Remote Procedure Call

Giovanni Agosta

Piattaforme Software per la Rete – Modulo 2

Outline

Introduction

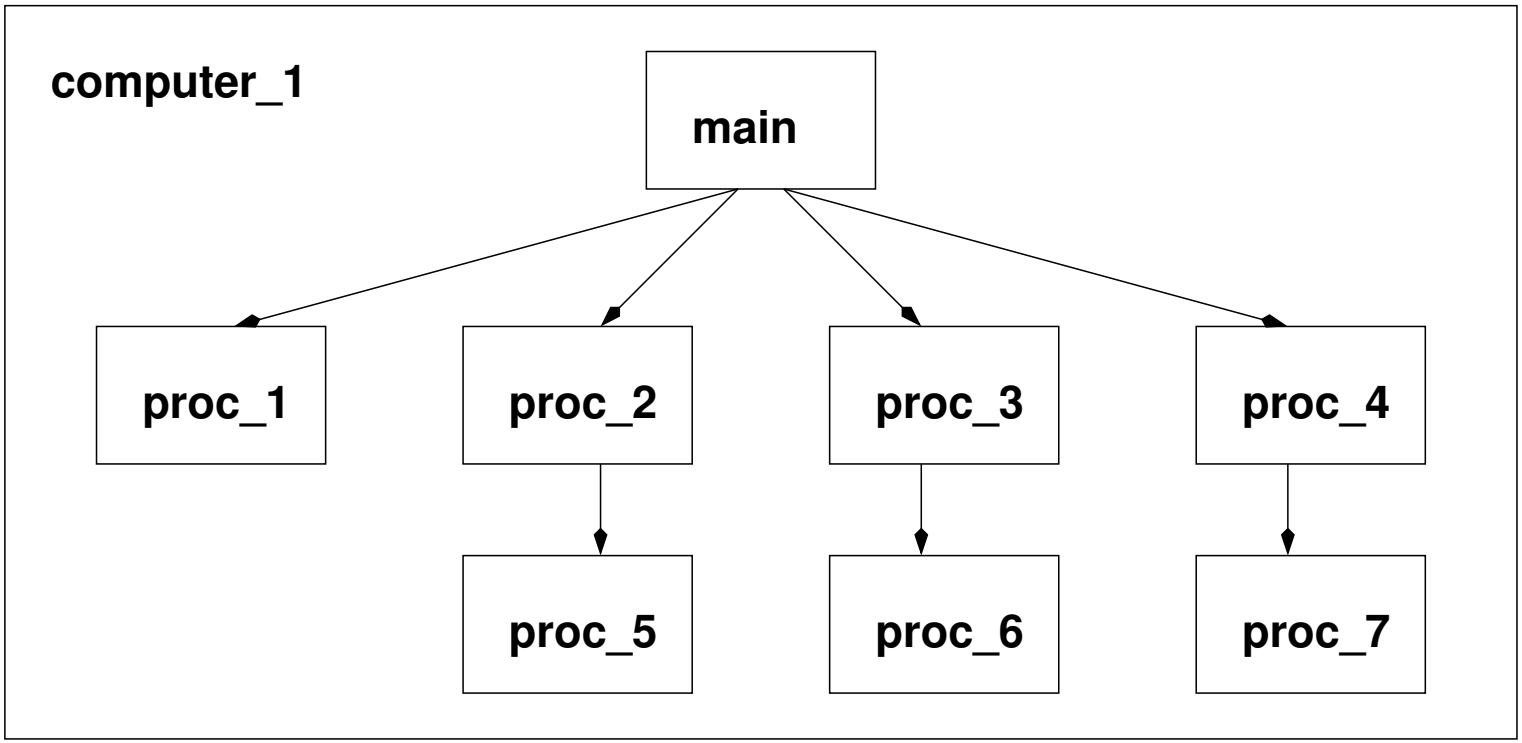
Designing Distributed Programs

- Communication-Oriented Design
- Application-Oriented Design

