The Internals of Distributed TyCO

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Talk Outline

- The DiTyCO Calculus
- The Programming Language
- The Computational Model
- Current and Future Work

The TyCO Calculus • Syntax

x			channels
X			procedures
l			method labels
P	$::=$	$\mathbf{0}$	terminated process
	$\mid$	$P \mid P$	concurrent composition
	$\mid$	**new** $x\ P$	new local variable
	$\mid$	$x!l[\tilde{v}]$	asynchronous message
	$\mid$	$x?\{l_1(\tilde{x}_1) = P_1, \ldots, l_n(\tilde{x}_n) = P_n\}$	object
	$\mid$	**def** $X_1(\tilde{x}_1) = P_1\ \ldots\ X_n(\tilde{x}_n) = P_n$ **in** P	definition
	$\mid$	$X[\tilde{v}]$	instantiation

The DiTyCO Calculus • Syntax

s			sites
P	$::=$	$\mathbf{0}$	terminated process
	$\mid$	$P \mid P$	concurrent composition
	$\mid$	**new** $x\ P$	new local variable
	$\mid$	$x!l[\tilde{v}]$	asynchronous message
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	$\mid$	**def** $X_1(\tilde{x}_1) = P_1\ \ldots\ X_n(\tilde{x}_n) = P_n$ **in** P	definition
	$\mid$	$X[\tilde{v}]$	instantiation
N	$::=$	$\mathbf{0}$	terminated network
	$\mid$	$N\ \|\|\ N$	concurrent composition
	$\mid$	**new** $x@s\ N$	new local variable
	$\mid$	**def** $D@s$ **in** N	definition
	$\mid$	$s[P]$	site running process

(cf. talks on LSDπ by Francisco Martins and António Ravara)

The Base Calculus • Operational Semantics

- reduction (always local, within sites):

Communication	$x?\{\ldots, l(\tilde{x}) = P, \ldots\} \mid x!l[\tilde{v}] \rightarrow \{\tilde{v}/\tilde{x}\}P$
Instantiation	**def** $X(\tilde{x}) = P$ **in** $X[\tilde{v}] \mid Q \rightarrow$ **def** $X(\tilde{x}) = P$ **in** $\{\tilde{v}/\tilde{x}\}P \mid Q$

- weak migration (site-to-site, triggered by lexical scope):

Message Migration	$r[x@s!l[\tilde{v}]] \rightarrow s[x!l[\tilde{v}\sigma_{rs}]]$
Object Migration	$r[x@s?M] \rightarrow s[x?M\sigma_{rs}]$
Remote Instantiation	**def** $D@s$ **in** $r[X@s[\tilde{v}]] \rightarrow$ **def** $D@s$ **in** $s[X[\tilde{v}\sigma_{rs}]]$

The Programming Language

Abstractions:

- straightforward extension of TyCO;
- sites are the programming modules;
- interface channels are explicitly located at sites;
- **export** defines the external site interface;
- **import** establishes bindings with remote resources.

Semantics:

- channels and procedures are the distributed resources;
- migration triggered by lexical scope;
- computation is always local.

The Programming Language

Server

```
def AppletS (self) =
    self ? {
        applet_1(p) =
            p?(x)= P_1  |  AppletS[self],
        ...
        applet_k(p) =
            p?(x)= P_k  |  AppletS[self]
    }
in export applets
in AppletS[applets]
```

