technische universität dortmund

fakultät für informatik

System Software (2)

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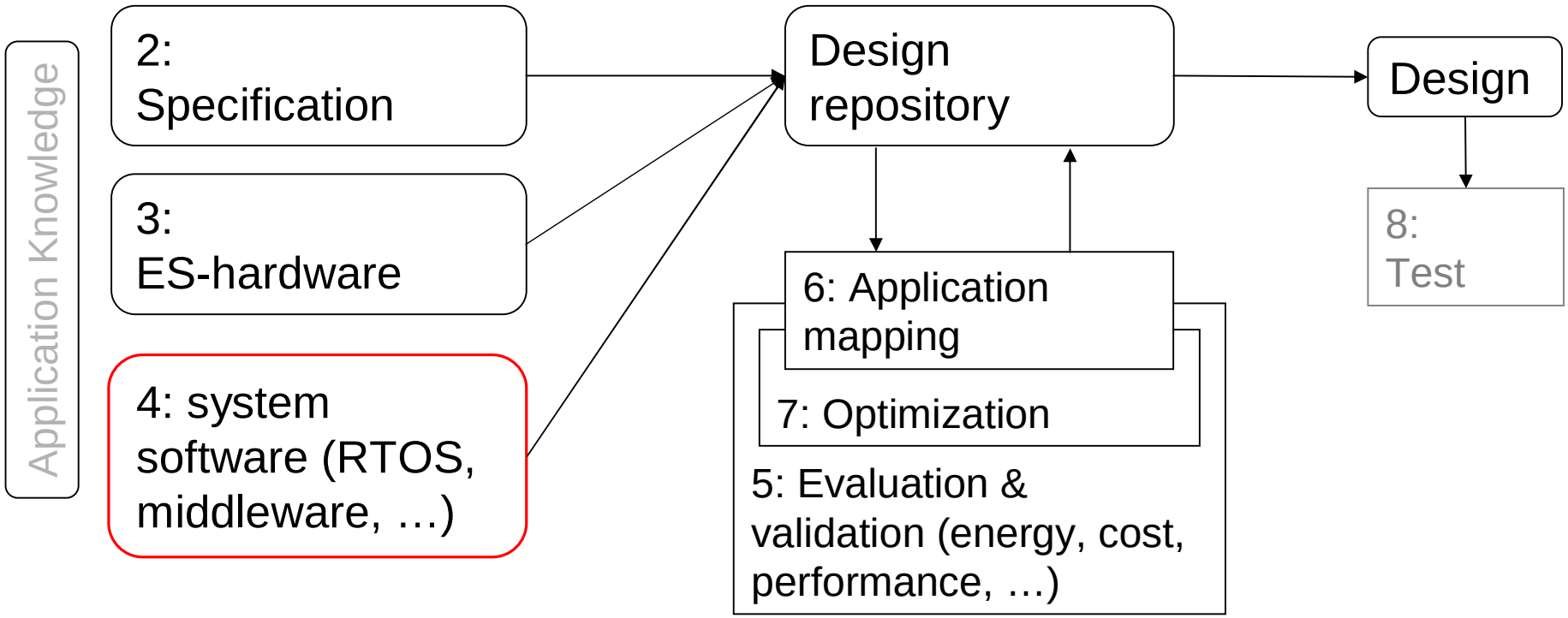
Structure of this course



Numbers denote sequence of chapters

Increasing design complexity + Stringent time-to-market requirements ☞Reuse of components

Reuse requires knowledge from previous designs to be made available in the form of **intellectual property** (IP, for **SW & HW**).

- HW
- Operating systems
- Middleware (Communication libraries, data bases, …)
- ….

