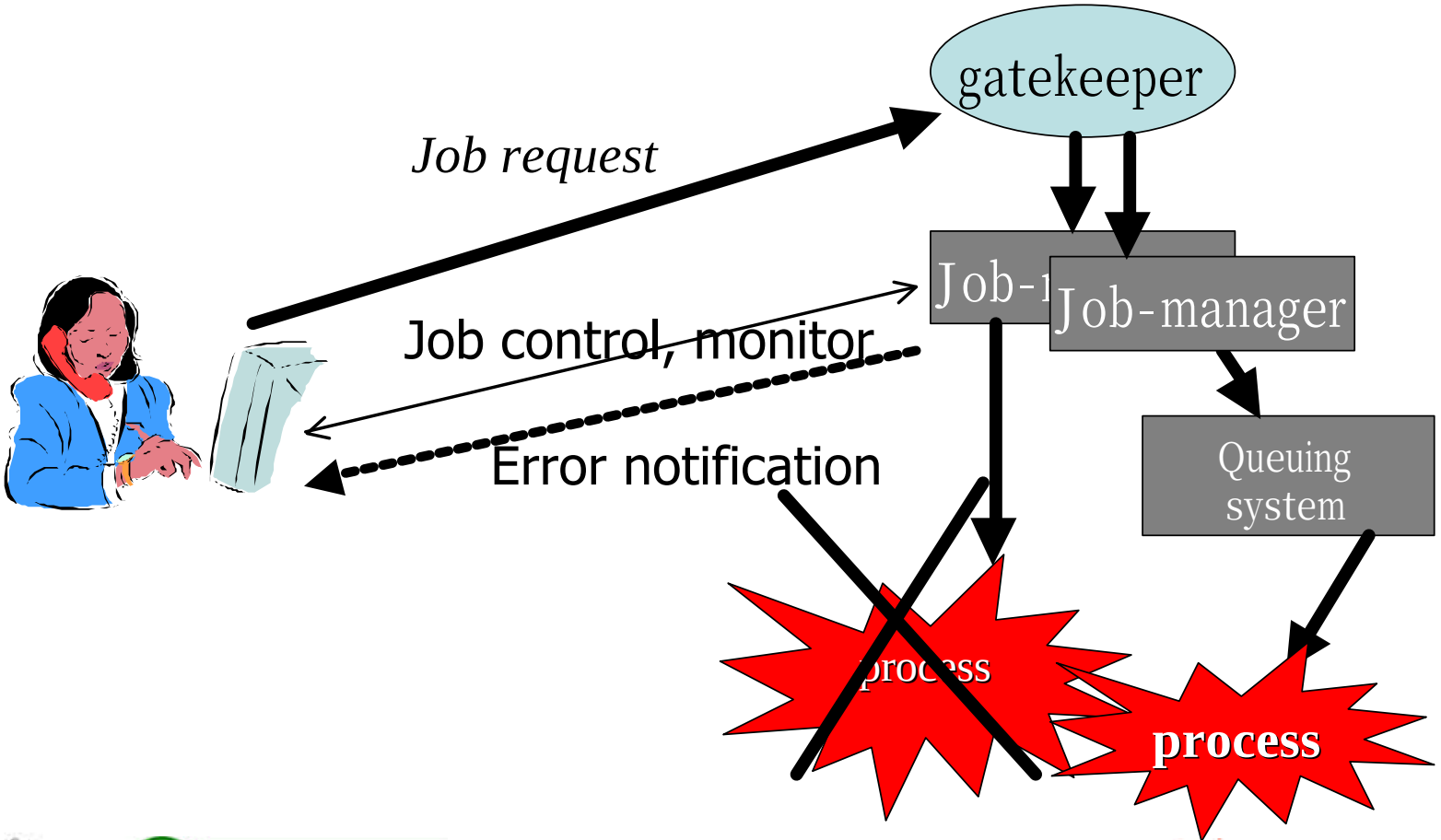
What is the Globus Toolkit?

- **A Toolkit which makes it easier to develop computational Grids**
- **Developed by the Globus Alliance and many others all over the world (mainly ANL and USC/ISI)**
- **Defacto standard as a low level Grid middleware**
  - Most Grid testbeds are using the Globus Toolkit
- **Three versions are exist**
  - 2.4.3 (GT2 / Pre-WS)
  - 3.2.1 (GT3 / OGSI)
  - 4.0.1 (GT4 / WSRF)
- **GT2 component is included in GT3/GT4**
  - Pre-WS components

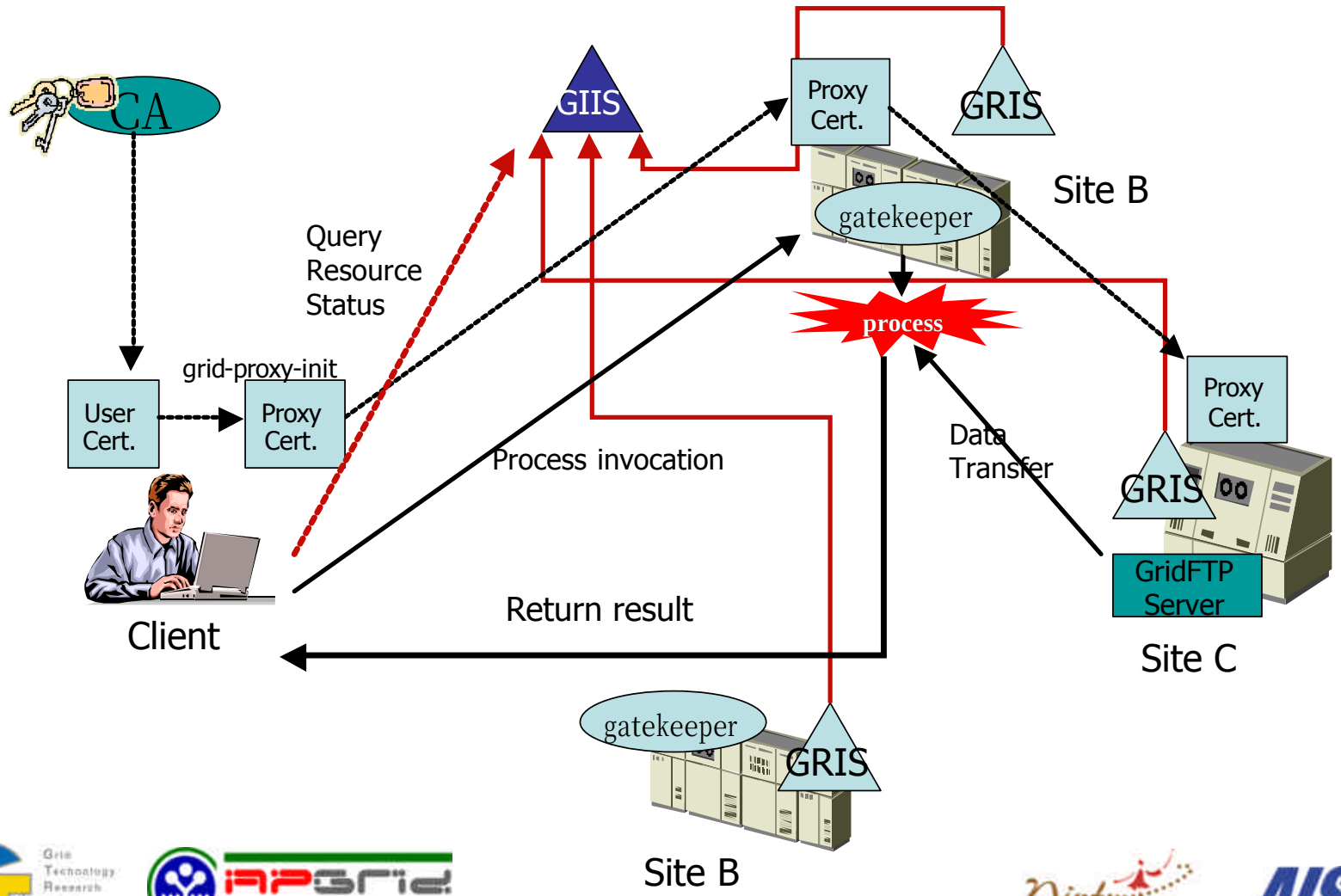
GT2 components

- **GSI: Single Sign On + delegation**
- **MDS: Information Retrieval**
  - Hierarchical Information Tree (GRIS+GIIS)
- **GRAM: Remote process invocation**
  - Three components:
    - Gatekeeper
    - Job Manager
    - Queuing System (pbs, sge, etc.)
- **Data Management:**
  - GridFTP
  - Replica management
  - GASS (excluded in GT4)
- **Globus XIO**
- **GT2 provides C/Java APIs and Unix commands for these components**

GRAM: Grid Resource Allocation Manager



Big picture of the GT2



Some notes on the GT2 (1/2)

- **Globus Toolkit is not providing a framework for anonymous computing and mega-computing**
  - Users are required
    - to have an account on servers to which the user would be mapped when accessing the servers
    - to have a user certificate issued by a trusted CA
    - to be allowed by the administrator of the server
  - Complete differences with mega-computing framework such as SETI@HOME

Some notes on the GT2 (2/2)

- **Do not think that the Globus Toolkit solves all problems on the Grid.**
  - The Globus Toolkit is a set of tools for the easy development of computational Grids and middleware
    - The Globus Toolkit includes low-level APIs and several UNIX commands
    - It is not easy to develop application programs using Globus APIs. High-level middleware helps application development.
  - Several necessary functions on the computational Grids are not supported by the Globus Toolkit.
    - Brokering, Co-scheduling, Fault Managements, etc.
  - Other supposed problems
    - using IP-unreachable resources (private IP addresses + MPICH-G2)
    - scalability (ldap, maintenance of grid-mapfiles, etc.)

