8th International Conference/Exhibition
on High Performance Computing
in Asia Pacific Region

Preliminary Study of A Task Farming API over The GridRPC Framework

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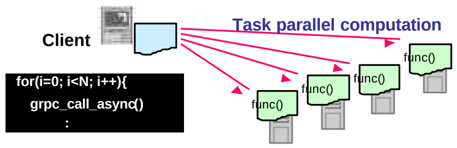
GridRPC

- **RPC mechanism for the grid computing**
- **A programming model for the grid applications**
  - The API is being standardized in the working group of GGF.
    - **An end-user API** is defined and available on two systems.
    - **A middleware API** is being discussed.
  - Reference implementation: **Ninf-G** and **GridSolve**
  - Task parallel programming with well-known RPC semantics
  - Easy to treat a server-side fault because of 1-N model



GridRPC programming

- **A typical GridRPC program (with the end-user API)**

```
grpc_init()                                         Library initialization
gprc_function_handle_init(handle, host, func)       Create a handle
  :
for(i=0; i<N; i++)                                  (Loop)
   gprc_call_async(handle, A, B, C)                 Invoke asynchronous RPC
  :
grpc_wait_all()                                     Wait all RPCs are completed
  :
grpc_function_handle_destruct()                     Destruct each handle
grpc_finalize()                                     Library finalization
```

- **Save time to develop applications using GridRPC API**
  - Machine heterogeneity is wrapped by the library.
  - Data communication is wrapped by the library.
  - A client program written in the standard API is portable.

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

Case studies until today

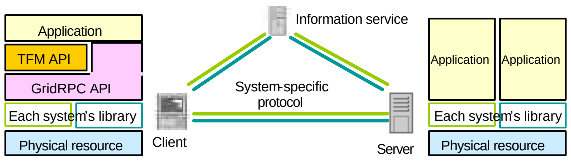
- **Tests with real science**
  - Scalability: Multi-sites simulation using 500 CPUs in SC'03
  - Long-time execution: Routine-based experiment on the Asia Pacific Grid testbed for 3 months in 2004
    - The client could continue to run for a week.
  - Scalability + Long-time execution
    - Simulation with 1800 CPUs for 10 hours just before SC'04
    - Simulation with 768 CPUs for 4.7 days just before SC'05
- **Lessons learned**
  - Needed to implement error handling, enabling heartbeat, background recovery, and remote re-initialization
  - More sophisticated API could be provided.
    - Automation in task assignment and fault recovery
    - Higher-level APIs rather than the end-user API of the GridRPC

Our purpose

- **Design and implement a high-level API (TFM API) library to develop production-quality applications**
- **Give feedback to standardizing process**
  - Show essential functionality for implementing a high-level API library
- **Focus on Task Farming (TFM)**
  - Execute a single program in parallel while changing input data and parameters
  - Easy to describe these 3 points by the TFM API
    - Set input data and parameters range
    - Submit tasks
    - Receive results

Position of TFM API

- **TFM API targets on client-side programming**
  - A user don’t have to care about remote side.
- **TFM API is implemented over the GridRPC framework to work on any GridRPC systems.**



Users’ requirements

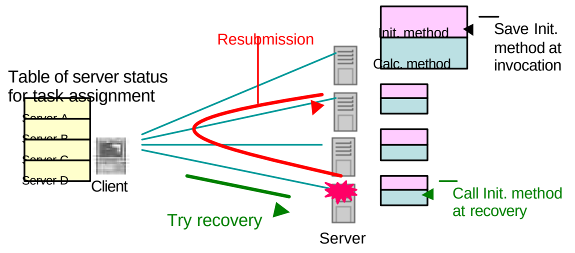
- **Automatic task assignment to the machine**
  - Scheduling by performance and stability
    - Ex. Assignment priority, duplicated task submission
- **Fault-tolerant mechanism inside of the library**
  - Multiple retries until the task execution succeeds
  - Automatic recovery of the remote program
- **Simple API to program parameter generation and result analysis for TFM application**
  - Higher tools (Ex. TFM on Matblab) should be implemented for the specific application.
    - Ex. Interactive task execution, parameter generation
  - API for initializing a TFM environment

Proposed TFM library

- **Support automatic task assignment**
  - Measured execution time reflects on the next assignment.
  - Support automatic tuning of task window
    - The window is tuned so that the total execution time will be minimum.
    - Users can specify MAX for limited memory capacity
  - If users want, they can specify the host by ID.
- **Support task completeness**
  - Multiple retries until the task execution succeeds
- **Support duplicated submission**
  - One of the two same tasks will succeed.
- **Support automatic recovery of the remote program**
  - Periodical check and recovery in background
- **Support automatic initialization of the remote program**
  - Initialization method is saved with data in the library for the recovery operation

When a fault happens …

- **A failed task is resubmitted to another host.**
- **A failed server is invoked and initialized by “Initialization method” saved in advance.**


Resubmission
Init. method
Calc. method
Save Init. method at invocation
Table of server status for task assignment
Server A
Server B
Server C
Server D
Client
Try recovery
Server
Call Init. method at recovery

Proposed TFM API (1)

- **Initialization / finalization of TFM API library**

int grpcg_init(char * conf, sched_attr_t * sched, ft_attr_t * ft);
int grpcg_fin();

- **Invoke a remote program (Ninf-G server)**

int grpcg_remote_init(int num_pe, char * func, …);
  - All programs can have the same Initialization method.

int grpcg_remote_init_n(int server_id, int num_pe, char * func, …);
  - Each program can have a different initialization method with an ID.