Models of computation considered in this course

Communication/ local computations	Shared memory	Message passing Synchronous | Asynchronous	
Undefined components	Plain text, use cases | (Message) sequence charts		
Communicating finite state machines	StateCharts		SDL
Data flow	Scoreboarding + Tomasulo Algorithm (☞ Comp.Archict.)		Kahn networks, SDF
Petri nets		C/E nets, P/T nets, …	
Discrete event (DE) model	VHDL*, Verilog*, SystemC*, …	Only experimental systems, e.g. distributed DE in Ptolemy	
Imperative (Von Neumann) model	C, C++, Java [libraries]	C, C++, Java with libraries CSP, ADA |	

* Classification based on semantic model

Pthreads

- **Shared memory model**
- Consists of standard API
  - Originally used for single processor
  - Locks (mutex, read-write locks)

PThreads Example

```
threads = (pthread_t *) malloc(n*sizeof(pthread_t));
pthread_attr_init(&pthread_custom_attr);
for (i=0;i<n; i++)
  pthread_create(&threads[i],
&pthread_custom_attr, task, …);
for (i=0;i<n; i++) {
  pthread_mutex_lock(&mutex);
  <receive message>
  pthread_mutex_unlock(&mutex);
}
for (i=0;i<n; i++)
  pthread_join(threads[i], NULL);
```

```
void* task(void *arg) {
  …
  pthread_mutex_lock(&mutex);
  <send message>
  pthread_mutex_unlock(&mutex);
  return NULL
}
```

Based on W. Verachtert (IMEC): *Introduction to Parallelism,* tutorial, DATE 2008

Pthreads

- Consists of standard API
  - Locks (mutex, read-write locks)
  - Condition variables
  - Completely explicit synchronization
  - Synchronization is very hard to program correctly
- Typically supported by a mixture of hardware (shared memory) and software (thread management)
- Exact semantics depends on the memory consistency model
- Support for efficient producer/consumer parallelism relies on murky parts of the model
- Pthreads can be used as back-end for other programming models (e.g. OpenMP)

Based on W. Verachtert (IMEC): *Introduction to Parallelism,* tutorial, DATE 2008

OpenMP

Implementations target shared memory hardware

Parallelism expressed using pragmas

- Parallel loops
  (`#pragma omp for {…}` ;focus: data parallelism)
- Parallel sections
- Reductions

Explicit

- Expression of parallelism (mostly explicit)

Implicit

- Computation partitioning
- Communication
- Synchronization
- Data distribution

Based on W. Verachtert (IMEC): *Introduction to Parallelism,* tutorial, DATE 2008

Lack of control over partitioning can cause problems

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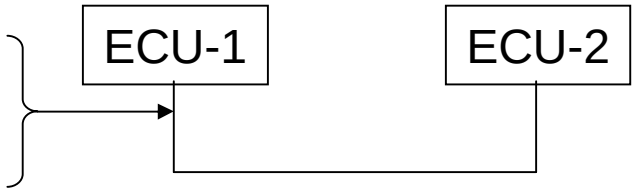
° Somewhat related: Scoreboarding + Tomasulo-Algorithm

OSEK/VDX COM

OSEK/VDX COM

- is a special communication standard for the OSEK automotive OS Standard
- provides an “Interaction Layer” as an API for internal and external communication via a “Network Layer” and a “Data Link” layer (some requirements for these are specified)
- specifies the functionality, it is not an implementation.

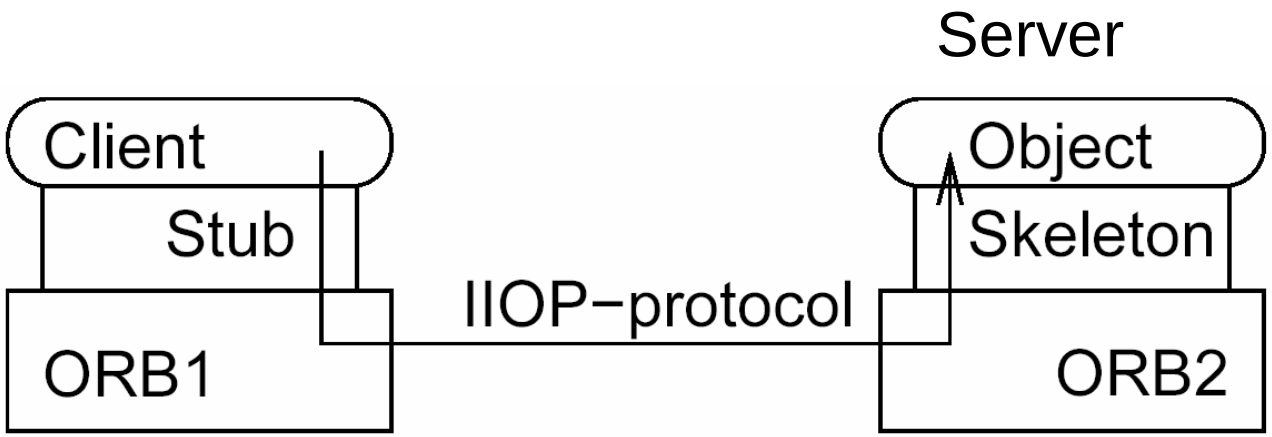


CORBA
(Common Object Request Broker Architecture)