Ninf-G

Overview and architecture

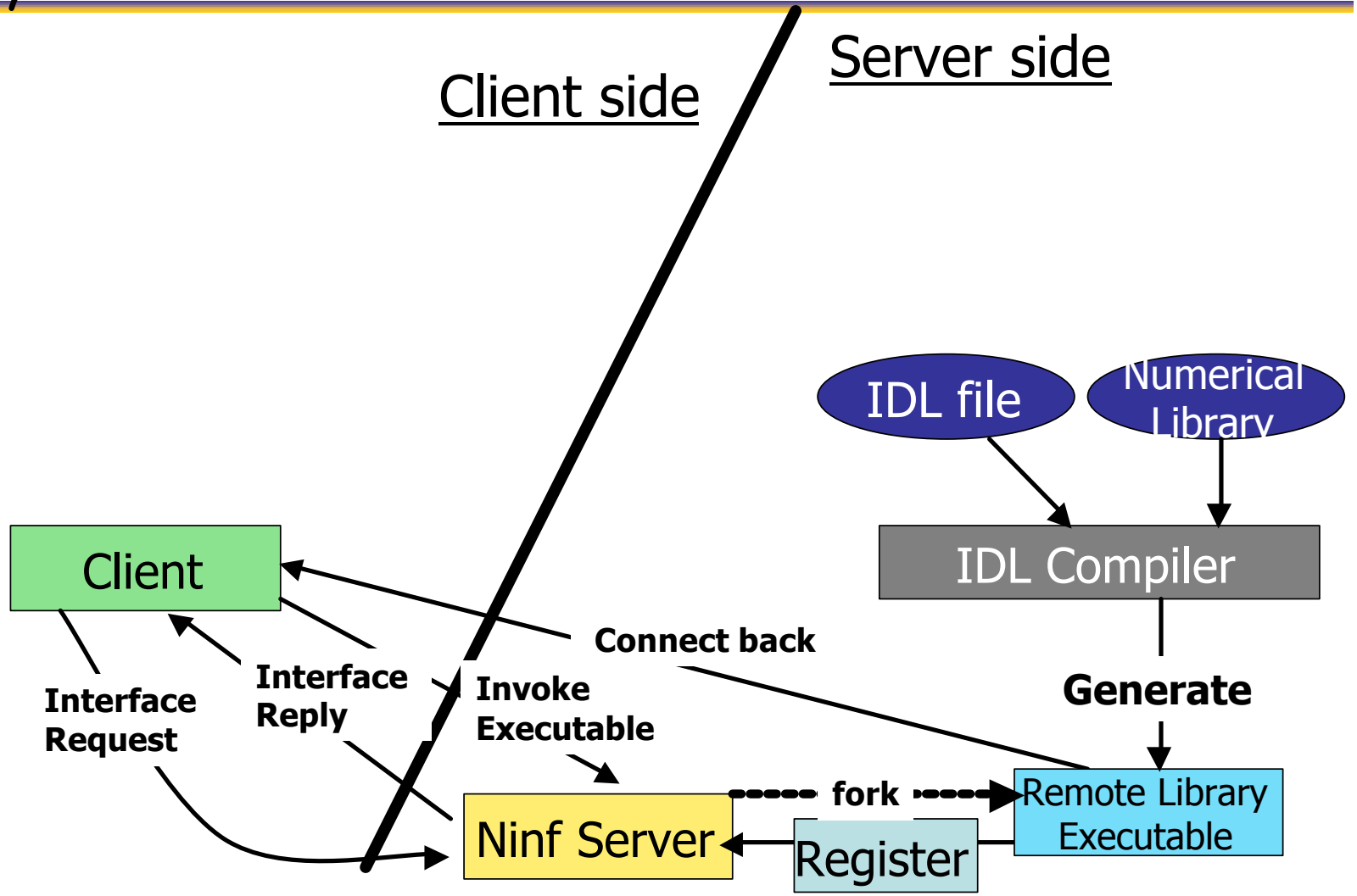
Terminology

- **Ninf-G Client**
  - This is a program written by a user for the purpose of controlling the remote execution of computation.
- **Ninf-G IDL**
  - Ninf-G IDL (Interface Description Language) is a language for describing interfaces for functions and objects those are expected to be called by Ninf-G client.
- **Ninf-G Stub**
  - Ninf-G stub is a wrapper function of a remote function/object. It is generated by the stub generator according to the interface description for user-defined functions and methods.

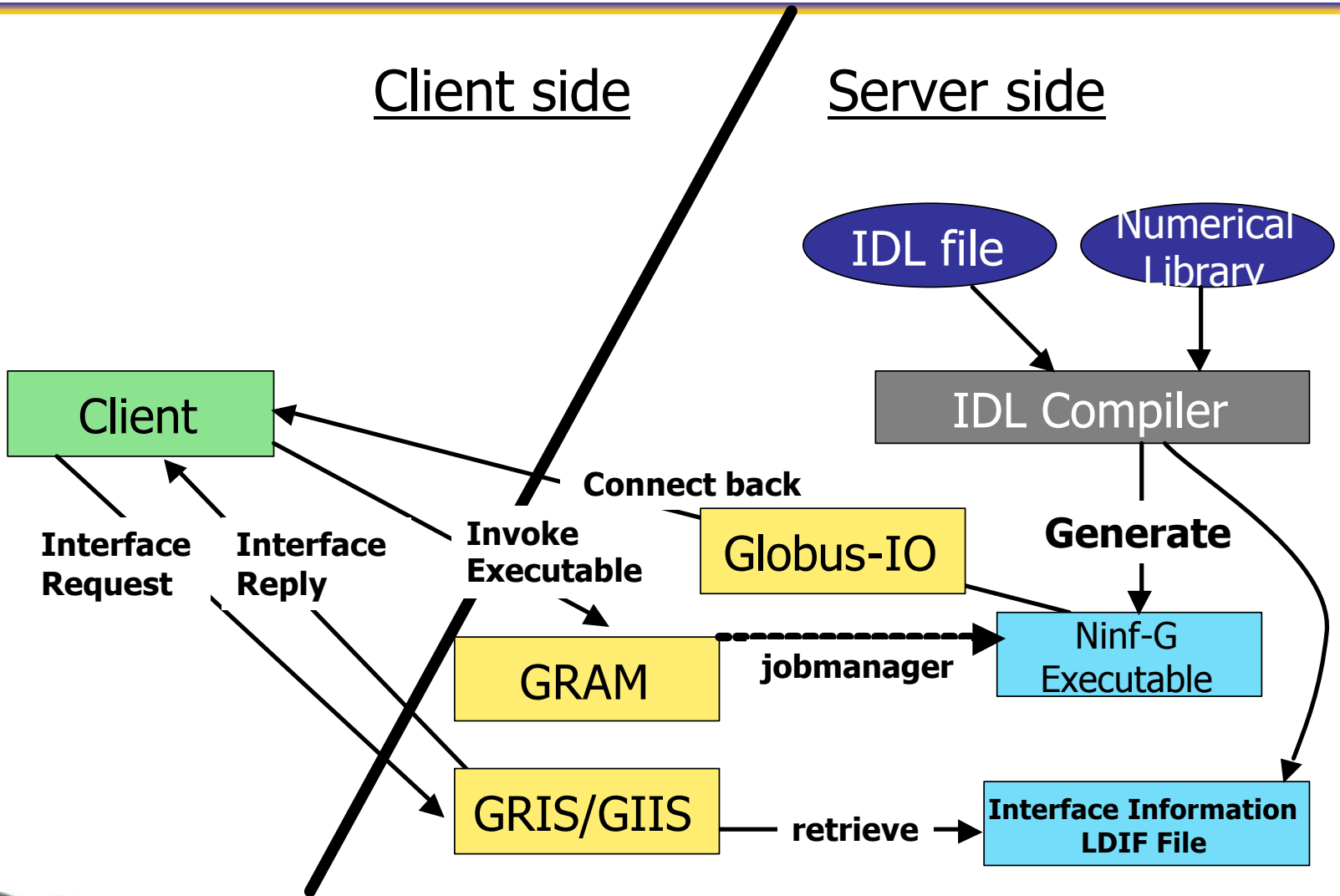
Terminloogy (cont'd)

- **Ninf-G Executable**
  - Ninf-G executable is an executable file that will be invoked by Ninf-G systems. It is obtained by linking a user-written function with the stub code, Ninf-G and the Globus Toolkit libraries.
- **Session**
  - A session corresponds to an individual RPC and it is identified by a non-negative integer called Session ID.
- **GridRPC API**
  - Application Programming Interface for GridRPC
  - The GridRPC API is going to be standardized at the GGF GridRPC WG.

