Space Based Computing – Leveraging the Coordination Paradigm

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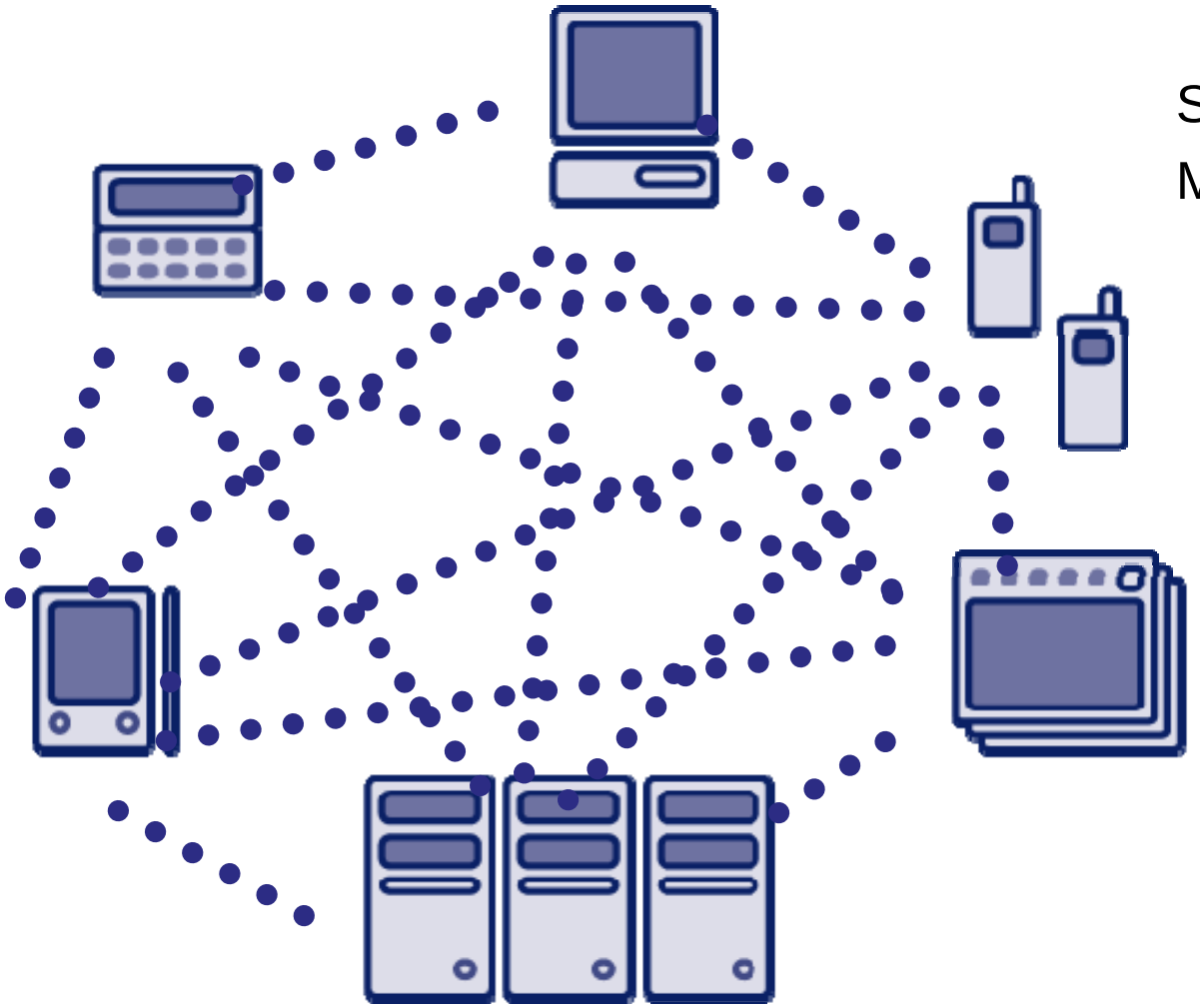
Distributed and Concurrent Systems

- Modern computer systems are implemented as distributed architectures
- Today we face a meta-challenge integrating a large amount of systems
  - different platforms
  - different technologies
- Our expectations on distributed systems:
  - seamless ubiquitous communication between systems
  - reliable
  - simple
  - flexible (“the agile enterprise”)
  - scalable
  - low cost
- Reality:
  - complex
  - costly
  - unreliable
  - hard to manage
- Aggravating assumption: “The exception is the rule”

