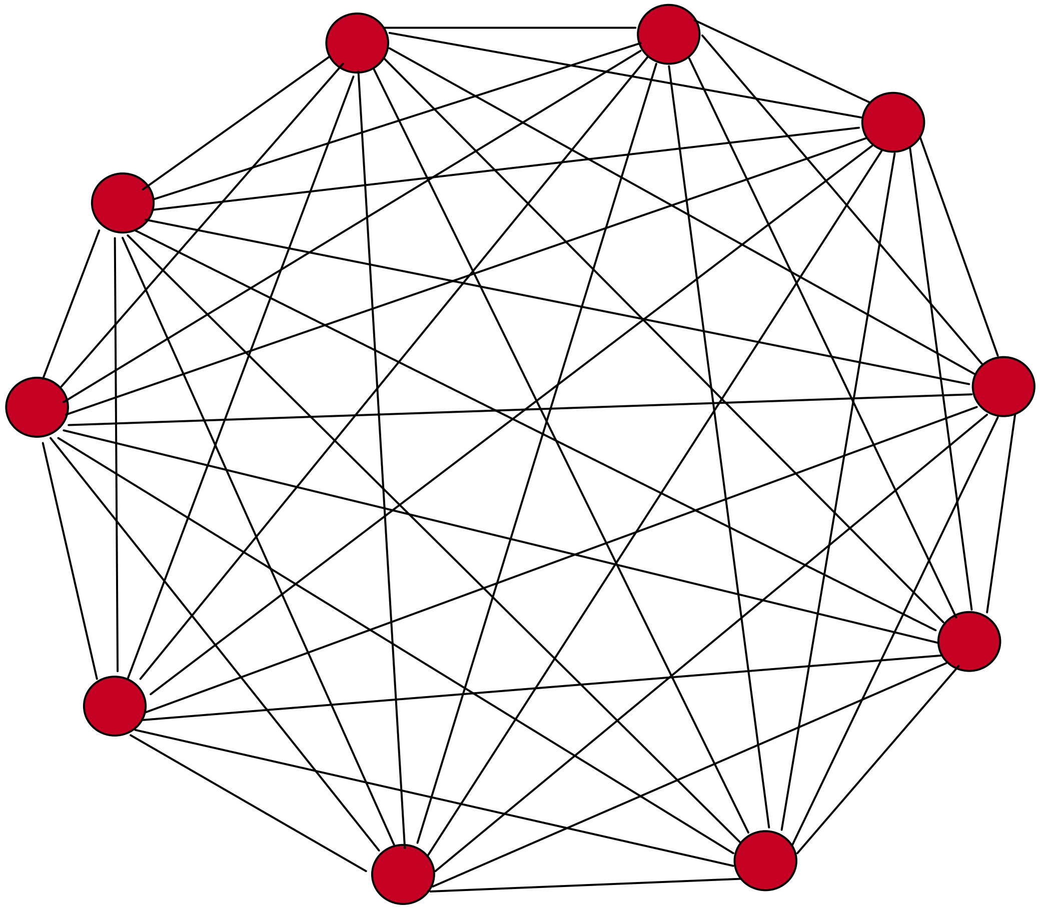
Embedded Networks

Models of Communication

Summer Term 2007

Interaction Structure in Co-operative Systems

**many-
to-
many**



managebility

goal → **sharing information and co-ordinating acitvities**

CO-OPERATIVE SYSTEMS

Which model of communication?