Sample Architecture and Protocol of GridRPC System – Ninf -



Architecture of Ninf-G



How to use Ninf-G

- **Build remote libraries on server machines**
  - Write IDL files
  - Compile the IDL files
  - Build and install remote executables
- **Develop a client program**
  - Programming using GridRPC API
  - Compile
- **Run**
  - Create a client configuration file
  - Generate a proxy certificate
  - Run

Sample Program

- **Parameter Survey**
  - No. of surveys: n
  - Survey function: survey(in1, in2, result)
  - Input Parameters: double in1, int in2
  - Output Value: double result[]

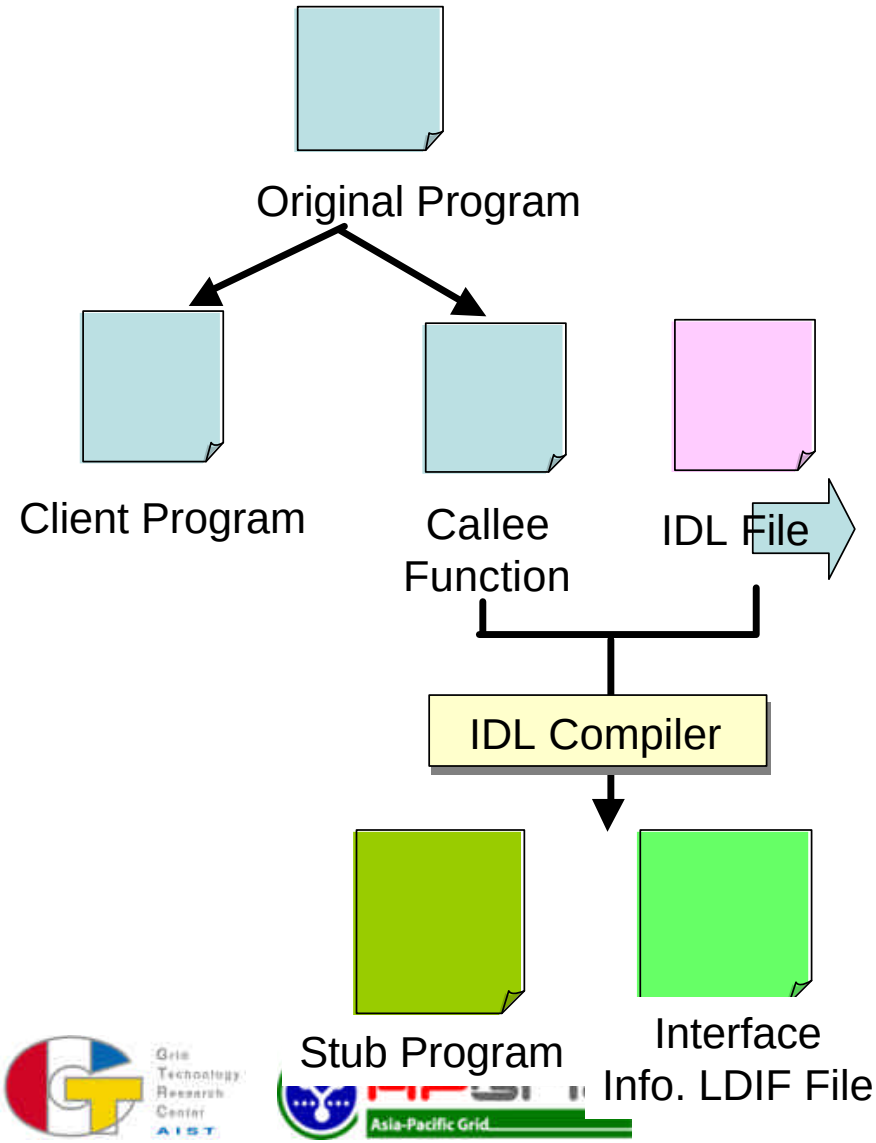
Main Program

```
Int main(int argc, char** argv)
{
int i, n, in2;
double in1, result[100][100];

Pre_processing();

For(I = 0; I < n, i++){
    survey(in1, in2, resul+100*n)
}

Post_processing();
```

Survey Function

```
survey(double in1, int in2, double* result)
{
 ...
  Do Survey
 ...

}
```

Build remote library (server-side operation)



Callee Function

```
survey
  (double in1, int in2, int size, double* result)
 ...
 Do Survey
 ...
}
```

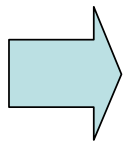
Specify size of argument

IDL File

```
Module Survey_prog;

Define survey
  (IN double in1, IN int in2, IN int size,
                  OUT double* result);

Required "survey.o"
Calls "C" survey(in1, in2, size, result);
```

Ninfy the original code (client-side)

```
Int main(int argc, char** argv)
{
int i, n, in2;
double in1, result[100][100];

Pre_processing();

For(I = 0; I < n, i++){
    survey(in1, in2, resul+100*n)
}

Post_processing();
```



```
Int main(int argc, char** argv) {
int i, n, in2;
double in1, result[100][100];
grpc_function_handle_t handle [100];

Pre_processing();

grpc_initialize();
for(I = 0; I < n; i++) {
   handle[i] = grpc_function_handle_init();
}

For(I = 0; I < n, i++){
    grpc_call_async
        (handles, in1,in2,100, result+100*n)
}
grpc_wait_all();

for(I = 0; i<n; i++){
  grpc_function_handle_destruct();
}
grpc_finalize();

Post_processing();
```

Declare func. handles

Init func. handles

Async. RPC

Retrieve results

Destruct handles

Ninf-G

How to build remote libraries

Ninf-G remote libraries

- **Ninf-G remote libraries are implemented as executable programs (Ninf-G executables) which**
  - contains stub routine and the main routine
  - will be spawned off by GRAM
- **The stub routine handles**
  - communication with clients and Ninf-G system itself
  - argument marshalling
- **Underlying executable (main routine) can be written in C, C++, Fortran, etc.**

Ninf-G remote libraries (cont'd)

- **Ninf-G provides two kinds of Ninf-G remote executables:**
  - Function
    - Stateless
    - Defined in standard GridRPC API
  - Ninf-G object
    - stateful
    - enables to avoid redundant data transfers
    - multiple methods can be defined
      - initialization
      - computation

How to build Ninf-G remote libraries (1/3)

- Write an interface information using Ninf-G Interface Description Language (Ninf-G IDL).
  Example:

```
Module mmul;
Define dmmul (IN int n,
              IN double A[n][n],
              IN double B[n][n],
              OUT double C[n][n])
Require "libmmul.o"
Calls "C" dmmul(n, A, B, C);
```

- Compile the Ninf-G IDL with Ninf-G IDL compiler

```
% ng_gen <IDL_FILE>
```

  ns_gen generates stub source files and a makefile (<module_name>.mak)

How to build Ninf-G remote libraries (2/3)

- Compile stub source files and generate Ninf-G executables and LDIF files (used to register Ninf-G remote libraries information to GRIS).