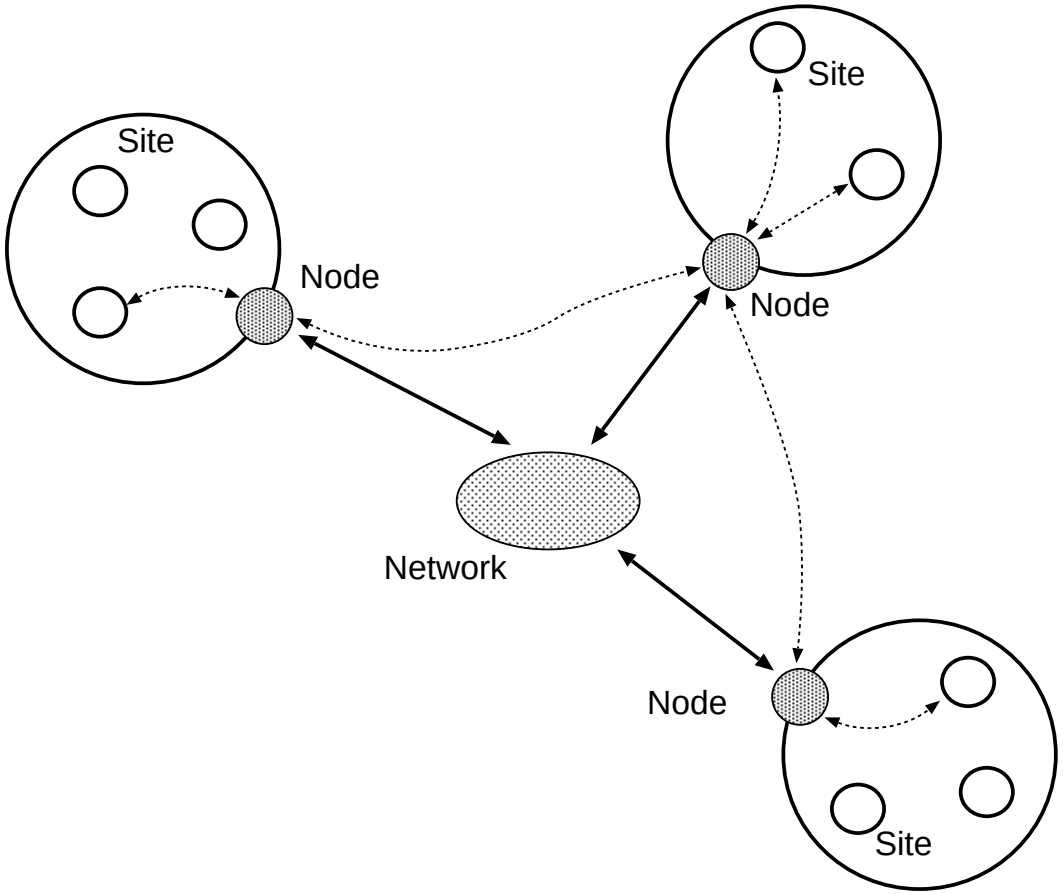
Client

```
import applets from Server
in new p applets!applet_j[p]  |  p![v]
```

The Computational Model

- flat network topology;
- peer-to-peer architecture;
- from a logical point of view we have just:
  - sites
- from an implementation point of view we have a three layered model:
  - network (provides a name-space);
  - nodes (proxies for sites);
  - sites.
- network and nodes do not compute;
- all computation is local to sites.

The Computational Model



The Computational Model • Software Organization

The Network

- **Interface NameSpace** – the name-space functionality;
- **Class Network implements NameSpace** – the network provides a name-space;

The Nodes

- **Interface Proxy** – the node manager for Distributed TyCO;
- **Class Node implements Proxy** – a Distributed TyCO node is a proxy for sites;

The Computational Model • Software Organization

The Sites

- **Interface InstructionSet** – the core TyCO instruction set;
- **Class VirtualMachine implements InstructionSet** – an implementation;
- **Class Externals** – operations external to the core TyCO definition;

