Porting of Real-Time Publish-Subscribe Middleware to Android

RTLWS15, Lugano-Manno
Distributed applications – problems

Sensor

TCP connection

Control Application

Motor
Distributed applications – problems

Sensor

Backup Sensor

Motor

Control Application

TCP connection
Distributed applications – problems

TCP connection

Redundancy
Distributed applications – problems
Distributed applications – problems

- Sensor
- Backup Sensor
- Motor

TCP connection

Scaling

Control Application

Control Application
Outline

- Data-Centric Publish Subscribe model
- Real-Time Publish-Subscribe protocol
- ORTE middleware
- Android porting
- Demo
Data-Centric Publish-Subscribe application model

Sensor
- Topic: "distance"
- Strength: 2

Backup Sensor
- Topic: "distance"
- Strength: 1

Motor
- Topic: "speed"
- Deadline: 1s
- Min. sep.: 0.1s

Control Application
- Topic: "distance"
- Deadline: 3s
- Min. sep.: 1s
- Topic: "speed"
- Strength: 1

Global data space
Data-Centric Publish-Subscribe application model

Sensor
Publish:
- topic: "distance"
- strength: 2

Backup Sensor
Publish:
- topic: "distance"
- strength: 1

Motor
Subscribe:
- topic: "speed"
- deadline: 1s
- min. sep.: 0.1s

Control Application
Subscribe:
- topic: "distance"
- deadline: 3s
- min. sep.: 1s

Publish:
- topic: "speed"
- strength: 1

- topic: "distance"
- deadline: 3s
- min. sep.: 1s

Publish:
- topic: "speed"
- strength: 1
How to implement this? RTPS.

- Real-Time Publish-Subscribe protocol
- OMG standard – interoperability wire protocol
- Transport independent part
- Transport specific part (UDP => control of timing)
- Implementation freedom
  - Simple implementation, high network bandwidth demand
  - Complex implementation, optimized network bandwidth.
- Utilizes multicast communication (one to many communication)
- Offers best-effort and reliable communication
- CDR encoding (endianing)
- Parts
  - Data exchange protocol
  - Discovery protocol
ORTE – Open Real-Time Ethernet

- Our open-source implementation of the RTPS protocol
- One of the first few implementations that supported standardization
- Uses custom API instead of the DDS API (another OMG standard)
- C language, based on POSIX
- IDL compiler to generate (de)serialization functions

Supported platforms
- Linux, FreeBSD, Mac OS X, Solaris
- Windows (MinGW, Cygwin, ReactOS)
- RTEMS
- BlackBerry
- Android
Minimal ORTE application

ORTEInit();
d=ORTEDomainAppCreate(0,NULL,NULL,0);
ORTETypeRegisterAdd(d,"HelloMsg",NULL,
   NULL,NULL,64);
p=ORTEPublicationCreate(
   d,
   "Example HelloMsg", // Topic
   "HelloMsg", // Type
   &instance2Send, // Data buffer
   TIME(3,0), // Persistance
   1, // Strength
   NULL, // Callback
   NULL, // Parameters
   NULL);

instance2Send = 123;
ORTEPublicationSend(p);

ORTEInit();
d=ORTEDomainAppCreate(0,NULL,NULL,0);
ORTETypeRegisterAdd(d,"HelloMsg",NULL,
   NULL,NULL,64);
s=ORTESubscriptionCreate(
   d,
   IMMEDIATE,
   BEST_EFFORTS,
   "Example HelloMsg", // Topic/
   "HelloMsg", // Type
   &instance2Recv, // Data buffer
   &deadline,
   &minimumSeparation,
   &recvCB, // callback
   NULL,
   IPADDRESS_INVALID); // Multicast

void recvCB(const ORTERecvInfo *info,
   void *instance, void *param) {
   switch (info->status) {
   case NEW_DATA:  
       printf("%s\n",instance); break;
   case DEADLINE:  
       printf("deadline occurred"); break;
   }
}
RTPS/ORTE internals

Sensor
- Publish:
  - topic: "distance"
  - strength: 2

Control Application
- Subscribe:
  - topic: "distance"
  - deadline: 3s
  - min. sep.: 1s
- Publish:
  - topic: "speed"
  - strength: 1

Motor
- Subscribe:
  - topic: "speed"
  - deadline: 1s
  - min. sep.: 0.1s
RTPS/ORTE internals

- Dynamic addition/removal of applications
- No single point of failure
- Fault tolerant applications
ORTE Discovery Protocol

Node 1

Sensor
- Publish: "distance"

Motor
- Subscribe: "speed"

Node 2

Control Application
- Subscribe: "distance"
- Publish: "speed"

ORTE Manager

ORTE
Participant discovery

Node 1

Sensor
- Publish: topic: "distance"
- ORTE Manager

Motor
- Subscribe: topic: "speed"
- ORTE Manager

Node 2

Control Application
- Subscribe: topic: "distance"
- ORTE Manager

- Publish: topic: "speed"
Endpoint discovery

Node 1

Sensor
- Publish: "distance"

Motor
- Subscribe: "speed"

Node 2

Control Application
- Subscribe: "distance"
- Publish: "speed"
Android

- Android is a Linux-based operating system developed by Google
- It runs on devices ranging from mobile phones and tablets to home media centers and digital cameras

- Applications developed in Java or C/C++ using Google toolkits
  - Android Software Development Kit – Java
  - Android Native Development Kit – C/C++
Porting ORTE to Android

Overview:
- Update Java Native Interface (JNI) wrapper and make it Android compatible
- Fix bugs that have not demonstrated themselves under the Oracle's VM
- Add support for Android build system
- Make Java version of ORTE Manager application to overcome problems with execution and termination of native processes
<table>
<thead>
<tr>
<th>Platform</th>
<th>Time to publish 10k integer values</th>
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</thead>
<tbody>
<tr>
<td>Android 4.0.3</td>
<td></td>
</tr>
<tr>
<td>Android 4.3</td>
<td></td>
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<tr>
<td>Oracle Java</td>
<td></td>
</tr>
</tbody>
</table>

- Reliable publisher and subscriber
- Publish as fast as possible
- Baseline: C publisher, C subscriber
Future development

- Make the ORTE compliant with the latest RTPS standard
  - Data with key
    - New type of data objects, that allows to distribute a set of data instances under a single topic
    - The key is used to distinguish between instances
  - Discovery protocol
    - Manager is replaced with the Simple Participant Discovery Protocol and the Simple Endpoint Discovery Protocol integrated into an user application
  - Data fragmentation
    - Allow a fragmentation of big data instances and sent them as multiple messages.

- Security
Demo

- Application for remote control of a robot
- Monitors robot's state (battery voltage, speed vector, output of Laser Range Finder)
- Controls robot's motion (direction and speed)
Conclusion

- ORTE can simplify both development and deployment of distributed applications
- We have successfully ported the ORTE library to Android
- http://orte.sourceforge.net/

Thank you!