Today‘s Situation:
Direct Communication / Message Passing



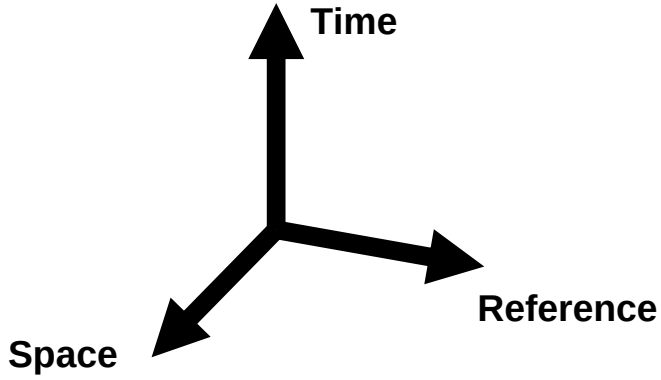
Sockets, RPC,
MOM, RMI

Today's Solution Approaches

- Enterprise Application Integration (EAI) systems:
  - object request broker (CORBA, DCOM, etc.)
  - message queues (MQ Series, MS-MQ, etc.)
  - message broker (routing, transformation, multi-cast, etc.)
  - enterprise service bus ESB (WS-* support, adapter, etc.)
  - business process execution environments (workflow, etc.)
- Evaluation:
  - message-oriented
  - complex
  - clumsy

Decoupling of Interaction

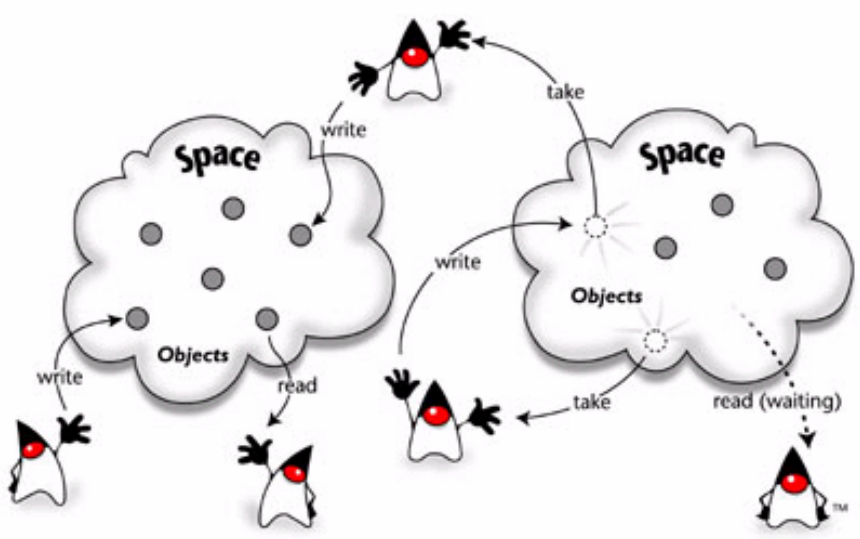
- SBC decouples interaction in three dimensions
  - Time
    - Applications can read and write data whenever they want to
  - Space
    - Applications only need to access the same space in order to communicate
  - Reference
    - Applications communicating with each other do not need to know explicitly from each other