Remote Procedure Call model

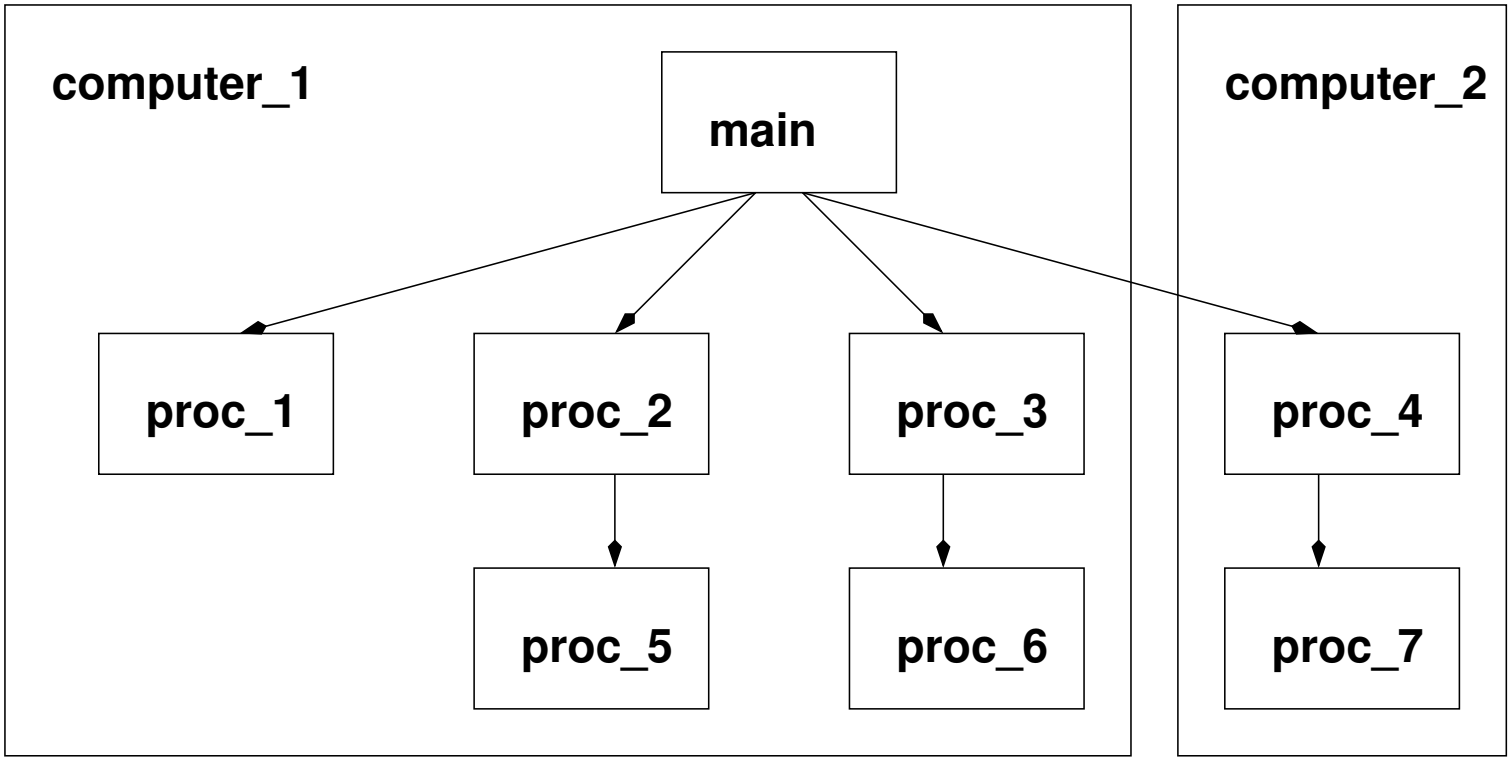
- Support the Client-Server model
- Allow Application-Oriented Design
- Divide the program at procedure boundaries into local and remote parts