Software package for access to remote objects;

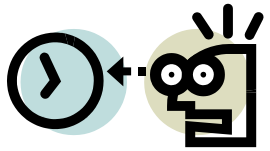
Information sent to Object Request Broker (ORB) via local stub.

ORB determines location to be accessed and sends information via the IIOP I/O protocol.



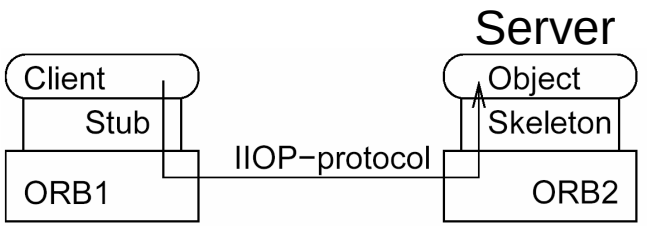
Access times unpredictable.

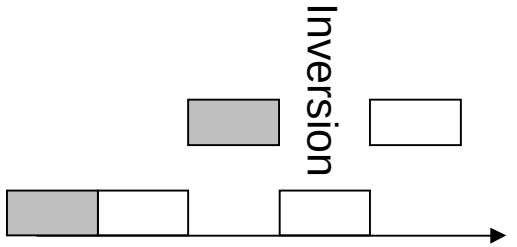
Real-time (RT-) CORBA



RT-CORBA

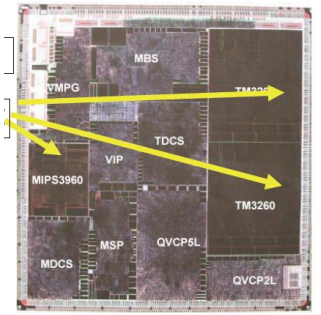
- provides *end-to-end predictability of timeliness in a fixed priority system*.
- *respects thread priorities between client and server for resolving resource contention*,
- provides thread priority management,
- provides priority inheritance,
- bounds latencies of operation invocations,
- provides pools of preexisting threads.





Message passing interface (MPI)

- Asynchronous/synchronous message passing
- Designed for high-performance computing
- Comprehensive, popular library
- Available on a variety of platforms
- Mostly for homogeneous multiprocessing
- Considered for MPSoC programs for ES;
- Includes many copy operations to memory (memory speed ~ communication speed for MPSoCs); Appropriate MPSoC programming tools missing.



http://www.mhpcc.edu/training/workshop/mpi/MAIN.html#Getting_Started

MPI (1)

Sample blocking library call (for C)**:**

- MPI_Send(*buffer,count,type,dest,tag,comm*) where
  - *buffer*: Address of data to be sent
  - *count*: number of data elements to be sent
  - *type*: data type of data to be sent (e.g. MPI_CHAR, MPI_SHORT, MPI_INT, …)
  - *dest*: process id of target process
  - *tag*: message id (for sorting incoming messages)
  - *comm*: communication context = set of processes for which destination field is valid
  - function result indicates success

http://www.mhpcc.edu/training/workshop/mpi/MAIN.html#Getting_Started

MPI (2)

Sample non-blocking library call (for C)**:**

- MPI_Isend(*buffer,count,type,dest,tag,comm,request*) where

  - *buffer … comm:* same as above

  - *request*: unique "request number". "handle" can be used (in a WAIT type routine) to determine completion

http://www.mhpcc.edu/training/workshop/mpi/MAIN.html#Getting_Started

Evaluation

Explicit

- Computation partitioning
- Communication
- Data distribution

Implicit

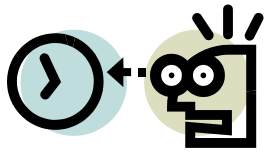
- Synchronization (implied by communic., explicit possible)
- Expression of parallelism (implied)
- Communication mapping