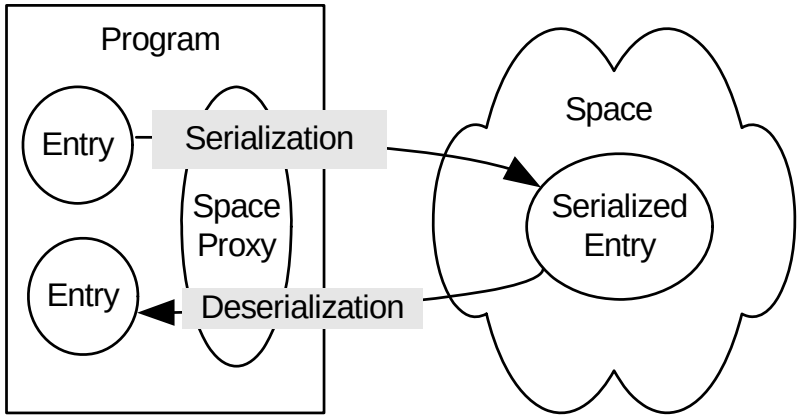
Representatives of SBC Technologies

- Tuple Spaces (Linda)
  - David Gelernter, Yale Univ.
- Java Spaces
  - SUN
- T-Spaces
  - IBM
- Corso (Coordinated Shared Objects)
  - eva Kühn, TU Vienna
- XML Spaces
  - Robert Tolksdorf, Free Univ. Berlin
- XVSM (eXtensible Virtual Shared Memory)
  - eva Kühn, TU Vienna

Heritage of Space Based Computing:
Java Spaces



- SUN Standard
- Based on Jini
- Space = Shared Memory
- Administrates Entries (Tuples – LINDA Model)
- Serialization (public fields)
- write, read, take, notify
- Associative search
- Indeterminism
- Transactions, Persistency
- Lease Times



Java Spaces Methods

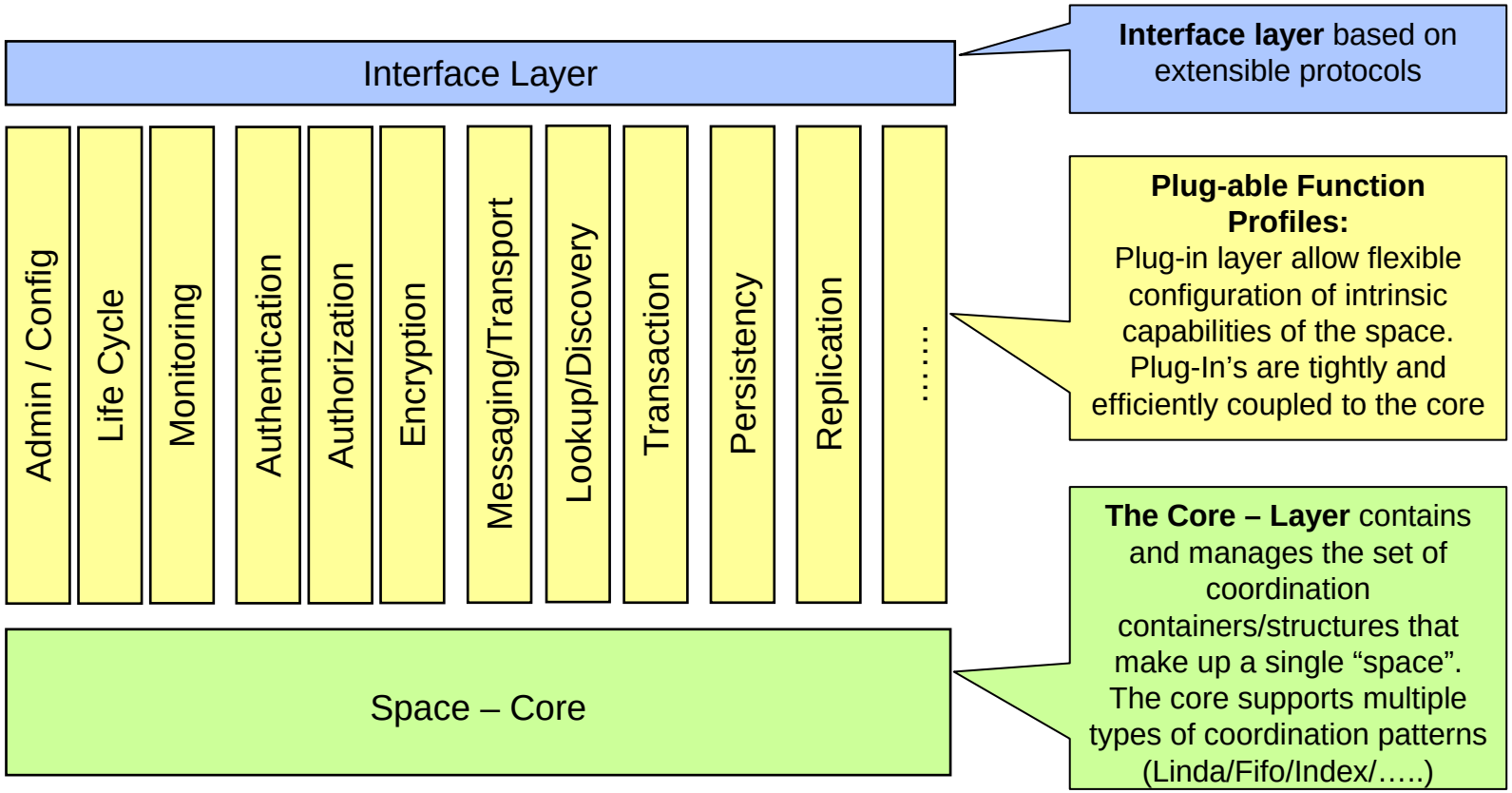
```
Lease write(entry e, Transaction txn, long timeout)
  throws   RemoteException, TransactionException;

Entry read(Entry tmpl, Transaction txn, long timeout)
  throws   TransactionException,UnusableEntryException,
           RemoteException, InterruptedException;

Entry take(Entry tmpl, Transaction txn, long timeout)
  throws   TransactionException,UnusableEntryException,
           RemoteException, InterruptedException;
```

```
EventRegistration notify(Entry tmpl, Transaction txn,
  RemoteEventListener listener, long lease, MarshalledObject
  handback) throws RemoteException, TransactionException;
```