Remote Procedure Call model



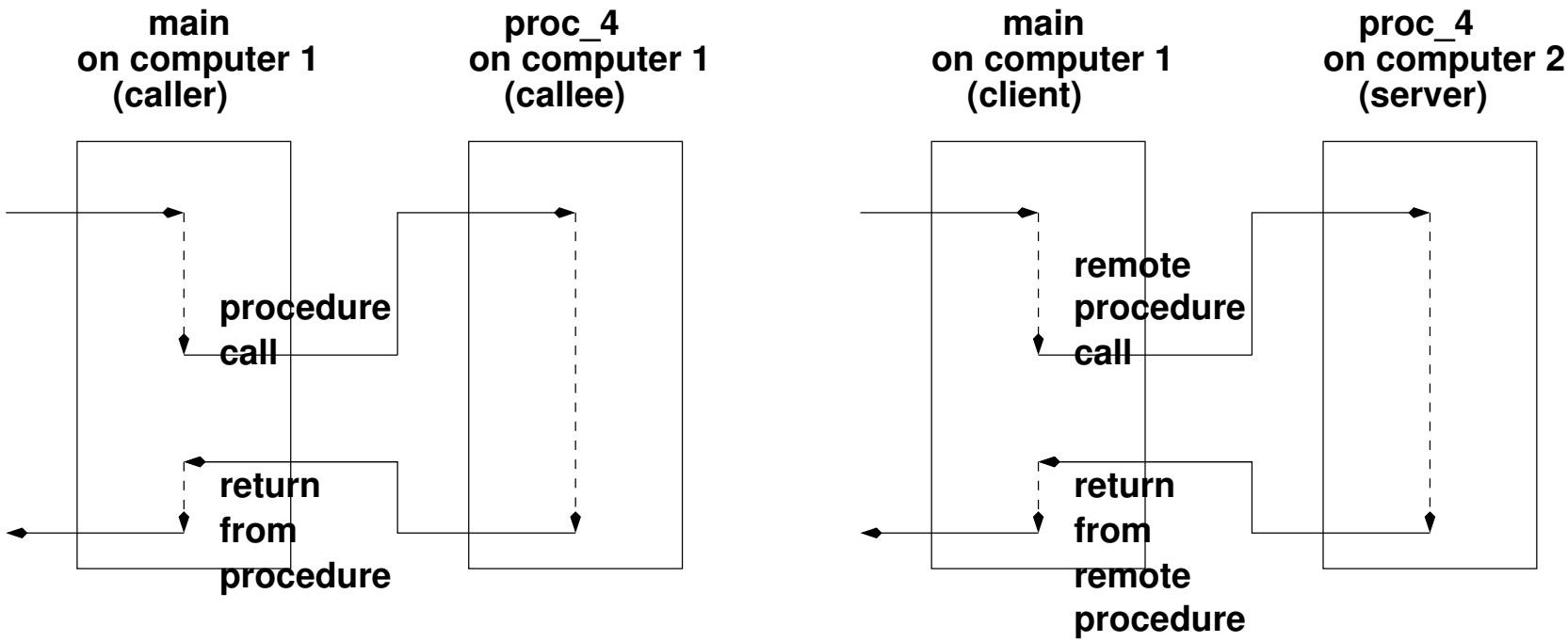
- A typical program, divided into a set of procedures (static view)

Remote Procedure Call model



- The same program, partitioned between two machines using the RPC model
- A communication protocol is needed between `main` and `proc_4`

Remote Procedure Call model



- However, remote calls are much slower
- Remote calls also do not happen in the same address space!
- And have no access to the environment (e.g., files)

Remote Procedure Call Addressing

- Derived from Sun Open Network Computing (ONC)
- Requires a tuple of *(program, version, procedure)* to work
- Uses unique, registered identifiers (integers) to identify remote programs (i.e., servers)
- RPC identifiers are mapped to IP ports
- The *portmapper* service is used to register programs to ports and obtain the port for a given program

rpcinfo -p

```
   program vers proto   port
    100000    2   tcp    111  portmapper
    100000    2   udp    111  portmapper
```

Remote Procedure Call Semantics

Semantics provided by Sun-style RPC

- Guaranteed mutual exclusion (at most one remote procedure active at any time in any server program)
- Only the weakest possible assumptions, based on the underlying protocols

  UDP if the procedure returns, assume *at least once* execution

  UDP if the procedure does not returns, assume *zero or more* execution

What to do?

- No need to worry about mutual exclusion
- When using UPD, remote procedures need to be *idempotent*

Remote Procedure Call Messages

Message Format

- Not fixed
- Uses External Data Representation (XDR) to provide a machine-independent data representation

External Data Representation (XDR)

- A symmetric data conversion solution:
  - Avoid having one conversion procedure for each server machine
  - However, double computational overhead
- XDR data structures are similar to C data structures

XDR Data types (1)