- **Terminate a remote program**

int grpcg_remote_fin(int num_pe);
int gprcg_remote_fin_n(int server_id, int_num_pe);

Proposed TFM API (2)

- **Task submission**

int grpcg_submit(char * func, …);
int grpcg_submit_n(int server_id, char * func, …);
  - Specify a target host of the task by server_id

int grpcg_submit_r(void * ref, char * func, …);
  - Set a pointer to the task for post-process

int grpcg_submit_nr(int server_id, void * ref, char * func, …);

- **Wait for task completion**

int grpcg_wait_all();
int grpcg_wait_any(int * task_id, void ** ref);

- **Task cancellation**

int grpcg_cancel(int task_id);

Sample program using TFM API

- **Case: ED code of NAS Grid Benchmark**

```
   :
rc = grpcg_init("server.list", &sched, NULL);
   :
grpcg_remote_init(NUM_PE, NULL);
   :
for(i=0; i<NUM_TASK; i++){
   grpcg_sumit("SP.S", "SP", …, &i, &width, &depth, …);
}
rc = grpcg_wait_all();

grpcg_remote_fin(NUM_PE);
grpcg_fin();
   :
```

Invoke a remote program without the initialization method

Submit a task without specifying the host (If a fault happens, the task will be resubmitted to anywhere else.)

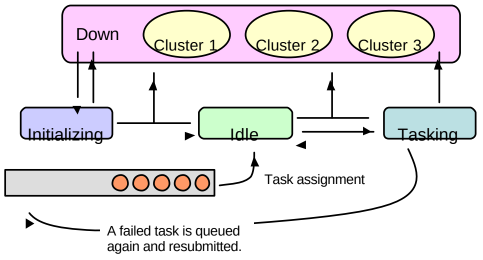
Initialization parameter of SP.S

Implementation

- **1. Prepare common components**
  - Remote program (GridRPC server) management
  - Task management
  - Fault detection & background recovery of servers
- **2. Implement TFM API**
- **Use of Middleware API of GridRPC and Ninf-G extensions**
  - Argument Array (Argument Stack) API
  - Remote object (Temporary storage function on remote)
  - API to retrieve execution information of each RPC
  - Complete non-blocking data transfer
  - Invocation of multiple remote programs by one call

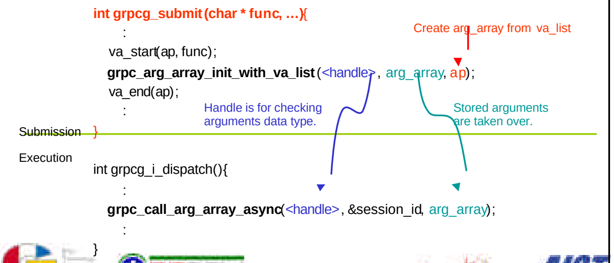
Status mgmt. of task and server

- **Servers are periodically sorted in the Idle pool.**
- **Down status is managed by each Handle Array.**
  - Because recovery is operated by each Handle Array



Use of Argument Array API

- **Provided a new API (TFM API) over standard RPC calls**
  - Ninf-G (Ver. 2.3) provides the Argument Stack API that will be redefined as the Argument Array API. The Argument Array API will be able to treat va_list.



```
int grpcg_submit(char * func, …){
   :
  va_start(ap, func);
  grpc_arg_array_init_with_va_list(<handle>, arg_array, ap);
  va_end(ap);
   :
}
```

```
int grpcg_i_dispatch(){
   :
  grpc_call_arg_array_async(<handle>, &session_id, arg_array);
   :
}
```

Submission
Execution
Create arg_array from va_list
Handle is for checking arguments data type.
Stored arguments are taken over.

Feedback to GridRPC-WG

- **Some extensions like that Ninf-G provides should be standardized in the GridRPC.**
  - API to retrieve execution information on remote
    - The information is useful for load balancing.
      - Ex. Transfer speed of arguments data, calculation cost
  - Timing of data transfer
    - Complete non-blocking transfer should be provided.
      - The TFM library can implement optimized transfer.
- **"Arguments copy" function should be provided in the Argument Array API.**
  - Reason 1: A user need to be careful not to rewrite the input data for the task.
  - Reason 2: It is difficult to implement duplicate task submission.

Summary

- **Designed and implemented the Task Farming API library over the GridRPC**
  - Based on the end-user API that is almost standardized
  - Used the Argument Array API that is still being discussed
  - Used the Ninf-G extensions that is not available in other GridRPC systems
- **Revealed essential functionality to implement a higher-level API library such as TFM library**
  - Some of them should be standardized in the GridRPC.
  - Specially, the Argument Array API would be useful in many cases.