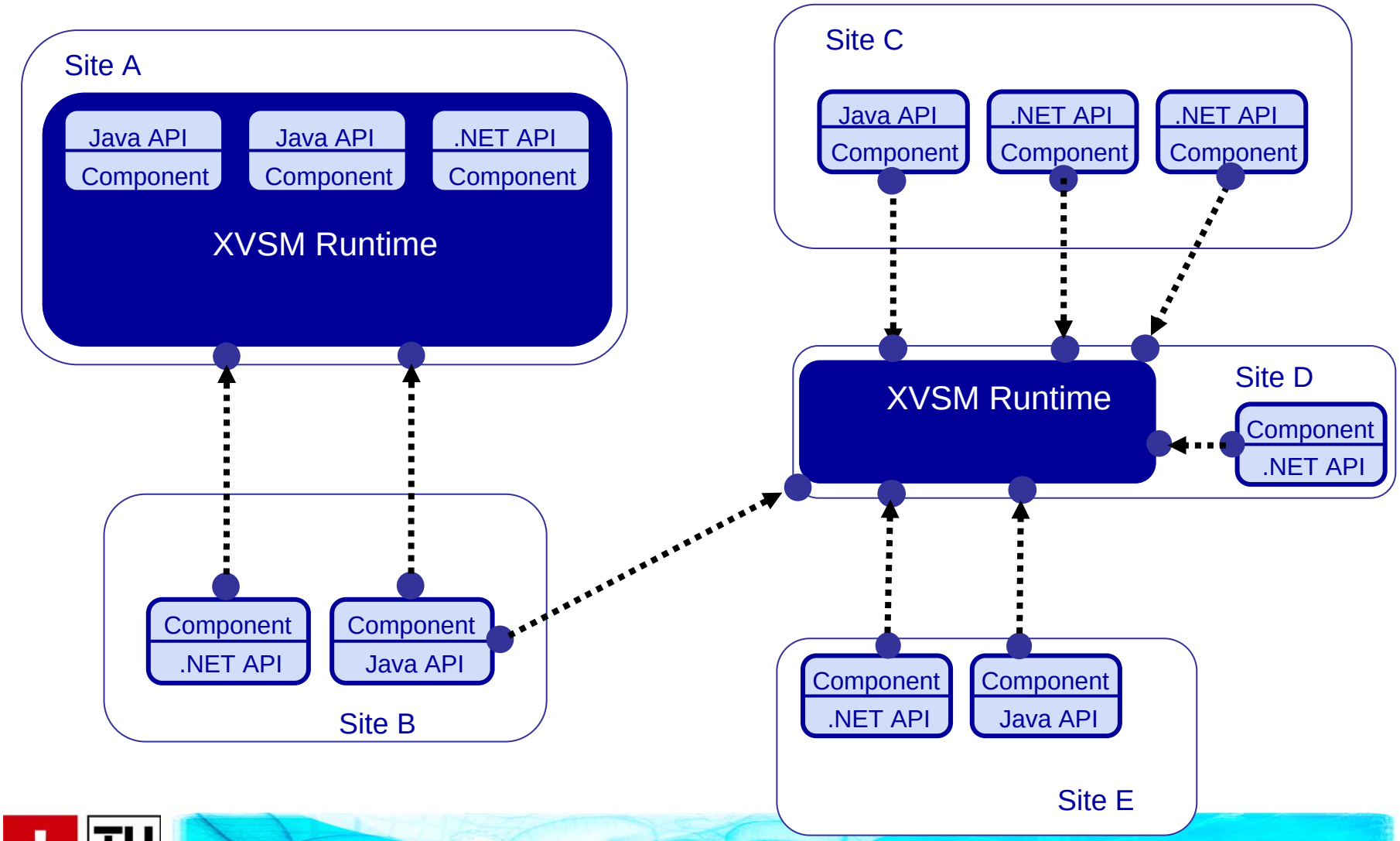
XVSM: eXtensible Virtual Shared Memory

- Extension of tuple space model and JavaSpaces
- Shall contribute to an open standard that canonizes relevant SBC efforts as promoted by the SpaceBasedComputing.org
- Structuring of the coordination space into sub-spaces that can be addressed via the Internet through URLs