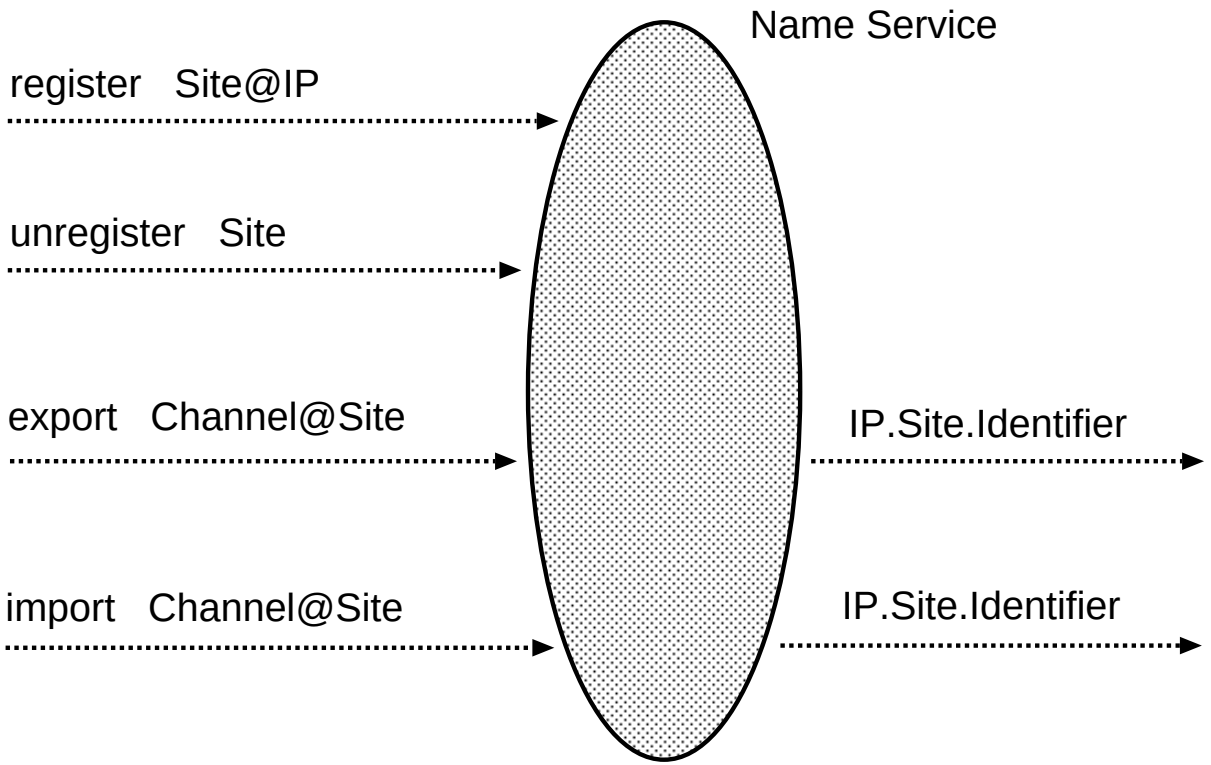
- **Class Site extends VirtualMachine**
  - I/O queues;
  - translation table;
  - operations supporting distribution and mobility implemented under the package Externals.