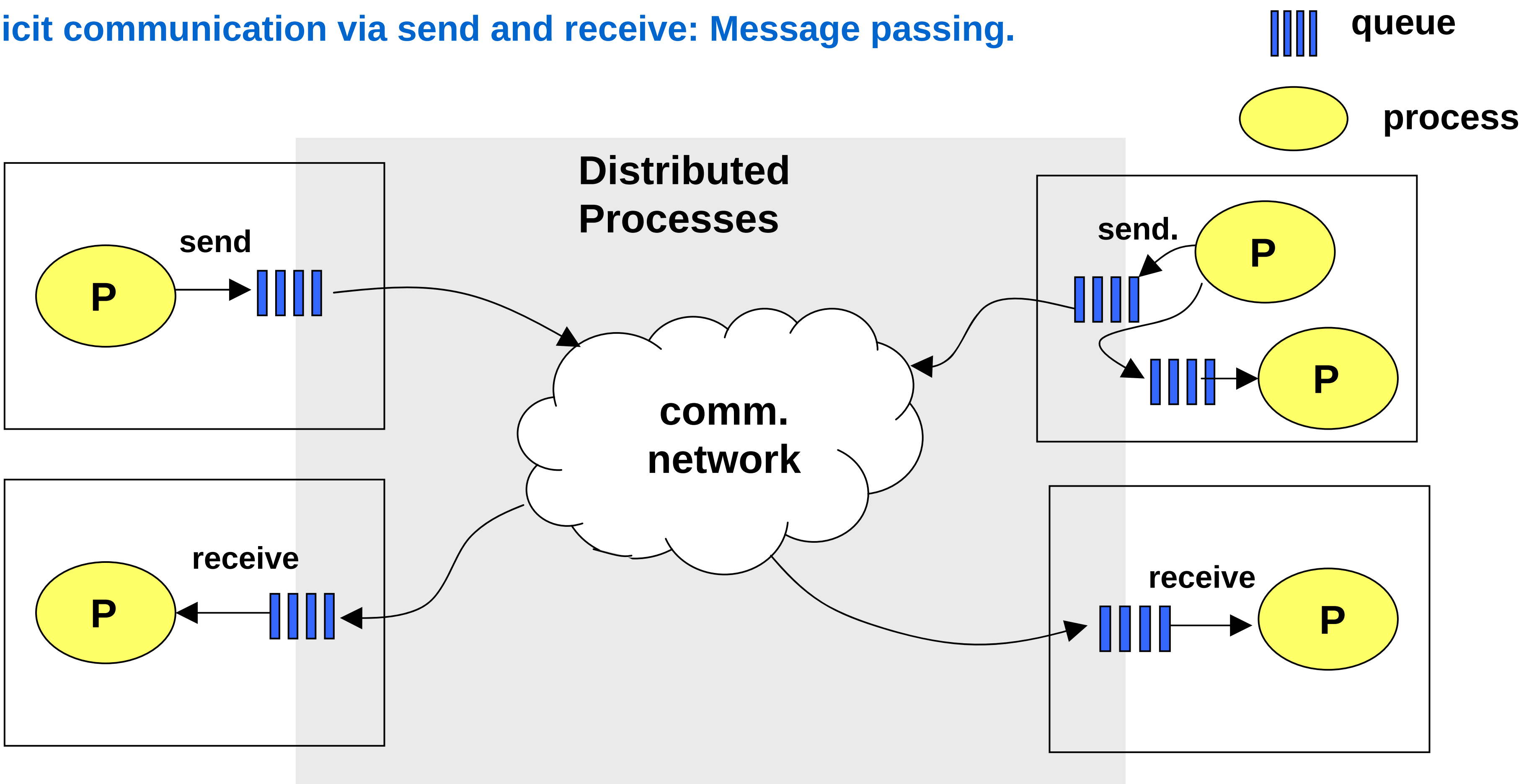
↓

What kind of addressing and routing should be supported by the network?

Which abstractions in the programming model?

Message Passing

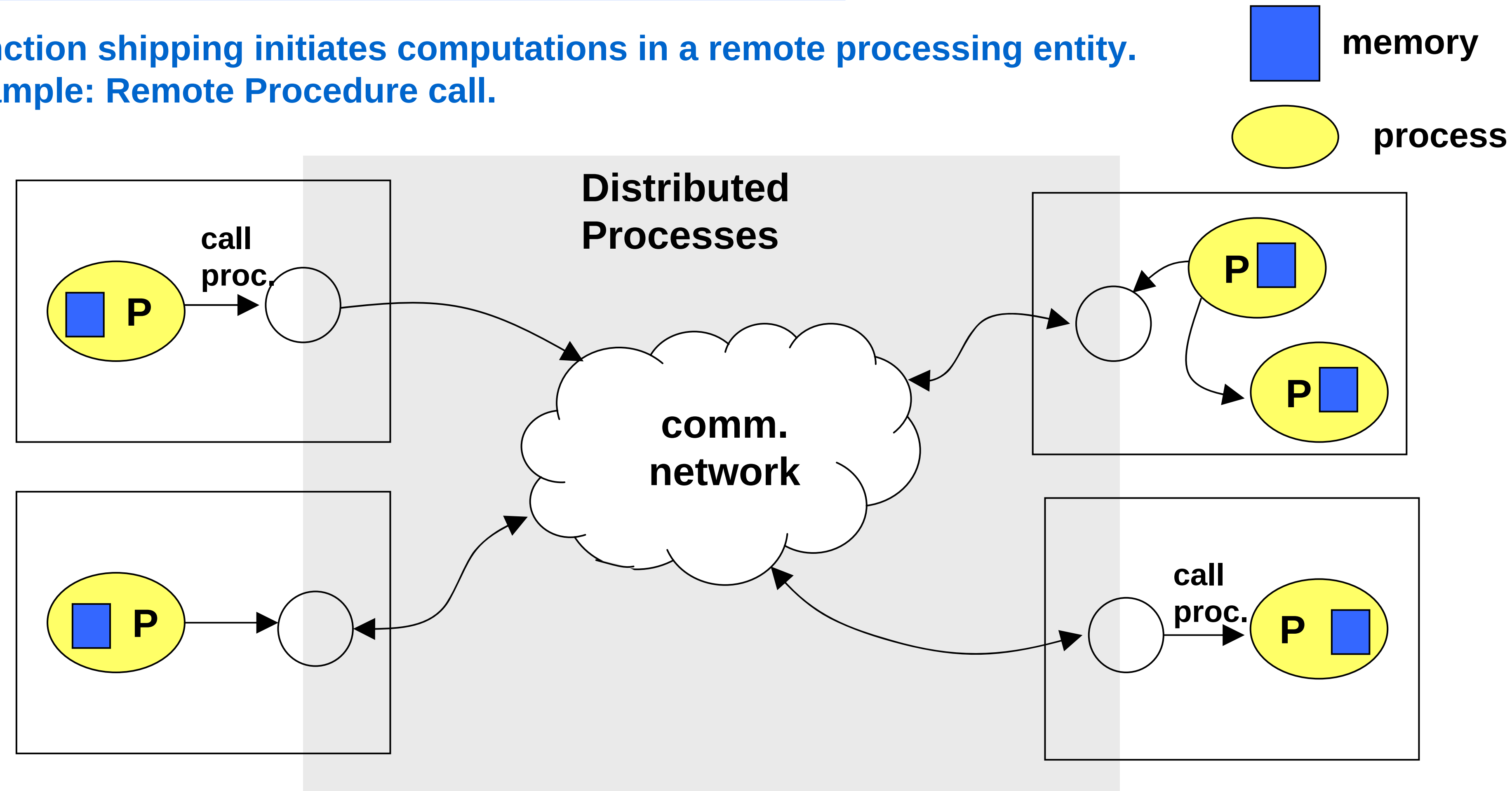
Explicit communication via send and receive: Message passing.