  - Basic concept: shared containers
- More expressive coordination models
  - FIFO, KEY, VECTOR, TEMPLATE, RDF etc.
- Internet capable protocols
- Core API extends the classical tuple space API
  - read, take, write, notify etc.

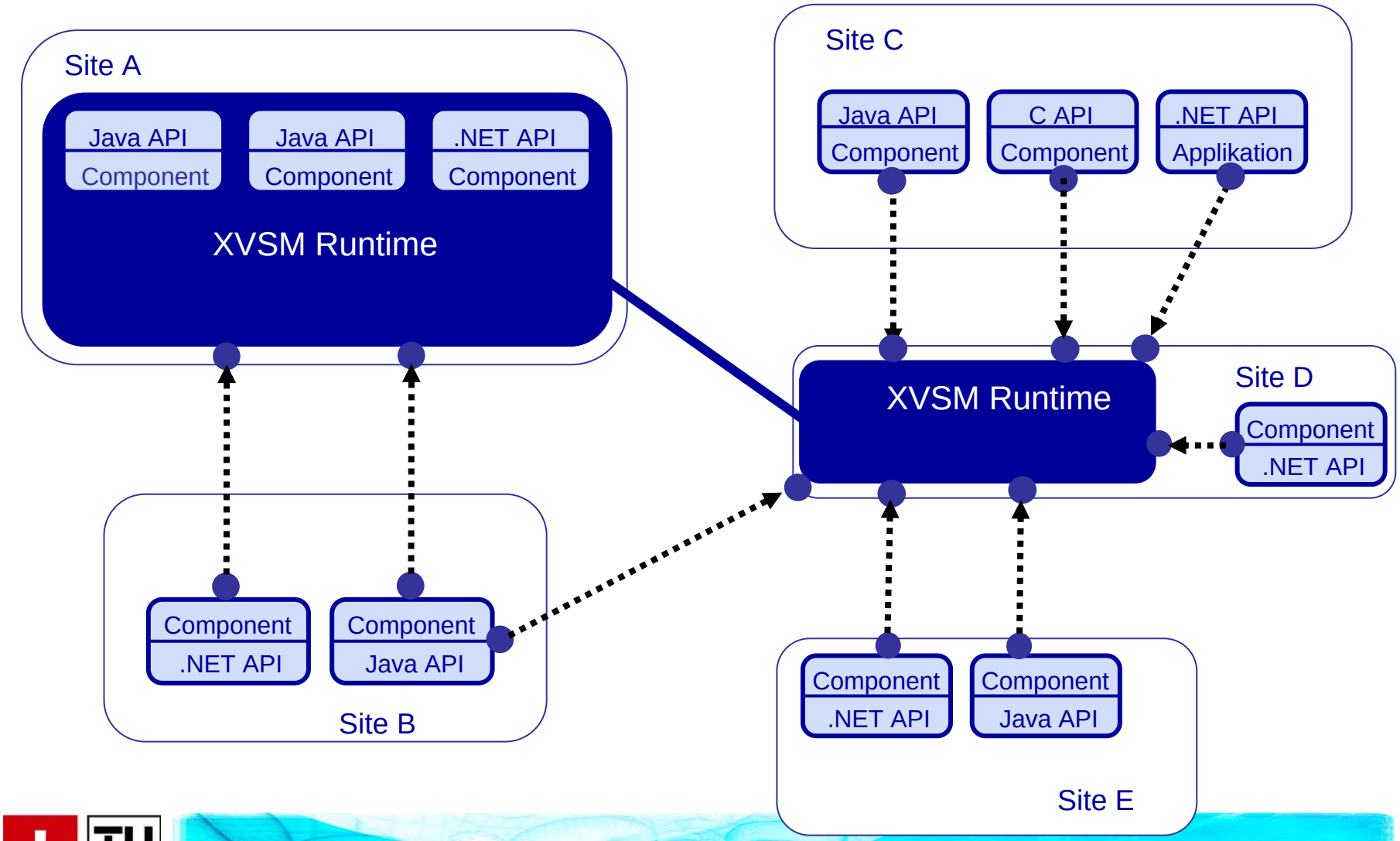
XVSM: Open, Configurable, Web-scalable system