The Computational Model • The Network Layer

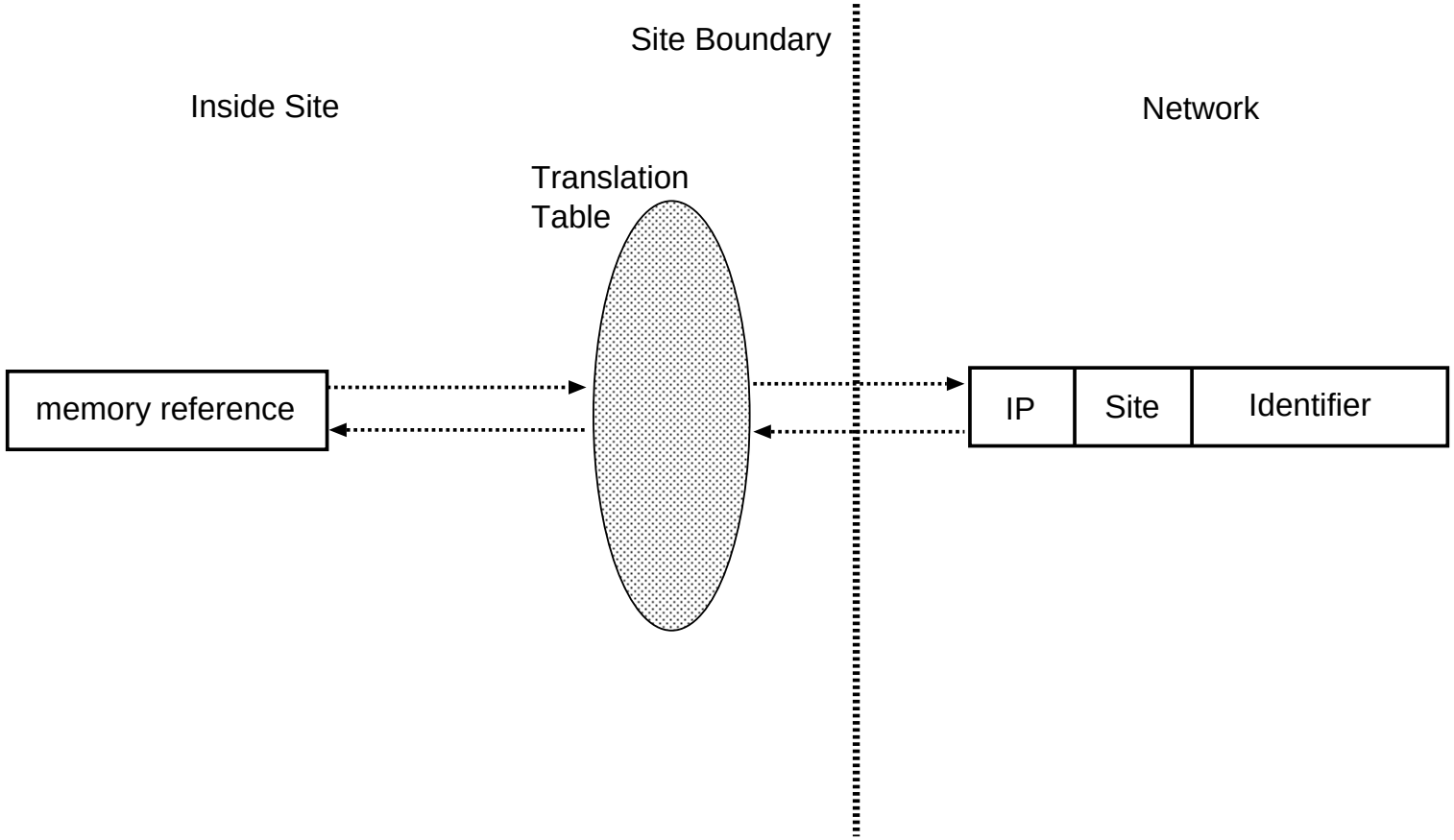
- network wide service that provides a name-space for computations;

- register a Site@IP;
- unregister a Site;
- register a resource Channel@Site;
- resolve a resource name Channel@Site.