Problem: very low level, very general, poorly defined semantics of communication

Remote Procedure Call

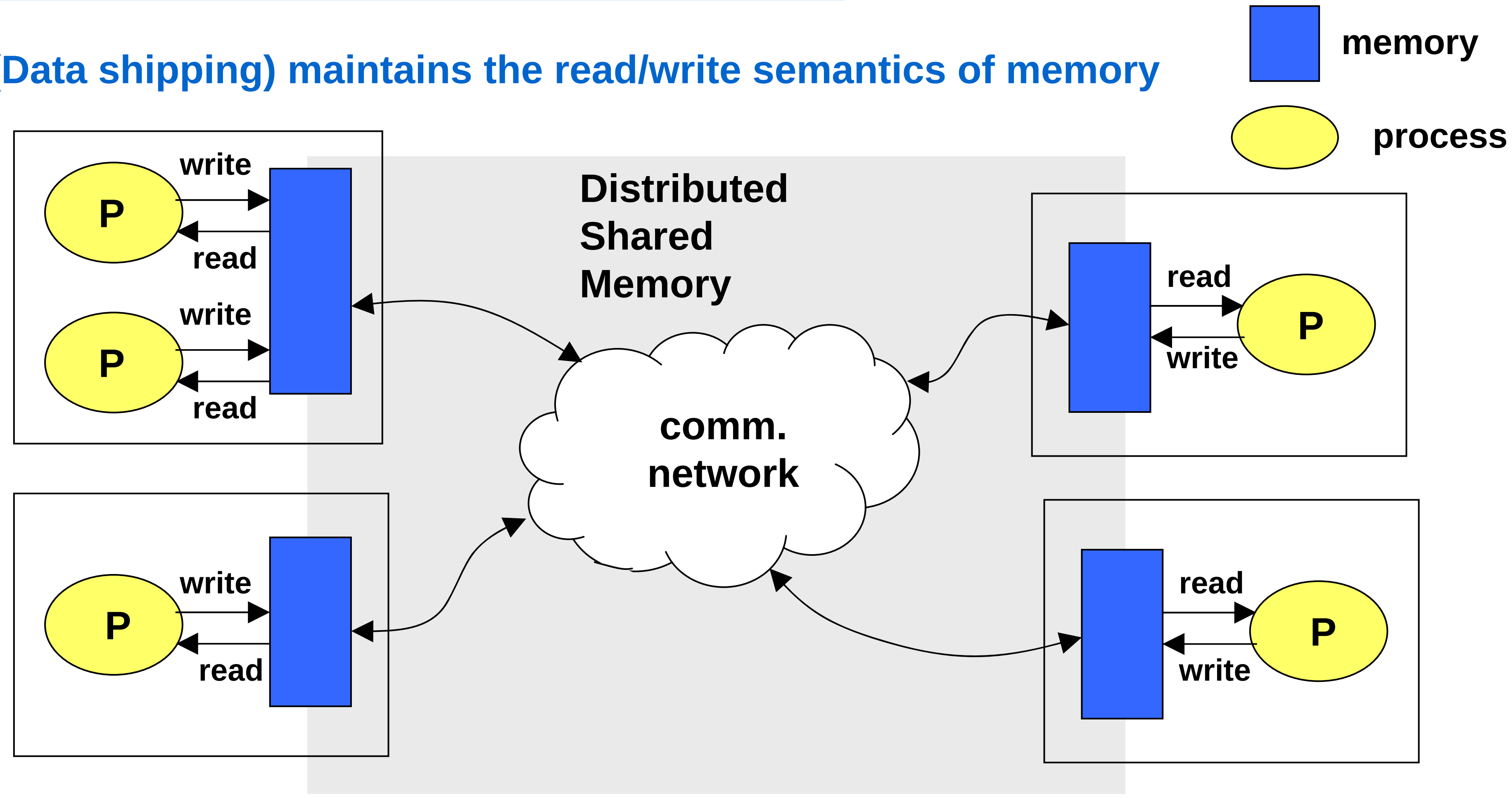
Function shipping initiates computations in a remote processing entity.
Example: Remote Procedure call.



Problem: computation bottlenecks, more complex programming model, references.

Distributed Shared memory

DSM (Data shipping) maintains the read/write semantics of memory



Problem: Consistency in the presence of concurrency and communcation delays

Abstractions for Communication

- Message passing
- Remote Procedure Call
- Remote Object Invocation
- Distributed shared memory
- Notifications
- Publish Subscribe
- Shared data spaces

Abstractions for Communication

Dimensions of Dependencies:

Flow coupling: Control transfer with communication

Defines whether there is a control transfer coupled with a message transfer. E.g. if the sender blocks until a message is correctly received.