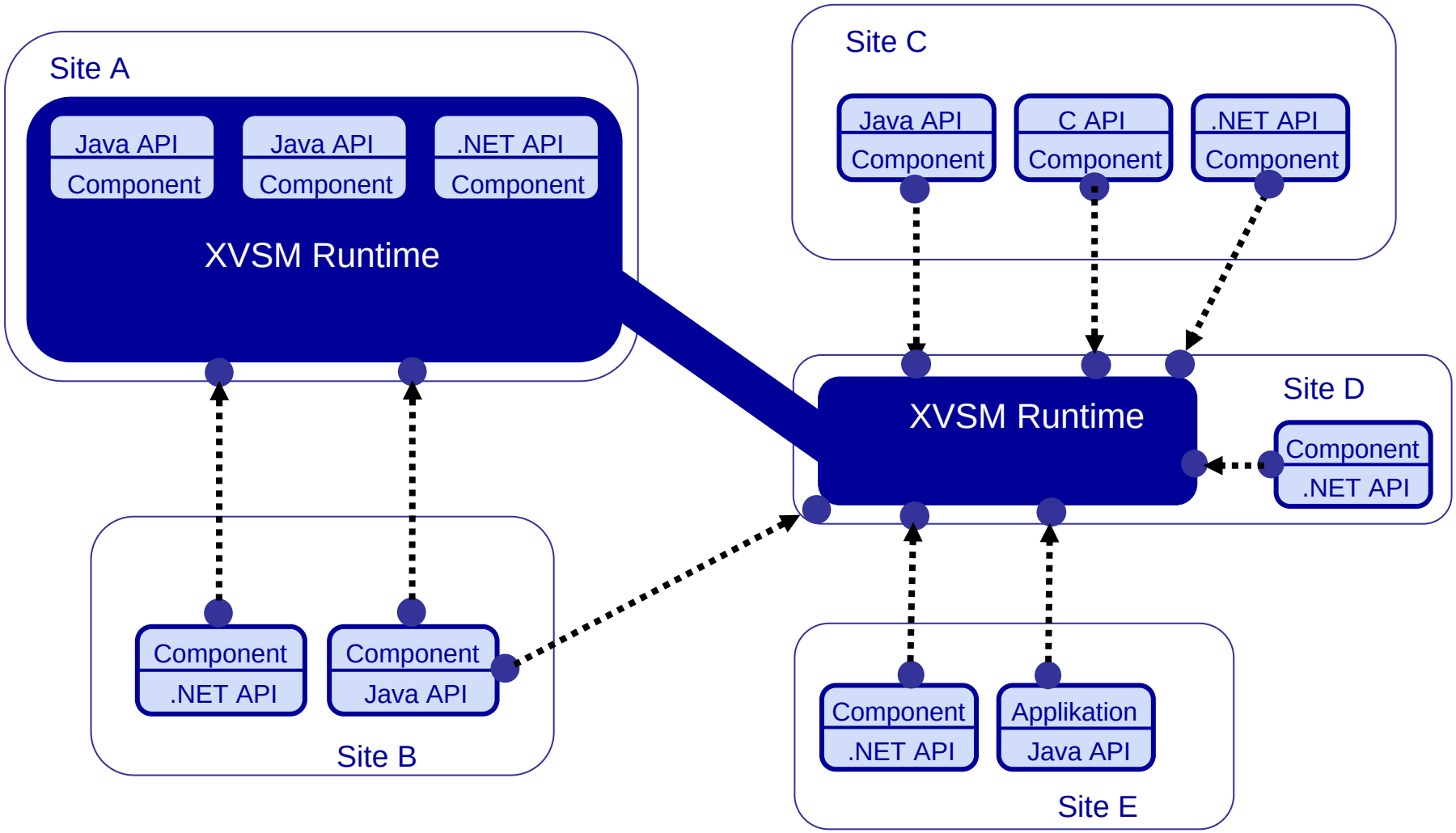
Architecture without Replication



Architecture with Lookup



Architecture with Lookup & Replication



Advantages

- Each application has a uniform & consistent view of the entire state (incl. history) of the distributed system in near time
- Based on this info each application can optimize its own behavior, manage itself, and join and leave dynamically
- Complete virtualization of the SW application level
- Orthogonal services (security, auditing, SLA, monitoring, billing) can easily be added and unified
- Built-in scalability, fault-tolerance, fail-over and reactivity (event-driven)

⇒**Autonomous Computing** *without a* central coordinator

⇒**Higher productivity, less LOCs, better architectures**

⇒**Enables new business scenarios**

Application Scenarios

Data distribution and acquisition

- publish/subscribe, push/pull, produce/consumer, monitoring, data communication in unreliable networks (satellite), logistics, backup support, data replication, conflict resolution, …