Properties

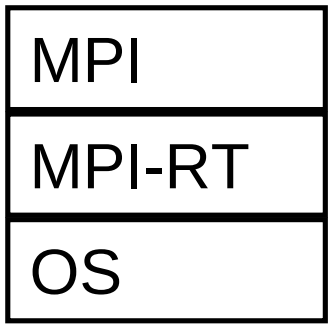
- Most things are explicit
- Lots of work for the user ("*assembly lang. for parallel prog*.")
- doesn't scale well when # of processors is changed heavily

Based on W. Verachtert (IMEC): *Introduction to Parallelism,* tutorial, DATE 2008

RT-issues for MPI



- MPI/RT: a real-time version of MPI [MPI/RT forum, 2001].
- MPI-RT does not cover issues such as thread creation and termination.
- MPI/RT is conceived as a potential layer between the operating system and standard (non real-time) MPI.



Universal Plug-and-Play (UPnP)

- Extension of the plug-and-play concept
- *Enable emergence of easily connected devices & simplify implementation of networks @ home & corporate environments!*
- Examples: Discover printers, storage space, control switches in homes & offices
- Exchanging data, no code (reduces security hazards)
- Agreement on data formats & protocols
- Classes of predefined devices (printer, mediaserver etc.)
- http://upnp.org

Devices Profile for Web Services (DPWS)

- More general than UPnP
- *… DPWS defines a minimal set of implementation constraints to enable secure Web Service messaging, discovery, description, and eventing on resource-constrained devices. …*
- *DPWS specifies a set of built-in services:*
  - *Discovery services …*
  - *Metadata exchange services…*
  - *Publish/subscribe eventing services…*
- *Lightweight protocol, supporting dynamic discovery, … its application to automation environments is clear.*

Network Communication Protocols
- e.g. JXTA -

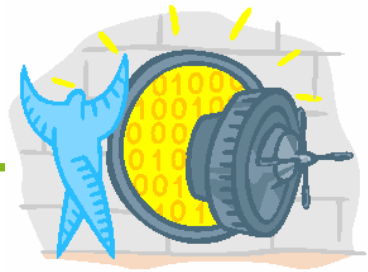
- *Open source peer-to-peer protocol specification.*
- *Defined as a set of XML messages that allow any device connected to a network to exchange messages and collaborate independently of the network topology.*
- *.. Can be implemented in any modern computer language.*
- *JXTA peers create a virtual overlay network, allowing a peer to interact with other peers even when some of the peers and resources are behind firewalls and NATs or use different network transports.*

Increasing design complexity + Stringent time-to-market requirements ☞Reuse of components

Reuse requires knowledge from previous designs to be made available in the form of **intellectual property** (IP, for **SW & HW**).

- HW
- Operating systems
- Middleware (Communication libraries, data bases, …)
- ….

Data bases



Goal: store and retrieve persistent information

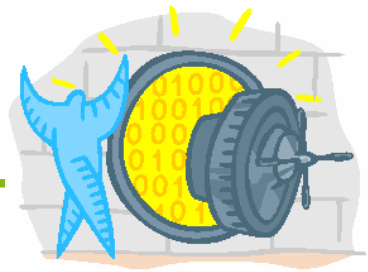
Transaction= sequence of read and write operations

Changes not final until they are committed

Requested ("ACID") properties of transactions

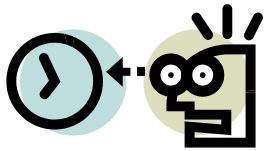
1. **Atomic:** state information as if transaction is either completed or had no effect at all.
2. **Consistent:** Set of values retrieved from several accesses to the data base must be possible in the world modeled.
3. **Isolation:** No user should see intermediate states of transactions
4. **Durability:** results of transactions should be persistent.

Real-time data bases



Problems with implementing real-time data bases:

1. transactions may be aborted various times before they are finally committed.
2. For hard discs, the access times to discs are hardly predictable.



Possible solutions:

1. Main memory data bases
2. Relax ACID requirements

Summary

- Communication middleware
  - Pthreads
  - OpenMP
  - OSEK/VDX COM
  - CORBA
  - MPI
  - JXTA
  - DPWS
- RT-Data bases (brief)