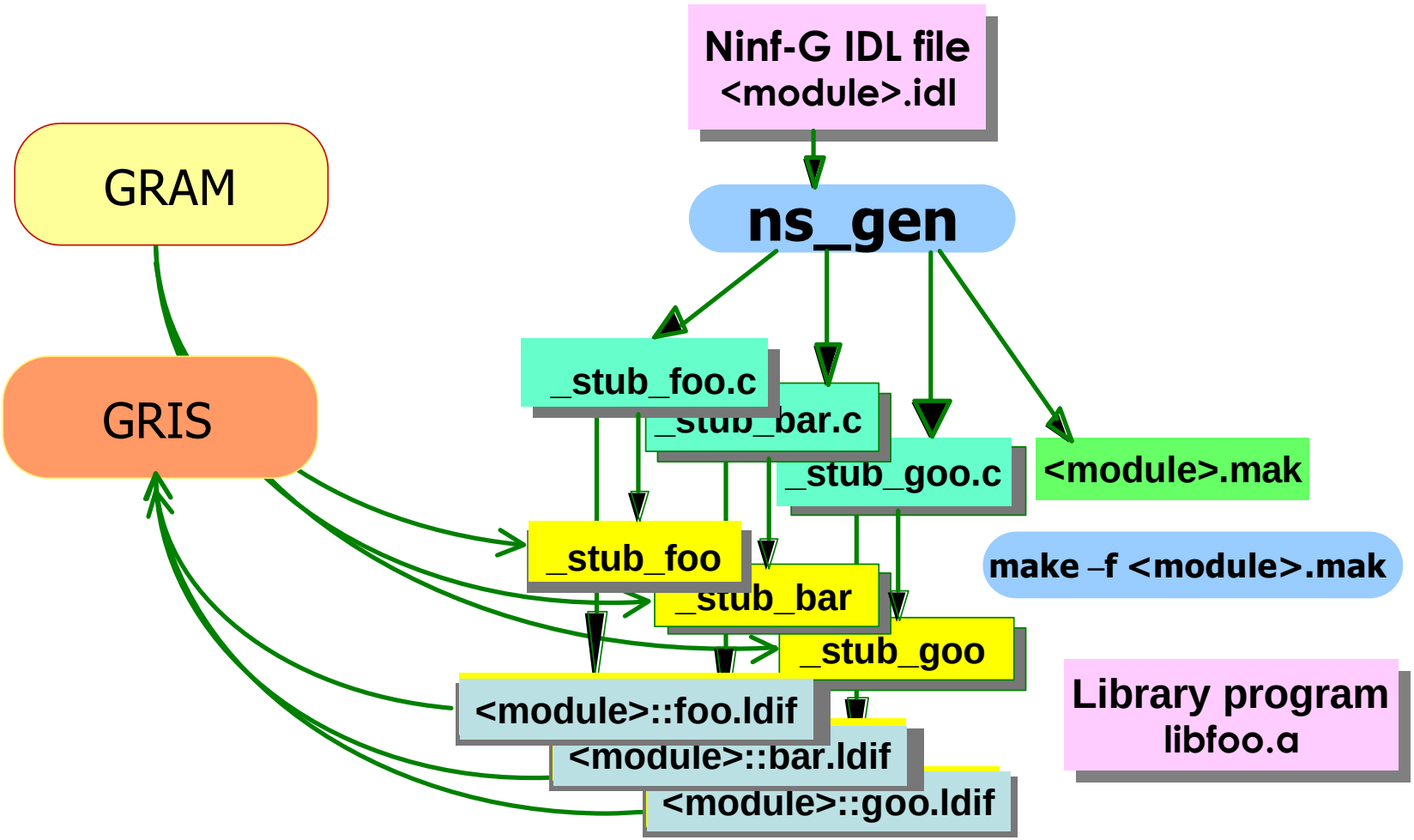
  % make –f <module_name>.mak

- Publish the Ninf-G remote libraries

  % make –f <module_name>.mak install

  This copies the LDIF files to ${GLOBUS_LOCATION}/var/gridrpc

How to build Ninf-G remote libraries (3/3)



Ninf-G IDL Statements (1/3)

- **Module module_name**
  - specifies the module name.
- **CompileOptions "options"**
  - specifies compile options which should be used in the resulting makefile
- **Library "object files and libraries"**
  - specifies object files and libraries
- **FortranFormat "format"**
  - provides translation format from C to Fortran.
  - Following two specifiers can be used:
    - %s: original function name
    - %l: capitalized original function name
  - Example:
    FortranFormat "_%l_";
    Calls "Fortran" fft(n, x, y);
    will generate function call
    FFT(n, x, y);
    in C.
- **Globals { ... C descriptions }**
  - declares global variables shared by all functions

How to define a remote function

- **Define routine_name (parameters...)**
  ["description"]
  [Required "object files or libraries"]
  [Backend "MPI"|"BLACS"]
  [Shrink "yes"|"no"]
  {{C descriptions} |
  Calls "C"|"Fortran" calling sequence}
  - declares function interface, required libraries and the main routine.
  - Syntax of parameter description:
    [mode-spec] [type-spec] formal_parameter
    [[dimension [:range]]+]+

How to define a remote object

- **DefClass** class name
  ["description"]
  [Required "object files or libraries"]
  [Backend "MPI" | "BLACS"]
  [Language "C" | "fortran"]
  [Shrink "yes" | "no"]
  { [DefState{ ... }]
    DefMethod method name (args...)
      {calling sequence}
  - Declares an interface for Ninf-G objects

Syntax of parameter description (detailed)

- **mode-spec: one of the following**
  - IN: parameter will be transferred from client to server
  - OUT: parameter will be transferred from server to client
  - INOUT: at the beginning of RPC, parameter will be transferred from client to server. at the end of RPC, parameter will be transferred from server to client
  - WORK: no transfers will be occurred. Specified memory will be allocated at the server side.
- **type-spec should be either char, short, int, float, long, longlong, double, complex, or filename.**
- **For arrays, you can specify the size of the array. The size can be specified using scalar IN parameters.**
  - Example: IN int n, IN double a[n]

Sample Ninf-G IDL (1/3)

- **Matrix Multiply**

```
Module matrix;

Define dmmul (IN int n,
                    IN double A[n][n],
                    IN double B[n][n],
                    OUT double C[n][n])
“Matrix multiply: C = A x B“
Required “libmmul.o”
Calls “C” dmmul(n, A, B, C);
```

Sample Ninf-G IDL (2/3)

```
Module sample_object;

DefClass sample_object
"This is test object"
Required "sample.o"
{
    DefMethod mmul(IN long n, IN double A[n][n],
        IN double B[n][n], OUT double C[n][n])
    Calls "C" mmul(n,A,B,C);

    DefMethod mmul2(IN long n, IN double A[n*n+1-1],
            IN double B[n*n+2-3+1], OUT double C[n*n])
    Calls "C" mmul(n,A,B,C);

    DefMethod FFT(IN int n,IN int m, OUT float x[n][m], float INOUT y[m][n]
)
    Calls "Fortran" FFT(n,x,y);
}
```

Sample Ninf-G IDL (3/3)

ScaLAPACK (pdgesv)

```
Module SCALAPACK;

CompileOptions "NS_COMPILER = cc";
CompileOptions "NS_LINKER = f77";
CompileOptions "CFLAGS = -DAdd_ -O2 –64 –mips4 –r10000";
CompileOptions "FFLAGS = -O2 -64 –mips4 –r10000";
Library "scalapack.a pblas.a redist.a tools.a libmpiblacs.a –lblas –lmpi –lm";

Define pdgesv (IN int n, IN int nrhs, INOUT double global_a[n][lda:n], IN int lda,
                    INOUT double global_b[nrhs][ldb:n], IN int ldb, OUT int info[1])
Backend "BLACS"
Shrink "yes"
Required "procmap.o pdgesv_ninf.o ninf_make_grid.of Cnumroc.o descinit.o"
Calls "C" ninf_pdgesv(n, nrhs, global_a, lda, global_b, ldb, info);
```

Ninf-G

How to call Remote Libraries
- client side APIs and operations -

(Client) User's Scenario

- Write client programs in C/C++/Java using APIs provided by Ninf-G
- Compile and link with the supplied Ninf-G client compile driver (ng_cc)
- Write a client configuration file in which runtime environments can be described
- Run grid-proxy-init command
- Run the program

GridRPC API / Ninf-G API

APIs for programming client applications

The GridRPC API and Ninf-G API

- **GridRPC API**
  - Standard C API defined by the GGF GridRPC WG.
  - Provides portable and simple programming interface.
  - Enable interoperability between implementations such as Ninf-G and NetSolve.
- **Ninf-G API**
  - Non-standard API (Ninf-G specific)
  - complement to the GridRPC API
  - provided for high performance, usability, etc.
  - ended by _np
    - eg: grpc_function_handle_array_init_np(...)

Rough steps for RPC

- **Initialization**

```
grpc_initialize(config_file);
```

- **Create a function handle**
  - abstraction of a connection to a remote executable

```
grpc_function_handle_t  handle;

grpc_function_handle_init(
  &handle, hostname, “library_name”);
```

- **Call a remote library**

```
grpc_call(&handle, args…);
          or
grpc_call_async(&handle, args…);
grpc_wait( );
```

Data types

- **Function handle – grpc_function_handle_t**
  - A structure that contains a mapping between a client and an instance of a remote function
- **Object handle – grpc_object_handle_t_np**
  - A structure that contains a mapping between a client and an instance of a remote object
- **Session ID – grpc_sessionid_t**
  - Non-negative integer that identifies a session
  - Session ID can be used for status check, cancellation, etc. of outstanding RPCs.
- **Error and status code – grpc_error_t**
  - Integer that describes error and status of GridRPC APIs.
  - All GridRPC APIs return error code or status code.

Initialization / Finalization

- **grpc_error_t grpc_initialize(char *config_file_name)**
  - reads the configuration file and initialize client.
  - Any calls of other GRPC APIs prior to grpc_initialize would fail
  - Returns success code (GRPC_NO_ERROR) or specific error code (GRPC_*)
- **grpc_error_t grpc_finalize()**
  - Frees resources (memory, etc.)
  - Any calls of other GRPC APIs after grpc_finalize would fail
  - Returns success code (GRPC_NO_ERROR) or specific error code (GRPC_*)

Function handles

- **grpc_error_t grpc_function_handle_default(**
  grpc_function_handle_t *handle,
  char *func_name)
  - Creates a function handle to the default server
- **grpc_error_t grpc_function_handle_init(**
  grpc_function_handle_t *handle,
  char *func_name)
  - Specifies the server explicitly by the second argument.
- **grpc_error_t grpc_function_handle_destruct(**
  grpc_function_handle_t *handle)
  - Frees memory allocated to the function handle

Function handles (cont'd)

- **grpc_error_t grpc_function_handle_array_default_np (**
  grpc_function_handle_t *handle,
  size_t nhandles,
  char *func_name)
  - Creates multiple function handles via a single GRAM call
- **grpc_error_t grpc_function_handle_array_init_np (**
  grpc_function_handle_t *handle,
  size_t nhandles,
  char *host_port_str,
  char *func_name)
  - Specifies the server explicitly by the second argument.
- **grpc_error_t grpc_function_handle_array_destruct_np (**
  grpc_function_handle_t *handle,
  size_t nhandles)
  - Specifies the server explicitly by the second argument.