The Computational Model • The Network Layer



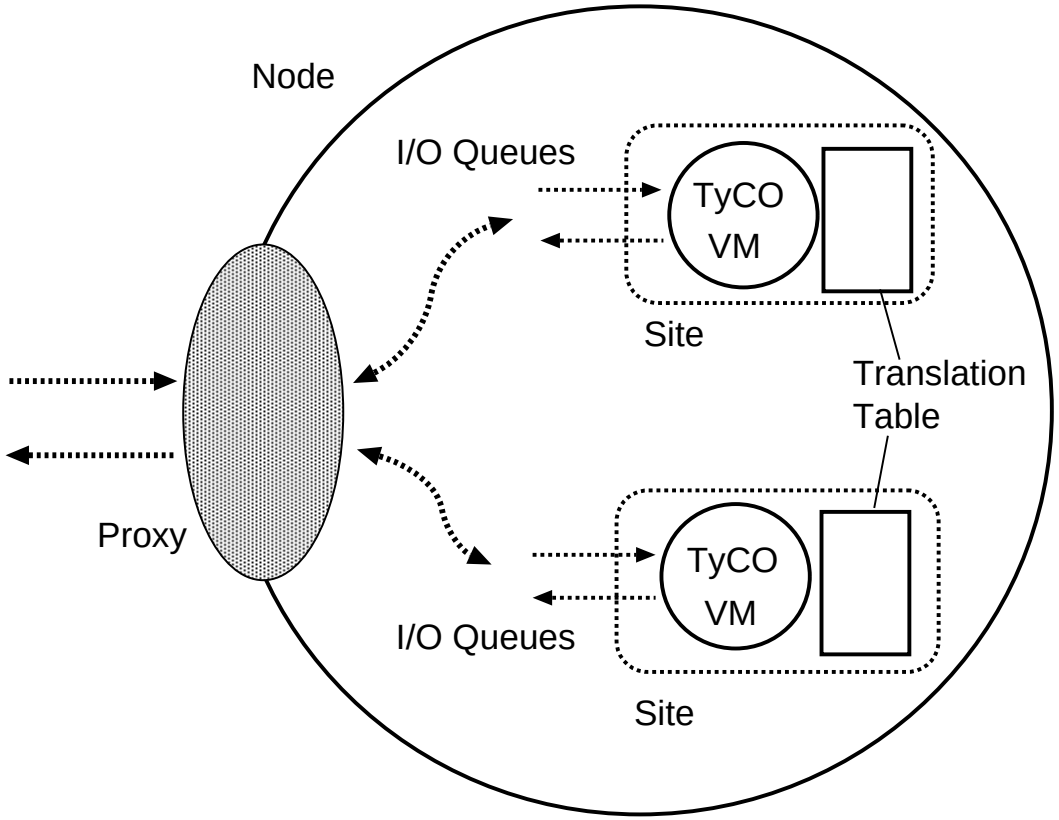
The Computational Model • The Network Layer



The Computational Model • The Node Layer

- one-to-one correspondence with physical/logical IP nodes;
- a proxy for sites that handles:
  - communication;
  - migration;
  - name-resolution;
- every IP node requires a Distributed TyCO proxy to run sites;
- the proxy shares an address space with the local sites;
- uses shared-memory for local communication.