Space Coupling: References must be known

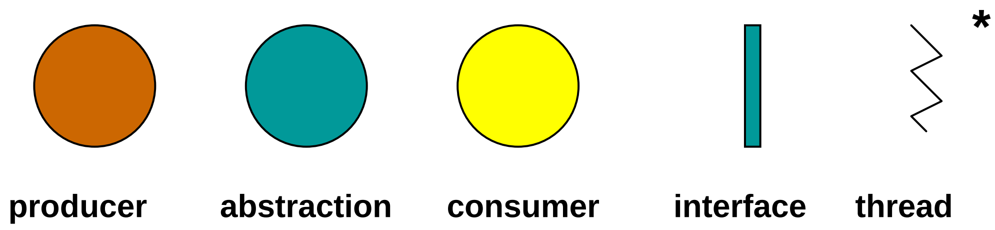
Explicit specification of the destination, i.e. producer must know where to send the message. Message contains an ID specifying an address or name.

Coupling in time: Both sides must be active

Communication can only take place if all partners are up and active.

Message passing

Connected socket, e.g. TCP



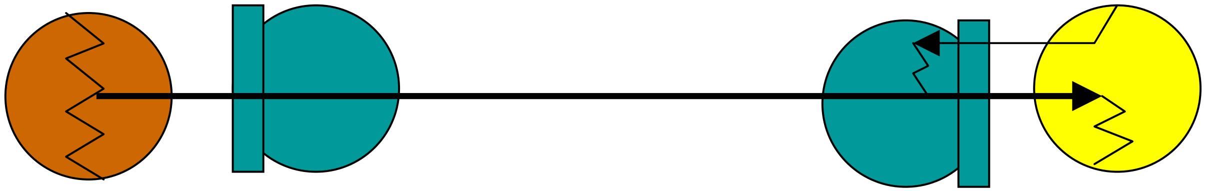
primitives: send (), receive ()

Coupling: flow, space, time

* **Notation acc. P. Eugster: Type-Based Publish Subscribe, PhD-thesis, EPFL, Nr. 2503, 2001**

Message passing

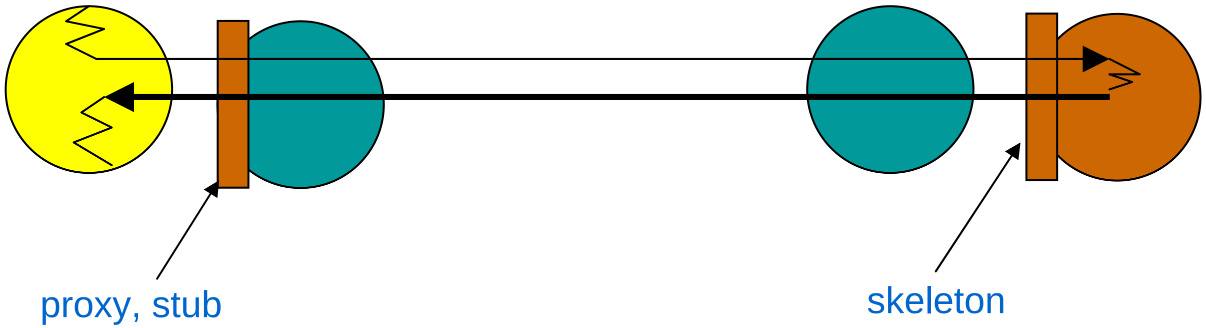
Unconnected socket, e.g. UDP



primitives: send (), receive ()

Coupling: (flow? unsuccessful if flow is not coordinated), space, time

Remote Procedure Call (RPC)



Relation: one-to-one

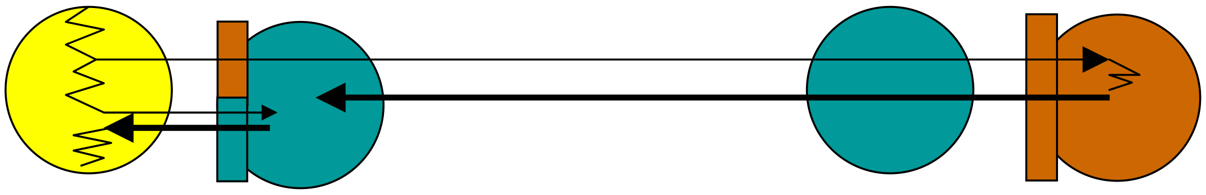
Coupling:

Space: destination is explicitely specified

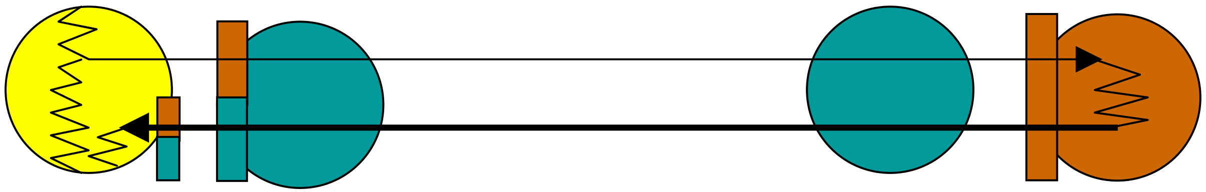
Flow: blocks until message is delivered

Time: both sides must be active

Variations of RPC



Asynchronous RPC with pull



Asynchronous RPC with call-back

Example: Concurrent Smalltalk

Relation: one-to-one

Coupling:

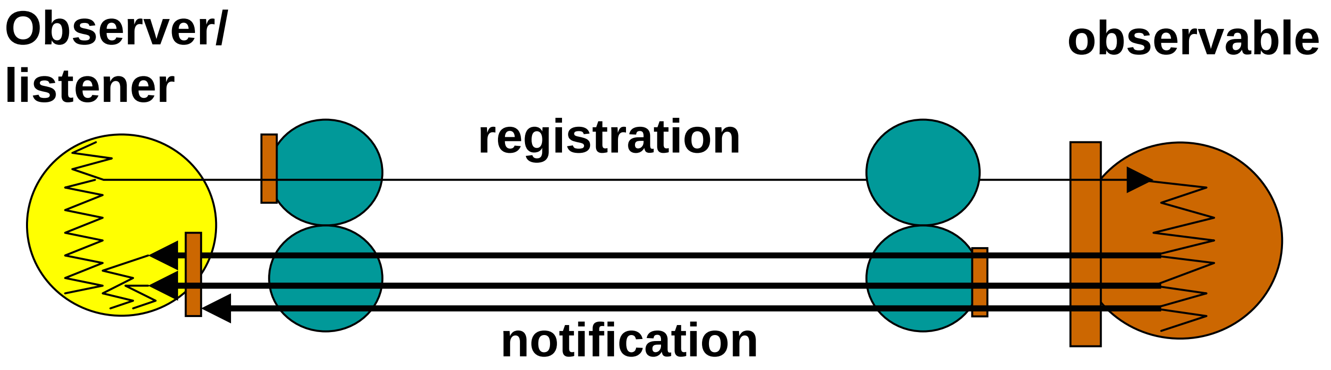
Space: destination is explicitely specified

Flow: no flow coupling

Time: both sides must be active

Example: Eiffel

Notification

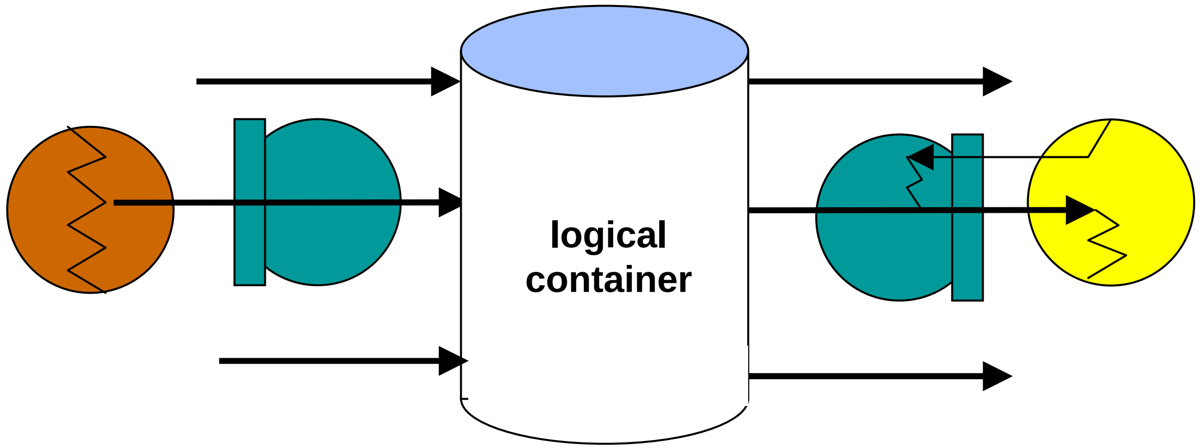


Examles:
Java

Relation: one-to-many

Coupling:
Space: Yes (Observable/Observer pattern (delegation))
Flow: none
Time: both sides must be active (notification performed by RMI)

Shared Data Spaces



Relation: many-to-many

Coupling:
Space: none
Flow: consumer side
Time: none

Examples:
Linda Tuple Space
Java Spaces
ADS Data field

Shared Data Spaces

Processes communicate via the "Tuple" Space,
A tuple is only data, non address, no identifier,
A tuple is a data structure similar to a struct in C,

Examples: ("3numbers", 3, 6, 7), ("matrix" , 1, 5, 3.23, 8),
("faculty", "is_member_of", "franz", "maria", "otto")

Primitives (operations) in LInda:

- **op. in:** **takes (and removes) an element from the tuple space**
- **op. read:** **reads an element from the tuple space**
- **op. out:** **puts a tuple into the tuple space**
- **op. eval:** **allows to eveluate the fields of a tuple, results are put in the tuple space [example: ("product", mult(4,7))]**

No Tuple is ever (over-) written! "out" always put a new item in the space.