Object handles

- **grpc_error_t grpc_object_handle_default_np (**
  grpc_object_handle_t_np *handle,
  char *class_name)
  - Creates an object handle to the default server
- **grpc_error_t grpc_object_handle_init_np (**
  grpc_function_object_t_np *handle,
  char *host_port_str,
  char *class_name)
  - Specifies the server explicitly by the second argument.
- **grpc_error_t grpc_function_object_destruct_np (**
  grpc_object_handle_t_np *handle)
  - Frees memory allocated to the function handle.

Object handles (cont'd)

- **grpc_error_t grpc_object_handle_array_default (**
  grpc_objct_handle_t_np *handle,
  size_t nhandles,
  char *class_name)
  - Creates multiple object handles via a single GRAM call.
- **grpc_error_t grpc_object_handle_array_init_np (**
  grpc_object_handle_t_np *handle,
  size_t nhandles,
  char *host_port_str,
  char *class_name)
  - Specifies the server explicitly by the second argument.
- **grpc_error_t grpc_object_handle_array_destruct_np (**
  grpc_object_handle_t_np *handle,
  size_t nhandles)
  - Frees memory allocated to the function handles.

Synchronous RPC v.s. Asynchronous RPC

Synchronous RPC

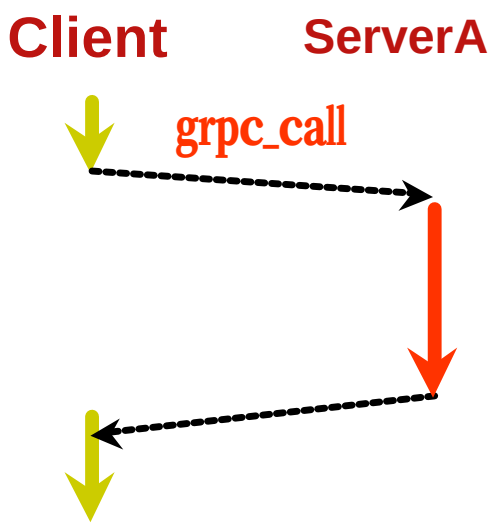
- Blocking Call
- Same semantics with a local function call.

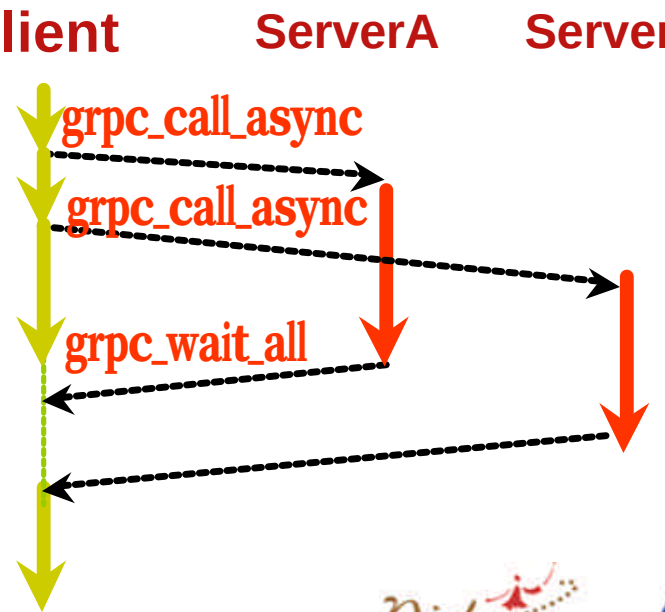
```
grpc_call(...);
```

Asynchronous RPC

- Non-blocking Call
- Useful for task-parallel applications

```
grpc_call_async(...);
grpc_wait_*(…);
```





RPC functions

- **grpc_error_t grpc_call (**
  grpc_function_handle_t *handle, ...)
  - Synchronous (blocking) call
- **grpc_error_t grpc_call_async (**
  grpc_function_handle_t *handle,
  grpc_sessionid_t *sessionID,
  ...)
  - Asynchronous (non-blocking) call
  - Session ID is stored in the second argument.

Ninf-G method invocation

- **grpc_error_t grpc_invoke_np (**
  grpc_object_handle_t_np *handle,
  char *method_name,
  ...
)
  - Synchronous (blocking) method invocation
- **grpc_error_t grpc_invoke_async_np (**
  grpc_object_handle_t_np *handle,
  char *method_name,
  grpc_sessionid_t *sessionID,
  ...)
  - Asynchronous (non-blocking) method invocation
  - session ID is stored in the third argument.

Session control functions

- **grpc_error_t grpc_probe (**
  grpc_sessionid_t sessionID)
  - probes the job specified by SessionID whether the job has been completed.
- **grpc_error_t grpc_probe_or (**
  grpc_sessionid_t *idArray,
  size_t length,
  grpc_sessionid_t *idPtr)
  - probes whether at least one of jobs in the array has been
- **grpc_error_t grpc_cancel (**
  grpc_sessionid_t sessionID)
  - Cancels a session
- **grpc_error_t grpc_cancel_all ()**
  - Cancels all outstanding sessions

Wait functions

- **grpc_error_t grpc_wait (**
  grpc_sessionid_t sessionID)
  - Waits outstanding RPC specified by sessionID
- **grpc_error_t grpc_wait_and (**
  grpc_sessionid_t *idArray,
  size_t length)
  - Waits all outstanding RPCs specified by an array of sessionIDs

Wait functions (cont'd)

- **grpc_error_t grpc_wait_or (**
  grpc_sessionid_t *idArray,
  size_t length,
  grpc_sessionid_t *idPtr)
  - Waits any one of RPCs specified by an array of sessionIDs.
- **grpc_error_t grpc_wait_all ()**
  - Waits until all outstanding RPCs are completed.
- **grpc_error_t grpc_wait_any (**
  grpc_sessionid_t *idPtr)
  - Waits any one of outstanding RPCs.

Ninf-G

Compile and run

Prerequisite

- **Environment variables**
  - GLOBUS_LOCATION
  - NG_DIR
- **PATH**
  - ${GLOBUS_LOCATION}/etc/globus-user-env.{csh,sh}
  - ${NG_DIR}/etc/ninfg-user-env.{csh,sh}
- **Globus-level settings**
  - User certificate, CA certificate, grid-mapfile
  - test
    % grid-proxy-init
    % globus-job-run server.foo.org /bin/hostname
- **Notes for dynamic linkage of the Globus shared libraries:**
  - Globus dynamic libraries (shared libraries) must be linked with the Ninf-G stub executables. In case of Linux, runpath is set automatically.

Compile and run

- Compile the client application using ng_cc command
  % ng_cc –o myapp app.c
- Create a proxy certificate
  % grid-proxy-init
- Prepare a client configuration file
- Run
  % ./myapp config.cl [args...]

Client configuration file

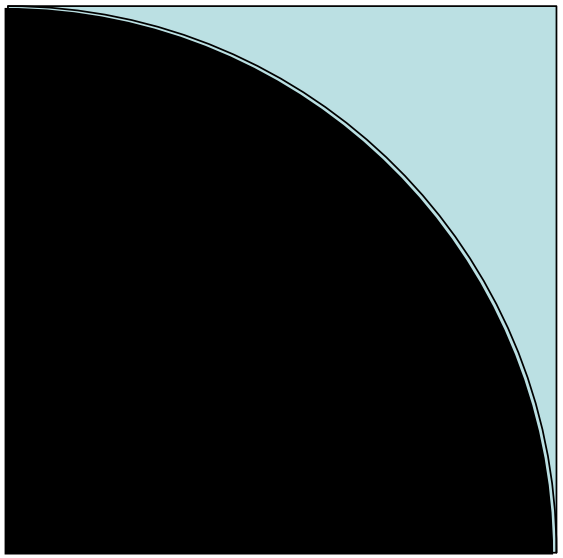
- **Specifies runtime environments**
- **Available attributes are categorized to sections:**
  - INCLUDE section
  - CLIENT section
  - LOCAL_LDIF section
  - FUNCTION_INFO section
  - MDS_SERVER section
  - SERVER section
  - SERVER_DEFAULT section

Frequently used attributes

- **<CLIENT> </CLIENT> section**
  - loglevel
  - refresh_credential
- **<SERVER> </SERVER> section**
  - hostname
  - mpi_runNoOfCPUs
  - jobmanager
  - job_startTimeout
  - job_queue
  - heatbeat / heatbeat_timeoutCount
  - redirect_outerr
- **<FUNCTION_INFO> </FUNCTION_INFO> section**
  - session_timeout
- **<LOCAL_LDIF> </LOCAL_LDIF> section**
  - filename

Example: Task Parallel Programs (Compute PI using Monte-Carlo Method)