The Computational Model • The Node Layer



The Computational Model • The Site Layer

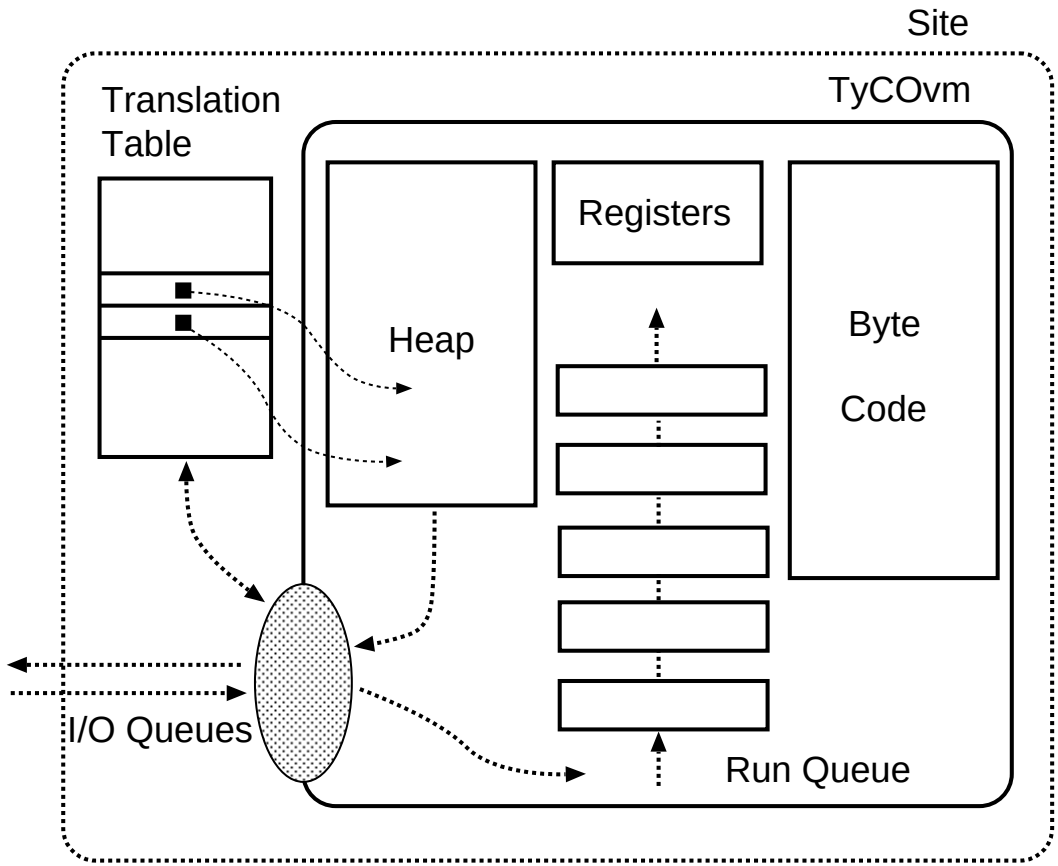
TyCO Virtual Machine

- register based virtual machine:
  - program area with byte code;
  - heap with activation records and channels;
  - general purpose registers;
  - run-queue for run-time generated tasks.
- single/multi-threaded.

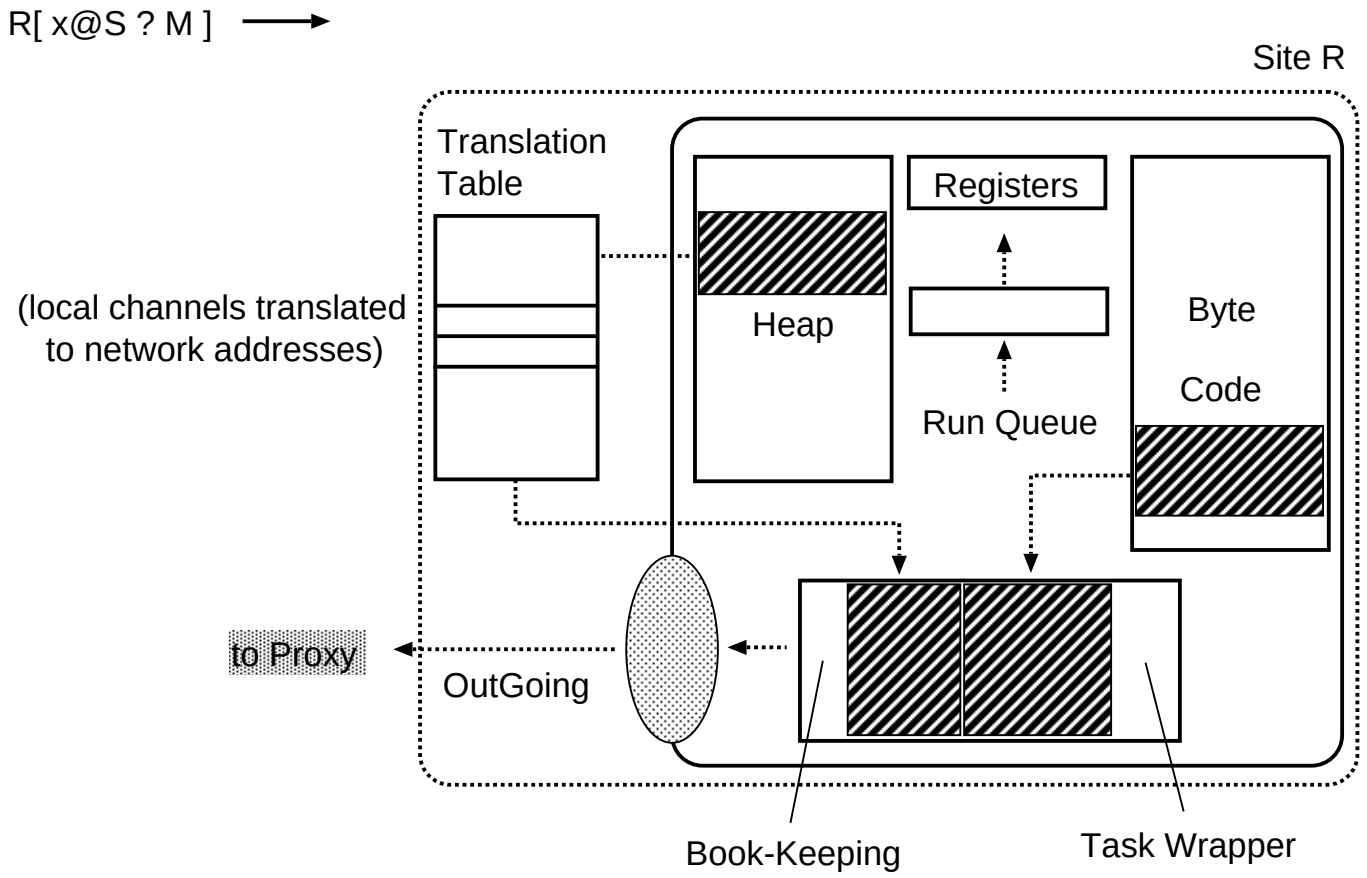
Extended with:

- queues for incomming/outgoing code;
- translation table for converting network references into local references;
- module of instructions for processing remote interactions.

The Computational Model • The Site Layer



Computational Model • Putting it all Together



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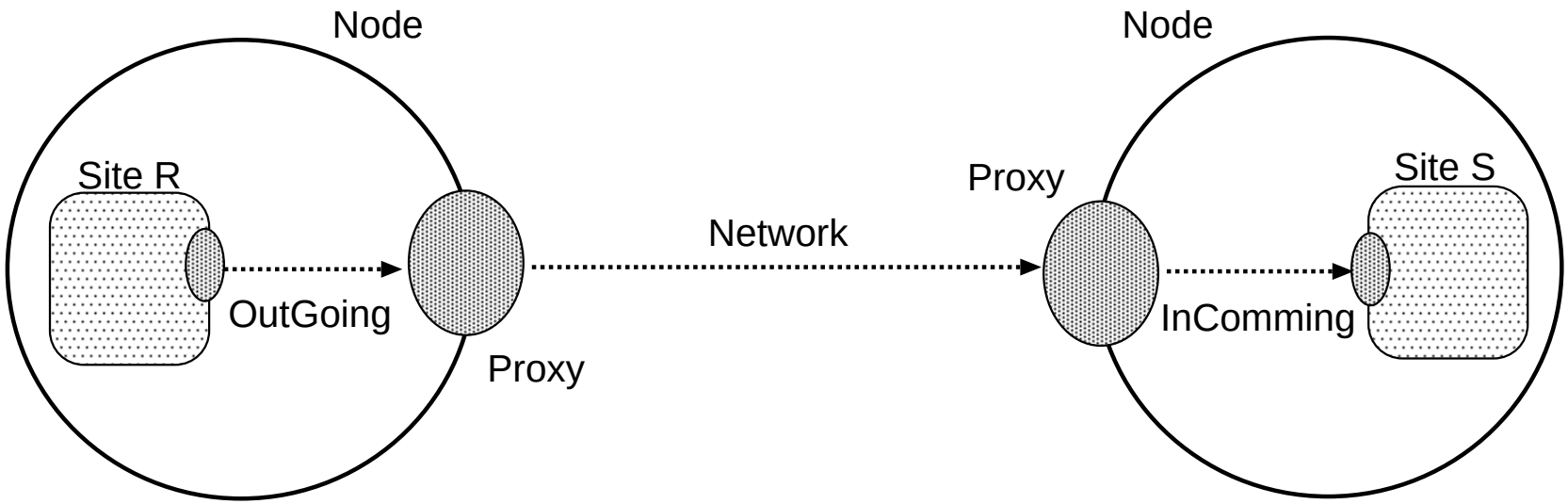