Shared Data Spaces

Content-Based Addressing by Tuple matching:

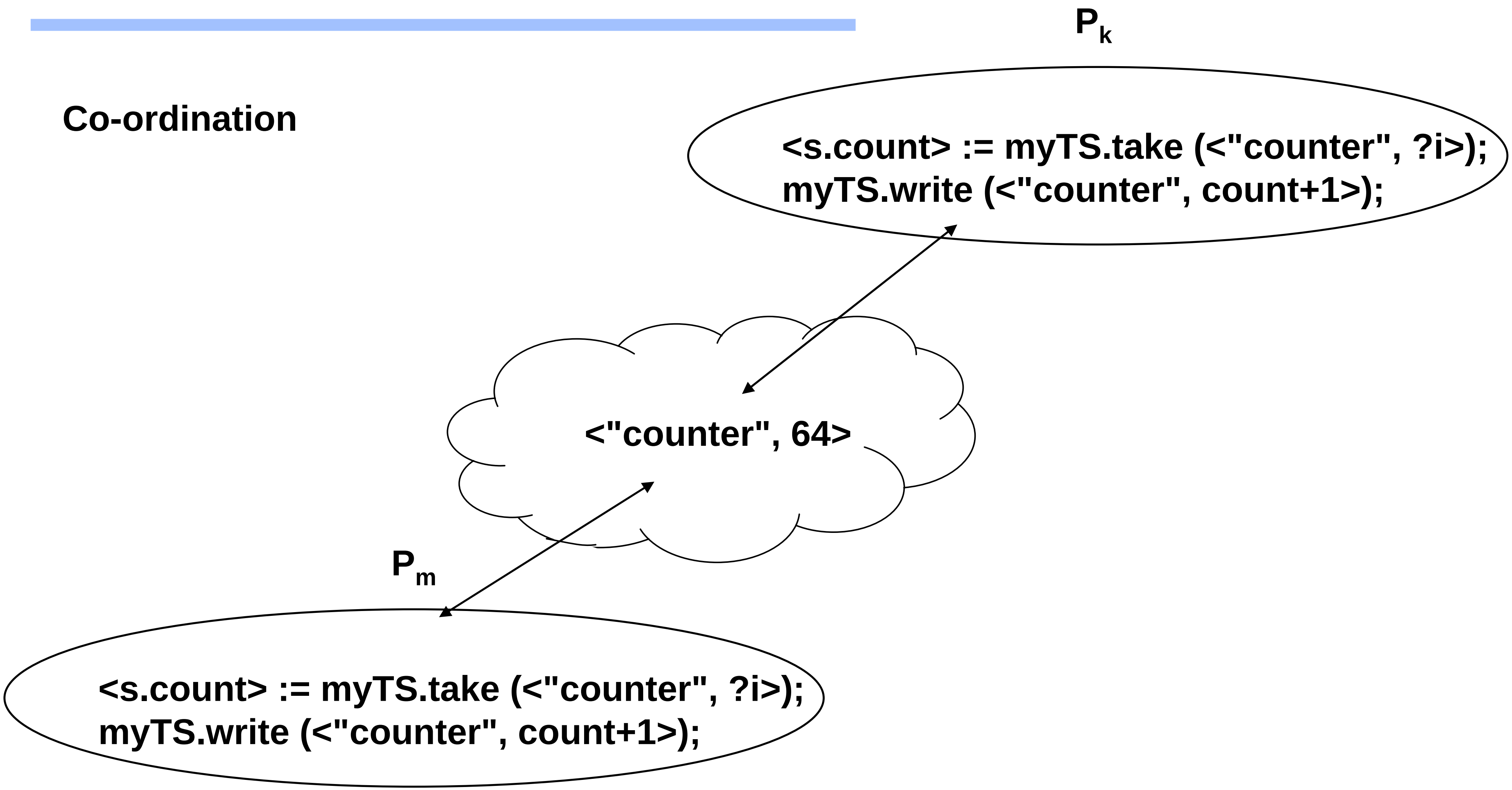
All fields in a template are compared to all tuples.
A match of a template occurs if:
tuple has the same number of fields
AND types of fileds are equivalent
AND contents corresponds

Example:
<"distance´_sensor", "N", 23>
<"distance´_sensor", "E", 127>
<"distance´_sensor", "S", 127>
<"distance´_sensor", "W", 12>

in(<"distance_sensor", " ", ?i> : reads all distance sensors and removes their values from the space.
read(<"distance_sensor", S, ?i>: subsequent read blocks until new S-value has been put to the Space.