- **Generate a large number of random points within the square region that exactly encloses a unit circle (1/4 of a circle)**
  - PI = 4 p



Compute PI - Server Side -

pi.idl

```
Module pi;

Define pi_trial (
  IN int seed,
  IN long times,
  OUT long * count)
"monte carlo pi computation"
Required "pi_trial.o"
{
  long counter;
  counter = pi_trial(seed, times);
  *count = counter;
}
```

pi_trial.c

```
long pi_trial (int seed, long times) {
  long l, counter = 0;

  srandom(seed);
  for (l = 0; l < times; l++) {
    double x =
      (double)random() / RAND_MAX;
    double y =
      (double)random() / RAND_MAX;

    if (x * x + y * y < 1.0)
      counter++;
  }
  return counter;
}
```

Compute PI - Client Side-

```
#include "grpc.h"
#define NUM_HOSTS 8
char * hosts[] =
  {"host00", "host01", "host02", "host03"
   "host04", "host05", "host06", "host07"
grpc_function_handle_t handles[NUM_HOSTS]

main(int argc, char ** argv){
  double pi;
  long times, count[NUM_HOSTS], sum;
  char * config_file;
  int i;
  if (argc < 3){
    fprintf(stderr,
    "USAGE: %s CONFIG_FILE TIMES ¥n",
    argv[0]);
    exit(2);
  }
  config_file = argv[1];
  times = atol(argv[2]) / NUM_HOSTS;

  /* Initialize */
  if (grpc_initialize(config_file)
      != GRPC_NO_ERROR){
    grpc_perror_np("grpc_initialize");
    exit(2);
  }
  /* Initialize Function Handles */
  for (i = 0; i < NUM_HOSTS; i++)
    grpc_function_handle_init(&handles[i],
         hosts[i], "pi/pi_trial");

  for (i = 0; i < NUM_HOSTS; i++)
    /* Asynchronous RPC */
    if (gprc_call_async(&handles[i], i,
          times, &count[i]) !=
GRPC_NO_ERROR){
      grpc_perror_np("pi_trial");
      exit(2);
    }
  /* Wait all outstanding RPCs */
  if (grpc_wait_all() != GRPC_NO_ERROR){
    grpc_perror_np("wait_all");
    exit(2);
  }
  /* Display result */
  for (i = 0, sum = 0; i < NUM_HOSTS; i++)
    sum += count[i];
  pi = 4.0 *
    ( sum / ((double) times * NUM_HOSTS));
  printf("PI = %f¥n", pi);
  /* Finalize */
  grpc_finalize();
}
```

Ninf-G

Summary

How to use Ninf-G (again)

- **Build remote libraries on server machines**
  - Write IDL files
  - Compile the IDL files
  - Build and install remote executables
- **Develop a client program**
  - Programming using GridRPC API
  - Compile
- **Run**
  - Create a client configuration file
  - Generate a proxy certificate
  - Run

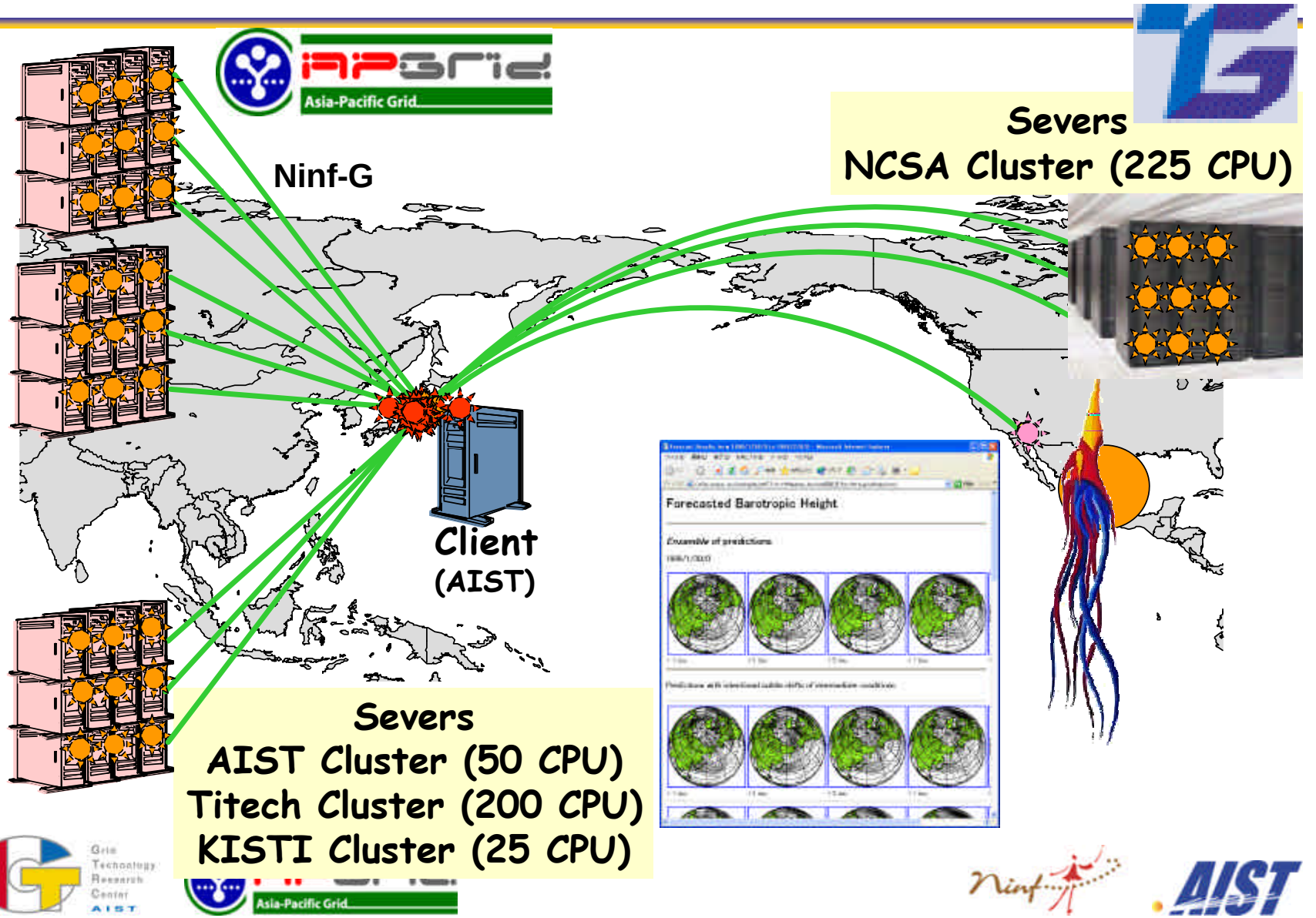
Ninf-G tips

- **How the server can be specified?**
  - Server is determined when the function handle is initialized.
    - grpc_function_handle_init();
      - hostname is given as the second argument.
    - grpc_function_handle_default();
      - hostname is specified in the client configuration file which must be passed as the first argument of the client program.
  - Ninf-G does not provide broker/scheduler/meta-server.
- **Should use LOCAL LDIF rather than MDS.**
  - easy, efficient and stable
- **How should I deploy Ninf-G executables?**
  - Deploy Ninf-G executables manually
  - Ninf-G provides automatic staging of executables
- **Other functionalities?**
  - heart-beating
  - timeout
  - client callbacks
  - attaching to debugger
  - ...