Collaboration (incl. competition, cooperation, negotiation)

- collaborative whiteboard, ad-hoc workflow, autonomic computing, self-organization and self-healing, load-balancing, distributed data cache, market-place, advanced message exchange patterns, …

Mobility (on/offline mode with mobile devices)

Orthogonal services (SLAs)

Research on Space Based Computing & Semantics: History of TripCom

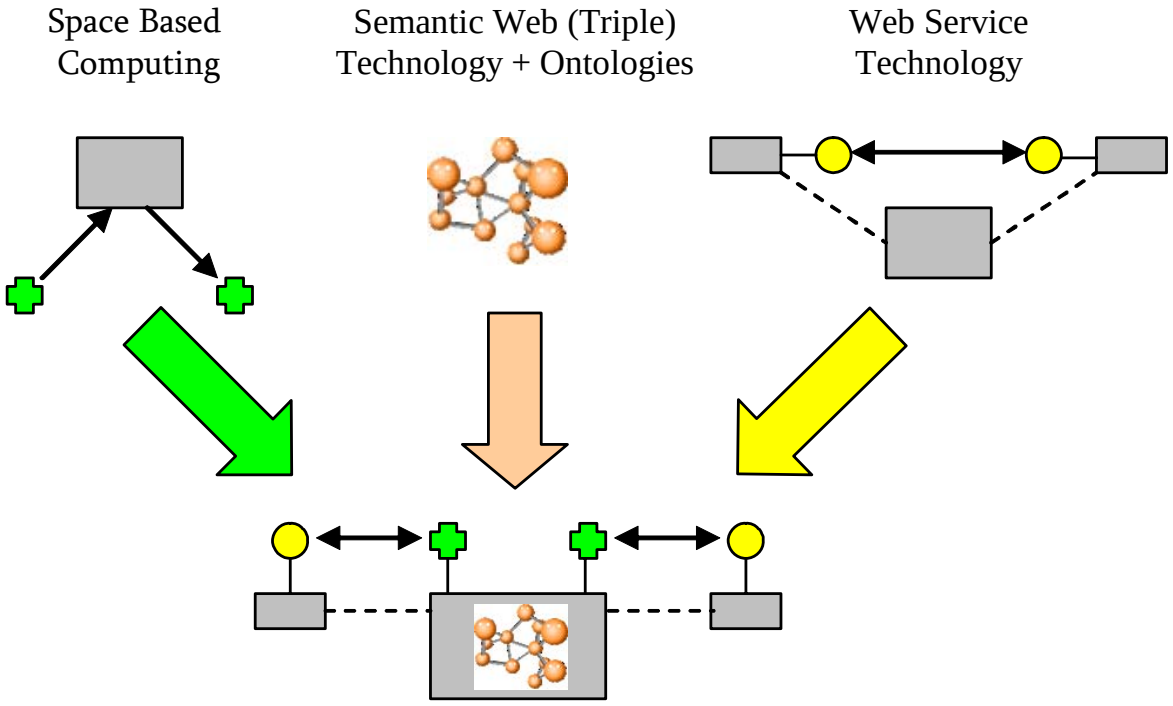
- 2003/2004:
  - Discussion between Frank Leymann and eva Kühn about **Web Services + Space Based Computing**
  - Prototype implementation of extending BPEL4J for mobile workers using Corso
- 2004:
  - Discussion between Dieter Fensel and Tim Berners Lee about **Web Services + Semantic Web**
  - Discussion between Dieter Fensel and eva Kühn about challenges to combine **Semantic Web + Space Based Computing**
  - Technical report about “Triple Based Computing” by Dieter Fensel
- 2005 - 2007:
  - Research Project: Triple Space Computing (TSC), AT
- 2006 - 2009:
  - Research Project: Triple Space Communication (TripCom), EU
  - Start: April 2006