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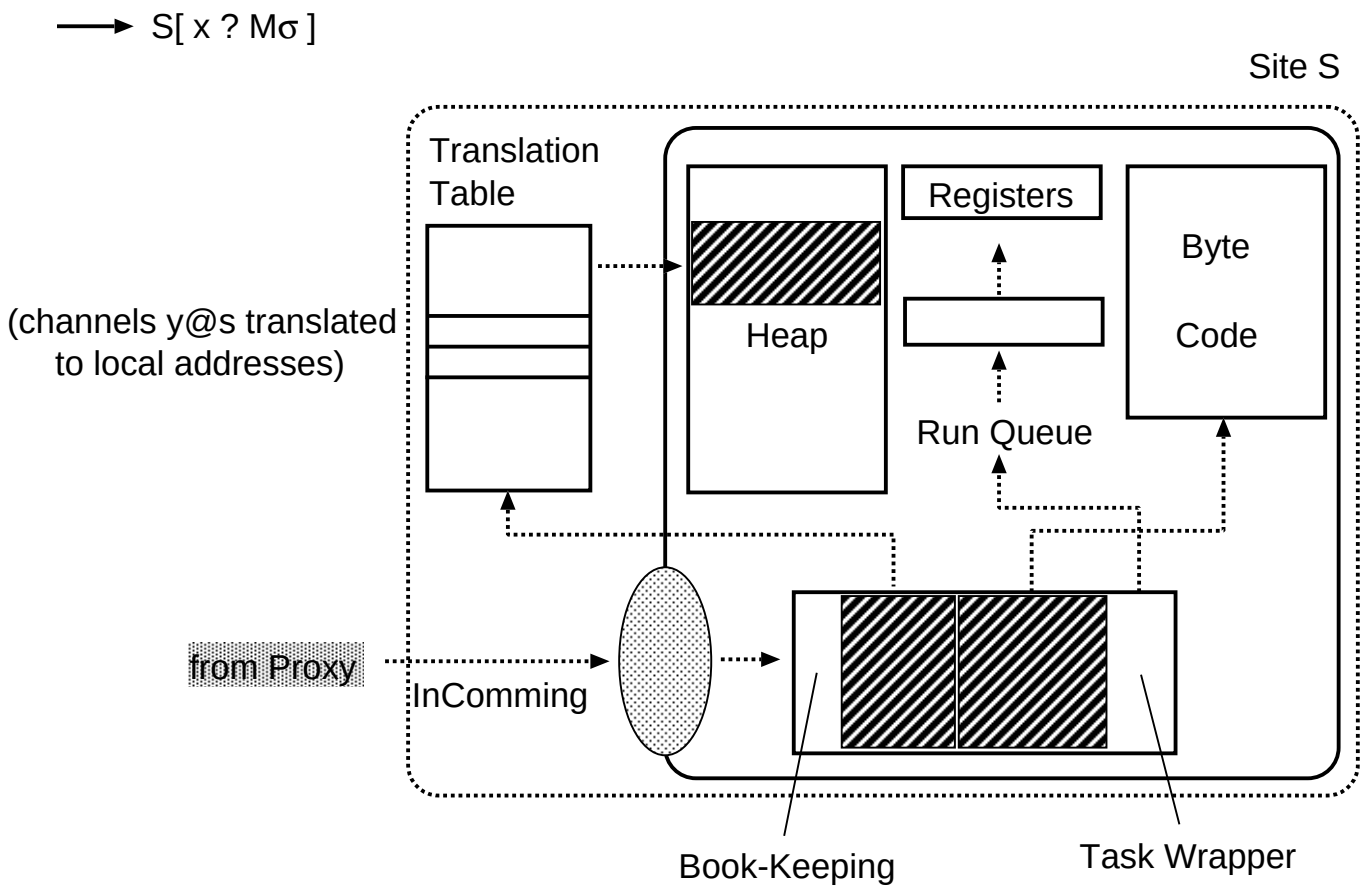

Current Work and Future Developments

- Preparation of next release of TyCO
  - major revisions of compiler and virtual machine;
  - infra-structure for distributed development;
  - system documentation;
  - open system.
- Implementation of Distributed TyCO in this environment
- Multithreaded Virtual Machine
- A Debugger for (Distributed) TyCO

URL $\Rightarrow$ `http://www.ncc.up.pt/~lblopes/tyco/`