Ninf-G

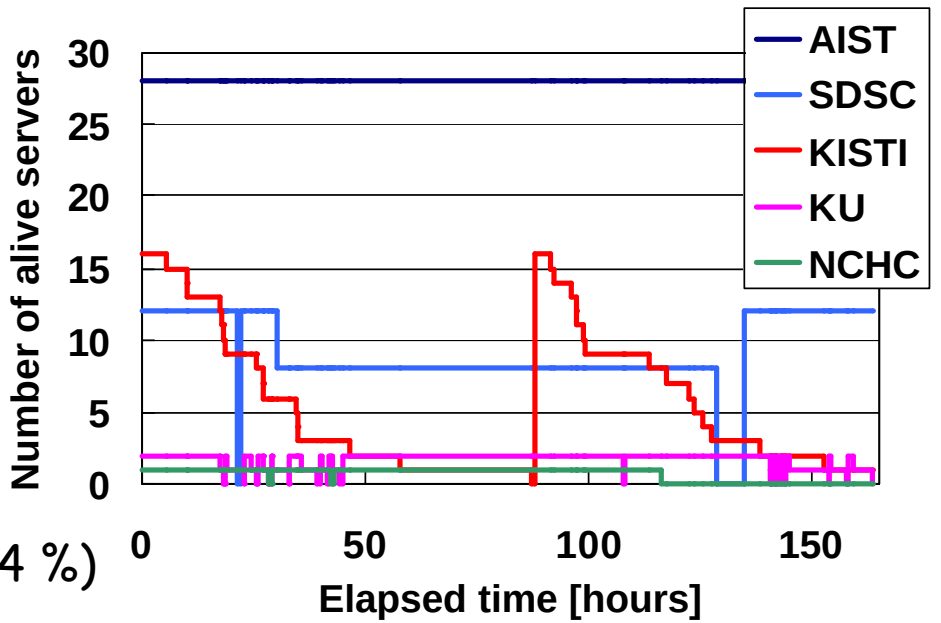
Recent achievements

Climate simulation on AIST-TeraGrid @SC2003



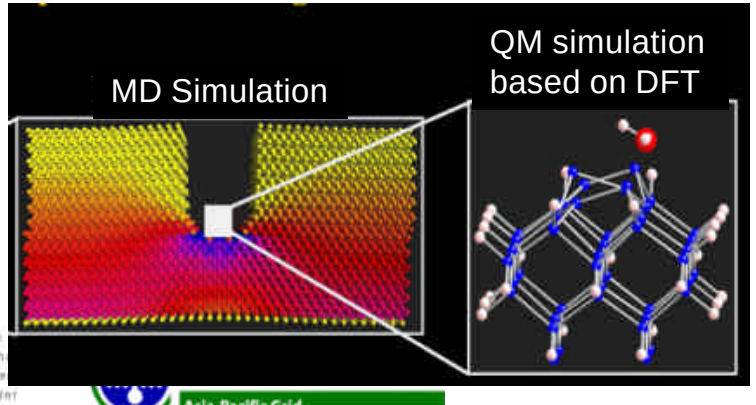
Experiments on long-run in 2004

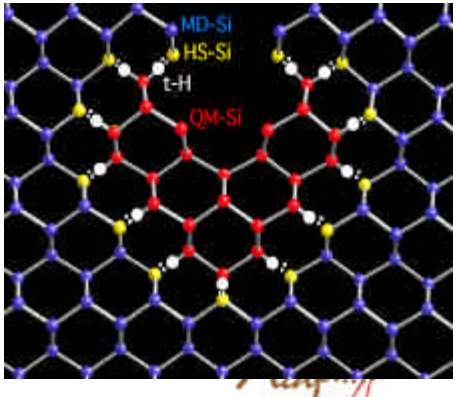
- **Purpose**
  - Evaluate quality of Ninf-G2
  - Have experiences on how GridRPC can adapt to faults
- **Ninf-G stability**
  - Number of executions : 43
  - Execution time
    (Total) : 50.4 days
    (Max) : 6.8 days
    (Ave) : 1.2 days
  - Number of RPCs:
    more than 2,500,000
  - Number of RPC failures:
    more than 1,600
    (Error rate is about 0.064 %)



Hybrid QM/MD Simulation in 2005

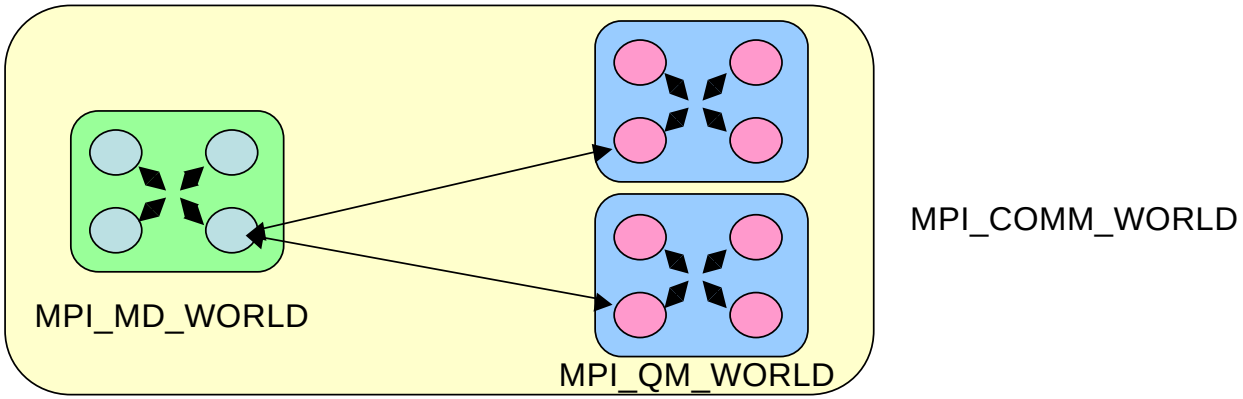
- **高精度大規模材料シミュレーションを現実的な時間内で可能にする**
  - 古典MDシミュレーションとQMシミュレーションを連携
    - MDシミュレーション
      - 全領域の原子の振る舞いを計算
      - 経験的な原子間ポテンシャルを用いた古典MD
    - QMシミュレーション
      - 興味のある領域におけるMDシミュレーションの結果を修正
      - density functional theory (DFT)に基づく計算