Shared Data Spaces

Co-ordination

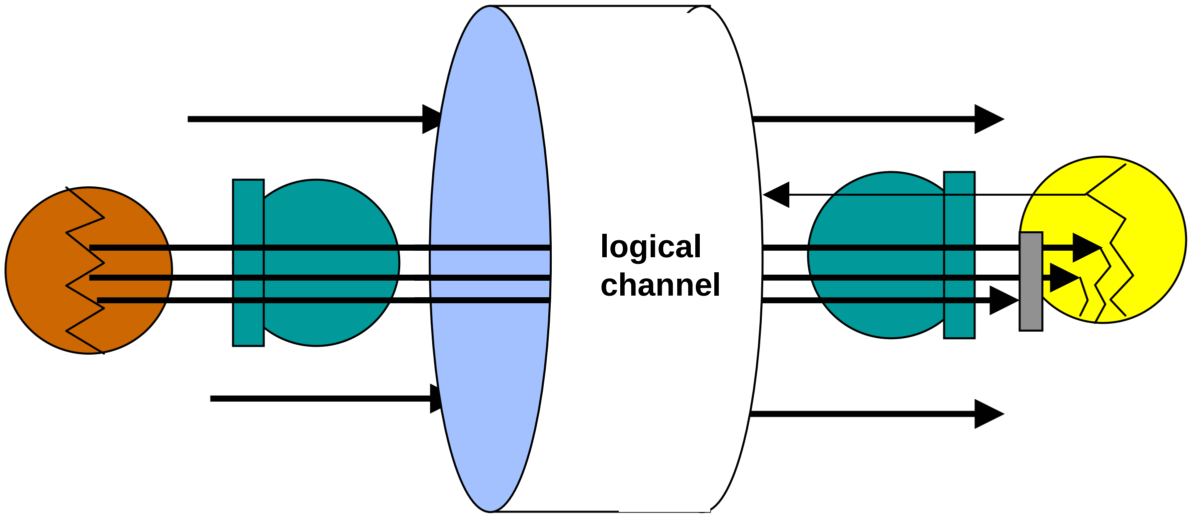


Shared Data Spaces

Immutable Data Storage:

- **no write operation!**
- **"out" always adds a data element to the storage**
- **destructive "in" and non-destructive "read"**
- **consistency is preserved by ordering accesses**
- **examples: Linda, JavaSpaces**

Publish/Subscribe



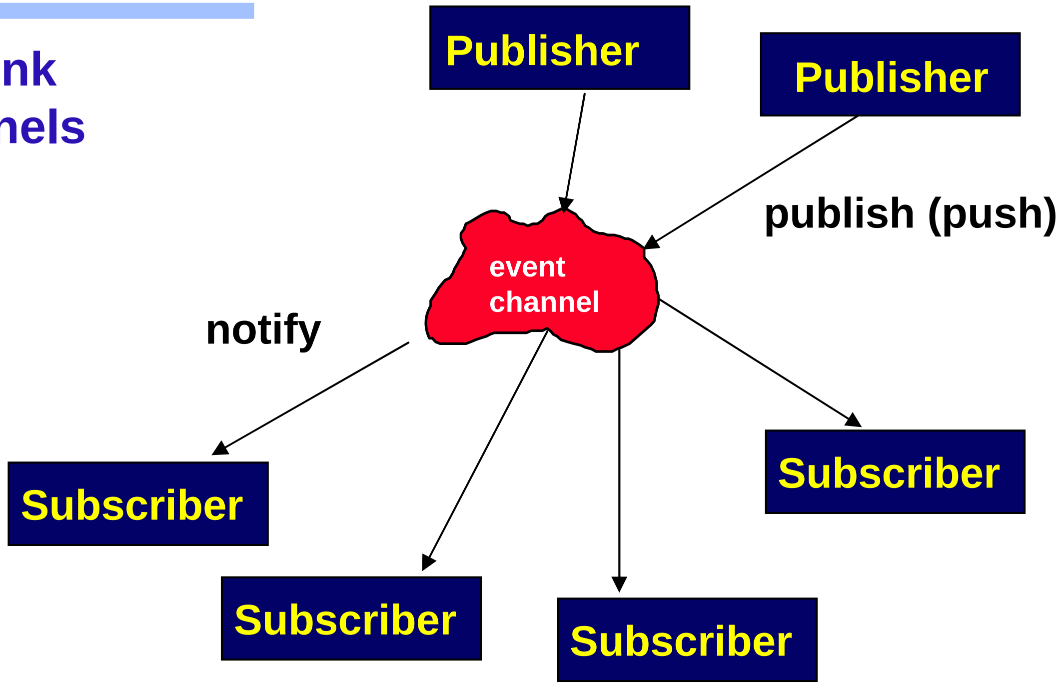
Relation: many-to-many

Coupling:
Space: none
Flow: none
Time: none

Examples:
Information Bus
NDDS
Real-Time P/S
COSMIC
....
....

The Publisher/Subscriber Model

Principle: Keep control local and link systems via event channels



Information Bus *(Oki, Pfluegl, Siegel, Skeen)*
iBus *(Maffeis)*
Real-Time P/S *(Rajkumar, Gagliardi, Sha)*
NDDS *(Real-Time Innovations, Inc.)*
SIENA *(Carzanoga, Rosenblum, Wolf)*
Directed Diff. *(Intanagonwiwat, Govindan, Estrin)*