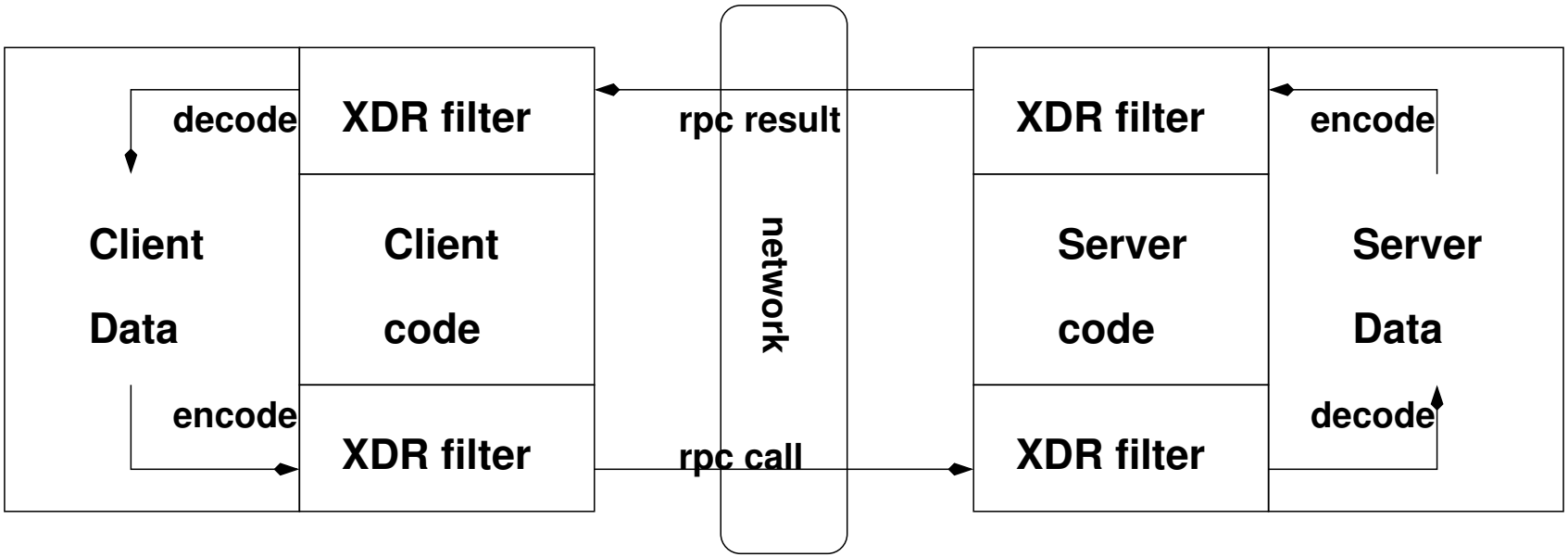
Type	Size	Description
int	32	32-bit integer
unsigned int	32	32-bit unsigned integer
bool	32	0 or 1
hyper	64	64-bit integer
unsigned hyper	64	64-bit unsigned integer
float	32	single precision float
double	64	double precision float
enum	arb	enumeration
string	arb	ASCII string
opaque	arb	raw data

XDR Data types (2)

Type	Size	Description
fixed array	arb	fixed-size array
counted array	arb	max-sized array
structure	arb	C struct
union	arb	Pascal variant records
void	0	no data
constant	arb	symbolic constant
optional data	arb	0 or 1 occurences of other type

- optional data used to represent pointers
- union uses type tags

Remote Procedure Call Mechanism



- Data flow through XDR filters in both directions

Remote Procedure Call Mechanism

A rather cumbersome mechanism...

1. Remote program registers to portmap
2. Caller program gets port from portmap
3. Caller program encodes input parameters
4. Caller program passes the data to remote host
5. Remote callee decodes the input parameters
6. Remote callee operates
7. Remote callee encodes results
8. Remote host returns the results to caller program
9. Caller program decodes the results and resumes execution

The rpcgen Compiler

Overview

- Writing calls to the XDR library directly is cumbersome
- Use a *domain specific language* for both XDR and RPC
- Use rpcgen compiler to compile XDR *and* RPC program specification

The rpcgen Compiler

Structures

Sample XDR Declaration

```
struct coord {
    int x;
    int y;
};
```

C translation

```
struct coord {
    int x;
    int y;
};
typedef struct coord coord;
```

The rpcgen Compiler

Discriminated Union

Sample XDR Declaration

```
union foo switch (int n)
{
  case 0:
    opaque data[1024];
  default:
    void;
};
```

C translation

```
struct foo {
  int n;
  union {
    char data[1024];
  } foo_u;
};
typedef struct foo foo;
```

The rpcgen Compiler

Constant, array, typedef and string

Sample XDR Declaration

```
const DOZEN = 12;
typedef string s<24>;
int palette[8];
int heights<12>;
```

C translation

```
#define DOZEN 12
typedef char *s;
int palette[8];
struct {
    u_int heights_len;
    int *heights_val;
} heights;
```

The rpcgen Compiler

Booleans, pointers and raw data

- Boolean type **typedef int** bool_t;
- Pointers are represented as *optional data*

Sample XDR Declaration

```
bool married;
listitem *next;
opaque diskblock[512];
opaque filedata<1024>;
```

C translation

```
bool_t married;
listitem *next;
char diskblock[512];
struct {
    u_int filedata_len;
    char *filedata_val;
} filedata;
```

The rpcgen Compiler

Defining remote procedures

Sample rpcgen Declaration

```
program TIMEPROG {
   version TIMEVERS {
      unsigned int TIMEGET(v
      void TIMESET(unsigned)
   } = 1;
} = 44;
```

C translation

```
#define TIMEPROG 44
#define TIMEVERS 1
#define TIMEGET 1
#define TIMESET 2
```

Using the rpcgen Compiler

- Write an `rpcgen` source file (e.g., `avg.x`)
- Compile it: `rpcgen avg.x`
  1. `avg.h` generated header file
  2. `avg_clnt.c` generated client stub
  3. `avg_svc.c` generated server stub
  4. `avg_xdr.c` common xdr routines
- Write server and client logic
- Compile server and client programs