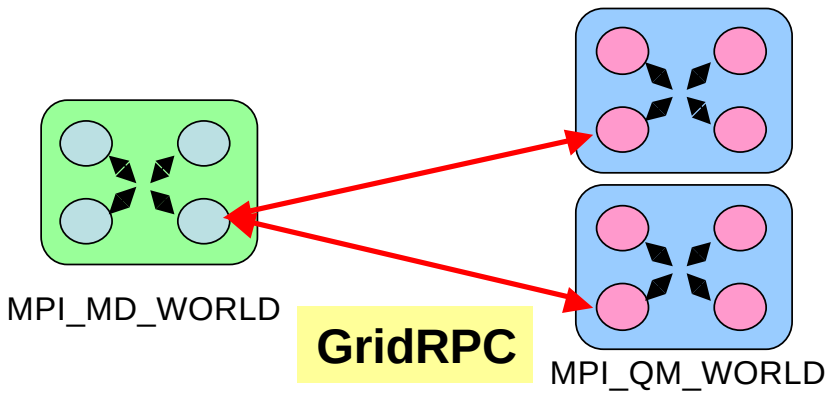


Re-implementation using GridRPC

- **Original implementation (MPI)**

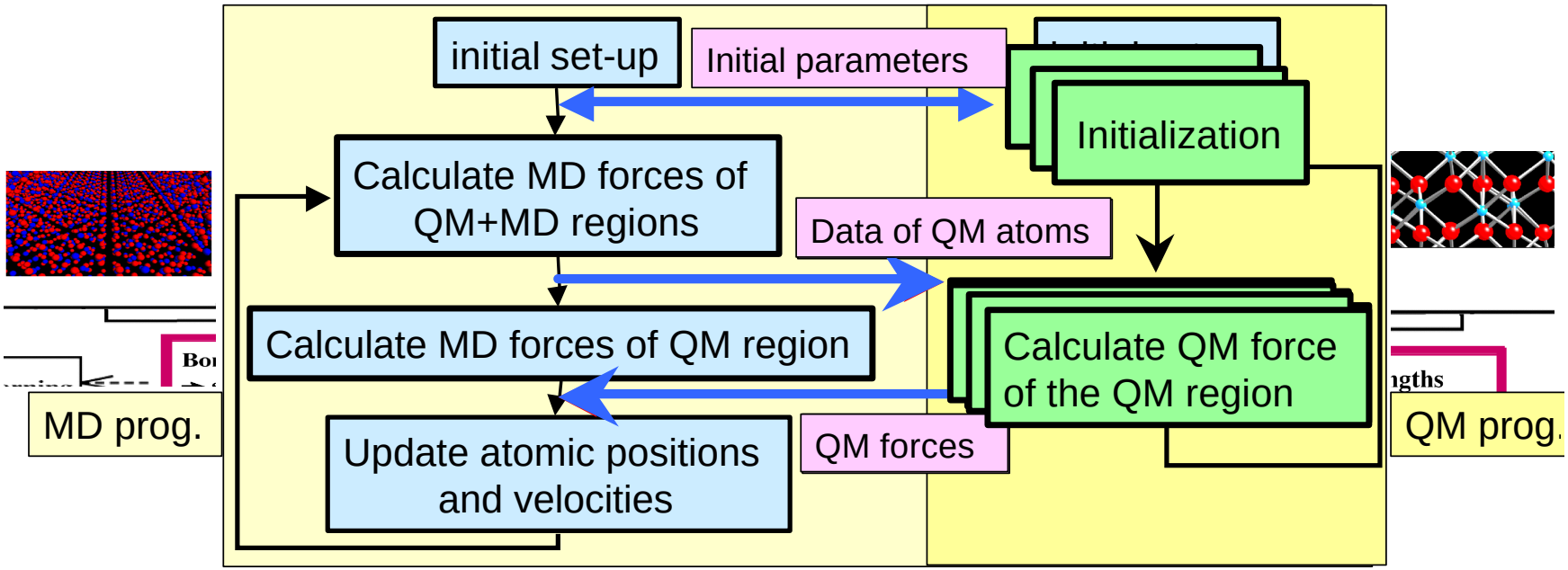


- **New implementation (GridRPC + MPI)**



QM/MDプログラムのGrid化

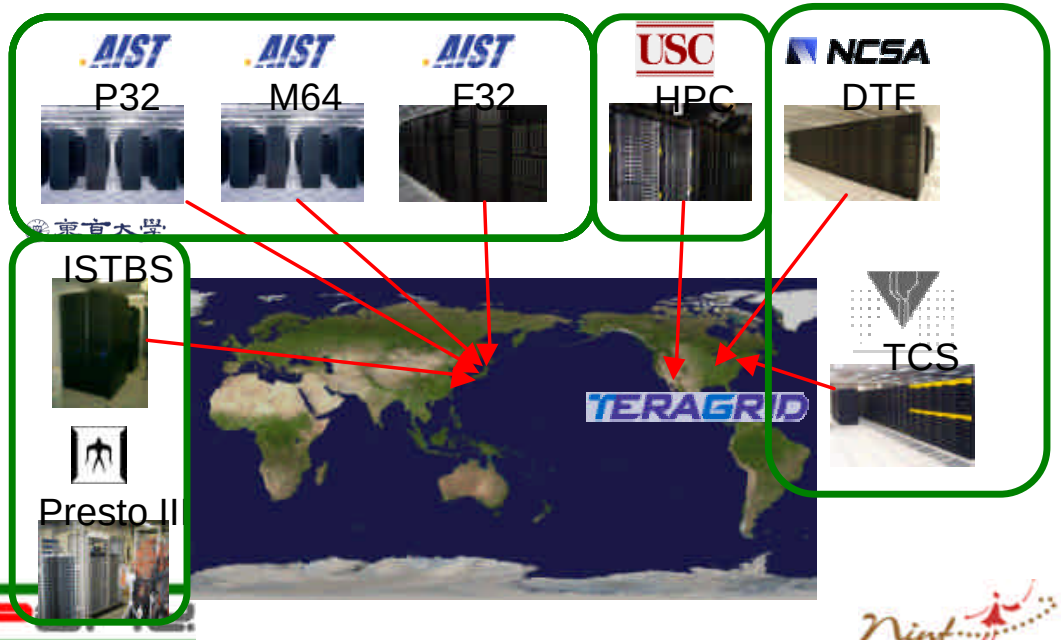
- 初期化関数の追加
- QMシミュレーション処理を関数化
- QM-MD間通信部分をMPIからNinf-G関数へ変



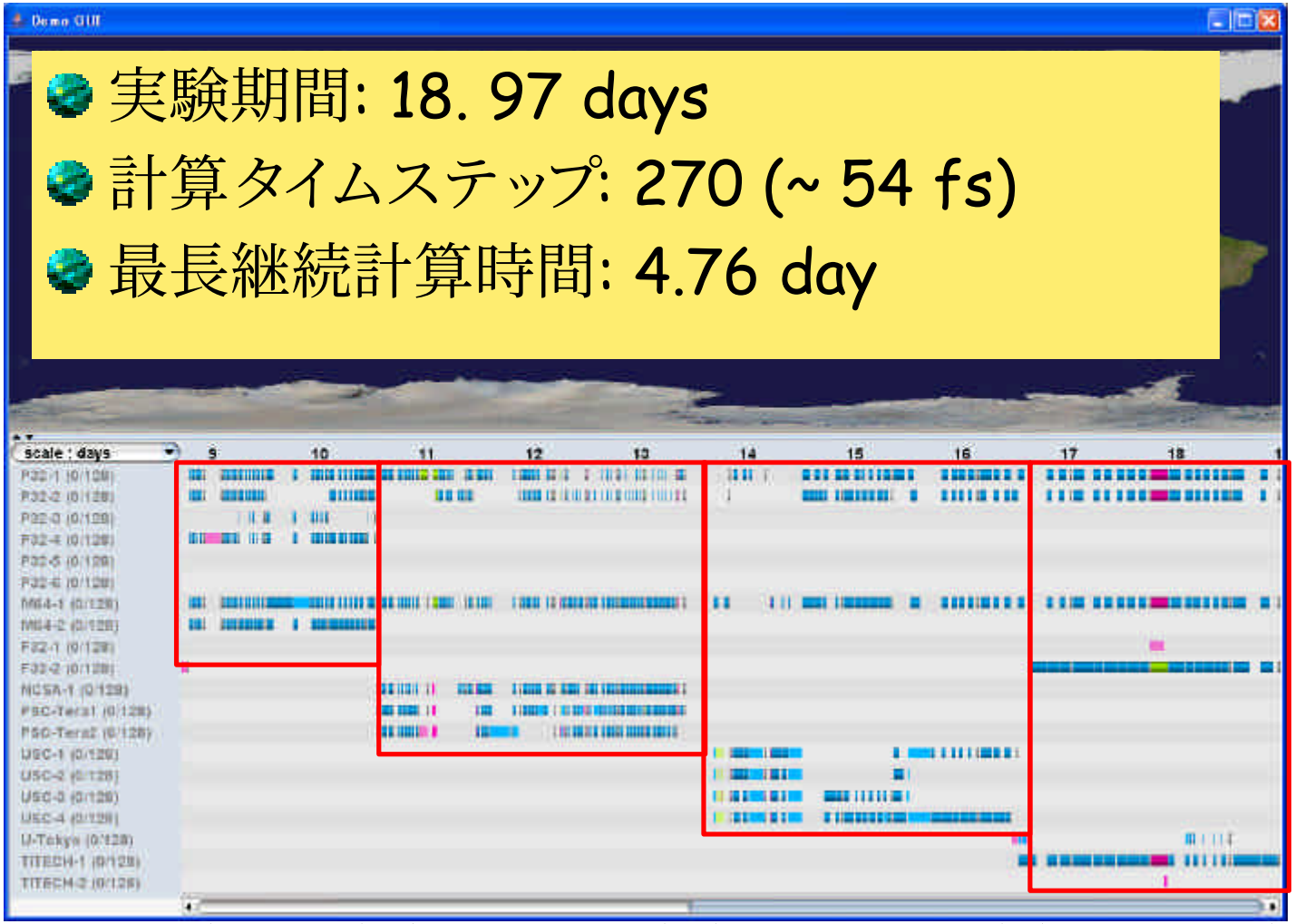
SIMOX Simulation用テストベッド

QM1	P32	P32	P32	P32	P32	USC	USC	USC	ISTBS	ISTBS
QM2	P32	P32	NCSA	NCSA	NCSA	USC	USC	USC	Presto	Presto
QM3	M64	M64	M64	M64	M64	M64	M64	M64	M64	M64
QM4	P32	P32	TCS	TCS	TCS	USC	USC	USC	P32	P32
QM5	P32	P32	TCS	TCS	TCS	USC	USC	USC	P32	P32
Reserve	F32	F32	P32	P32	P32	P32	P32	P32	F32	F32

Phase 1 Phase 2 Phase 3 Phase 4



実験結果


Demo GUI
実験期間: 18. 97 days
計算タイムステップ: 270 (~ 54 fs)
最長継続計算時間: 4.76 day
scale : days
9
10
11
12
13
14
15
16
17
18
Phase 1
Phase 2
Phase 3
Phase 4

Integrated to the NMI release 8

- **NMI-R8 marks two important "firsts" for the NMI program: the addition and integration of Ninf-G, the first non- U.S. developed component included in the GRIDS Center software suite;... (2005.10.8)**

Ninf Roll for Rocks 4.1 (x86, x86_64)

November 23, 2005

Ninf Roll for Rocks 4.1 is Released

The Ninf Roll for Rocks 4.1 (x86, x86_64) is Released.

Ninf-G is developed by the National Institute of Advanced Industrial Science and Technology (AIST) and National Institute of Informatics (NII) in Japan. The Ninf-G official website can be found at ninf.apgrid.org, and includes complete user and programmer documentation in both English and Japanese. Ninf-G is a Remote Proceduce Call (RPC) implementation for use on Globus-based Grids. The API implemented within Ninf-G is a reference implementation of the proposed GGF GridRPC API

Recent News

- Kasetsart University Releases SCE Roll for Rocks 4.1
- Application I/O Trace Roll for Rocks 4.1 is Released
- Grid Roll for Rocks 4.1 Itanium Released
- Ninf Roll for Rocks 4.1 is Released
- Grid Roll for Rocks 4.1 is Released
- Rocks Wins Two More HPCwire Awards
- Myricom Releases Myrinet Roll for Rocks 4.1

Ninf-G3 and Ninf-G4

- **Ninf-G3: based on GT3**
- **Ninf-G4: based on GT4**
- **Ninf-G3 and Ninf-G4 invoke remote executables via WS GRAM.**
- **Ninf-G3 alpha was released in Nov. 2003.**
  - GT 3.2.1 was so immature that Ninf-G3 is not practical for use ☹
- **We are now tackling with GT4 ☺**
  - Ninf-G 4.0.0 beta-2 that provides C and Java implementation of GridRPC API was released in Nov 15, 2005.
  - Tools and operations for building Ninf-G executables are the same with past version of Ninf-G.

For more info, related links

- **Ninf project ML**
  - ninf@apgrid.org
- **Ninf-G Users' ML**
  - ninf-users@apgrid.org
  - ninf-jp@apgrid.org (for Japanese)
- **Ninf project home page**
  - http://ninf.apgrid.org
- **Global Grid Forum**
  - http://www.ggf.org/
- **GGF GridRPC WG**
  - http://forge.gridforum.org/projects/gridrpc-wg/
- **Globus Alliance**
  - http://www.globus.org/