Many-to-many communication

Support for event-based spontaneous (generative) communication

Anonymous communication

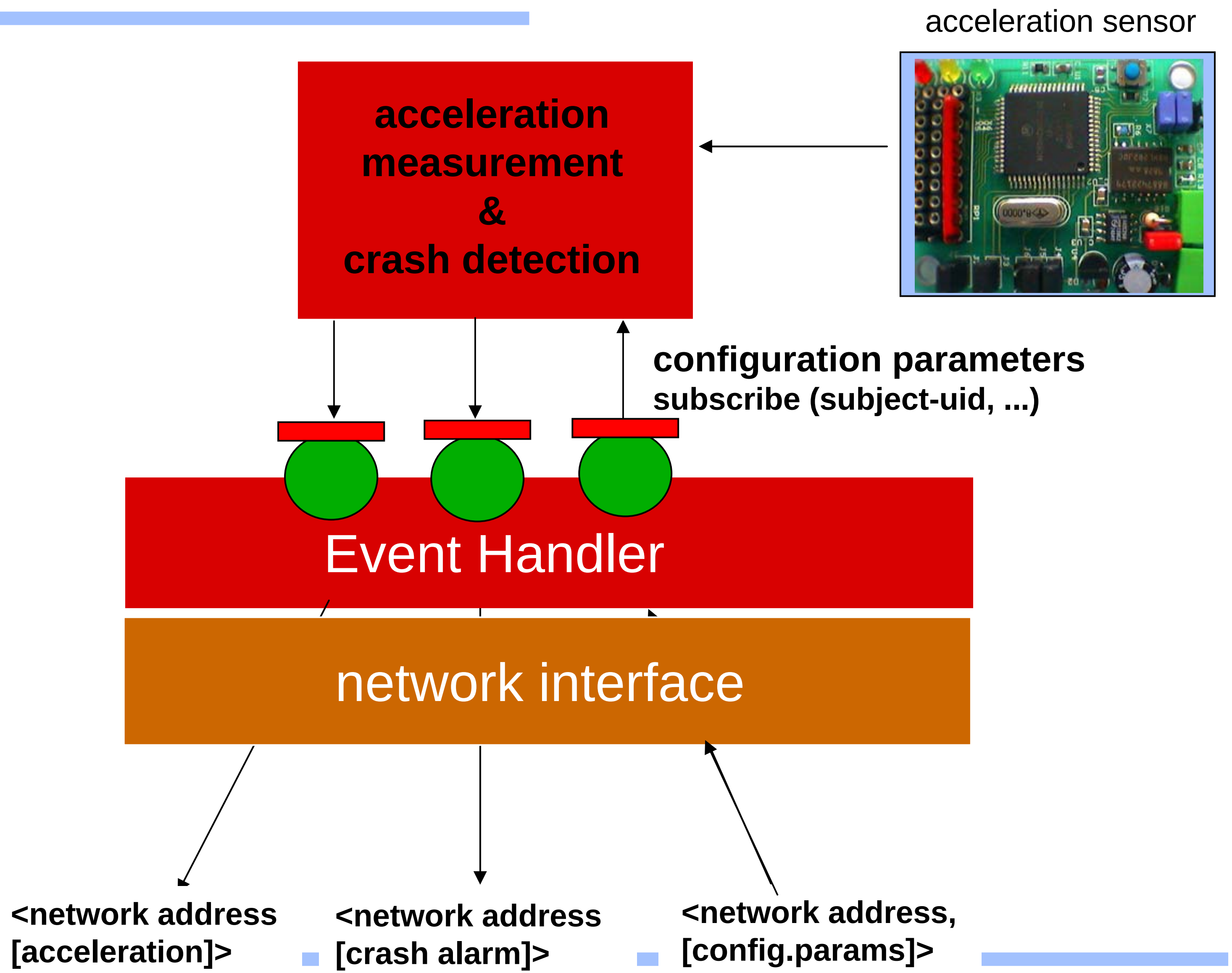
P/S in a smart sensor application

event: acceleration

publish (subject,attr., [acceleration]);

event: alarm

publish (subject, attr., [alarm]);



Overview

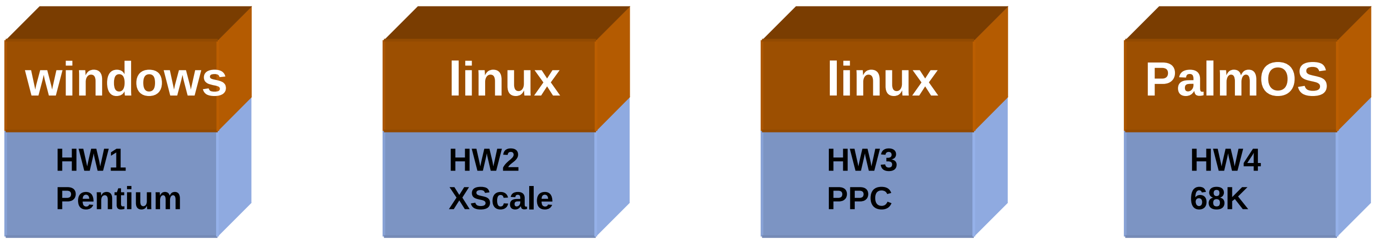
Abstraction	Space Coupling	Time Coupling	Flow Coupling
• Connected Sockets	Yes	Yes	Yes
• Unconnected Sockets	Yes	Yes	Consumer
• RPC	Yes	Yes	Consumer
• Oneway RPC	Yes	Yes	No
• async (Pull)	Yes	Yes	No
• async (Callback)	Yes	Yes	No
• Implicit Future	Yes	Yes	No
• Notications (Observer Design Pattern)	Yes	Yes	No
• Tuple Spaces (Pull)	No	No	Consumer
• Message Queues (Pull)	No	No	Consumer
• Subject-Based P/S	No	No	No
• Content-Based P/S	No	No	No

What are the options?

Communication model	Communication abstraction	Communication relation	Routing mechanism	Binding Time
message based	message	symmetric	address	design time
Remote procedure Call	invocation	client-server	address	design time
Distributed shared memory	memory cell	central	address	design time
Shared Data Spaces	object,tupel	central	contents	run time
Publish-Subscribe	event	Producer-consumer	contents/ subject	run time

Distributed system architecture

abstracting from HW



Distributed system architecture

abstracting
from local OS

abstracting
from HW