The TripCom Project Partners

- Leopold Franzens Universität, Innsbruck, Austria
- National University of Ireland, Galway, Ireland
- University of Stuttgart, Germany
- Vienna University of Technology, Austria
- Free University Berlin, Germany
- Ontotext Lab, Sirma Group Corp., Sofia, Bulgaria
- Profium OY, Finland
- CEFRIEL - Società consortile a Responsabilità Limitata, Milano, Italy
- Telefónica Investigación y Desarrollo Sociedad Anónima Unipersonal, Spain

Triple Space Technology

- Triple Space Computing results from the integration of three existing and well known core technologies



Space Based Computing Initiative

- SBC has not gained enough industrial attention
  - No open definition of the SBC paradigm
  - Existing implementations with incompatible feature sets that cannot easily interface
  - Lack of integration with other standards
- Recent research has shown that
  - Promising new technologies require new approaches towards distributed systems
    - Semantic Web, Service Oriented Architecture, GRID Computing
  - The space is an invaluable technology in these fields
- **SpaceBasedComputing.org** is an independent initiative
  - Currently being launched
  - To promote the SBC paradigm
  - Considering related efforts like TripCom (space + semantics)

Triple Spaces Vision

"Triple Spaces shall embody a communication paradigm for *anonymous, asynchronous, scalable* information exchange through publication that ensures persistency and unique identification (URI) of the communicated semantic data"

- **Triple Space shall become the web for *machines* as the web based on HTML became the Web for *humans*"**

Mission Statement (1)

- **SpaceBasedComputing.org** will
  - Be involved in standardisation efforts in the SBC area
  - Facilitate and support the process of acquiring and disseminating knowledge about SBC
  - Promote and propagate the paradigm of SBC
- **SpaceBasedComputing.org** aims to
  - Canonize SBC standards and to promote a common reference architecture to leverage the potential of SBC
  - Identify common features and differences in order to make them interoperable

Mission Statement (2)

- Particular focus: extension and adaptation of significant industry standards
  - Like Web Services, Semantic Web, and Business Process Languages
  - Empowering these to exploit SBC
- The **SpaceBasedComputing.org** initiative will
  - Continuously collect and publish documents
  - Foster publications
  - Act as a central facility for all activities around SBC
  - Announce events

Goals

- Make space-based computing accepted in the industry
  - Unfold its power in commercial applications and research projects
- Act as platform for a number of sub-initiatives
  - Supporting them in publishing their results as internationally approved standards
- Promote standards and implementations in the fields of SBC
  - Improving interoperability between different implementations
- Maximize visibility of the paradigm
  - Create widespread adoption in research and industrial environments

Links

- www.spacebasedcomputing.org
- www.tripcom.org
- www.xvsm.org