Impact of Research on Middleware Technology

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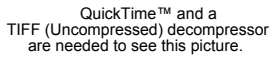
About the Impact Project

- http://www.acm.org/sigsoft/impact
- History of Science project funded by



- Aim: document impact that research has had on practice
- Areas of investigation:
  - Software configuration management
  - Programming languages
  - Middleware
  - Assertions
  - Testing
  - Software development environments
  - Design methods
  - …

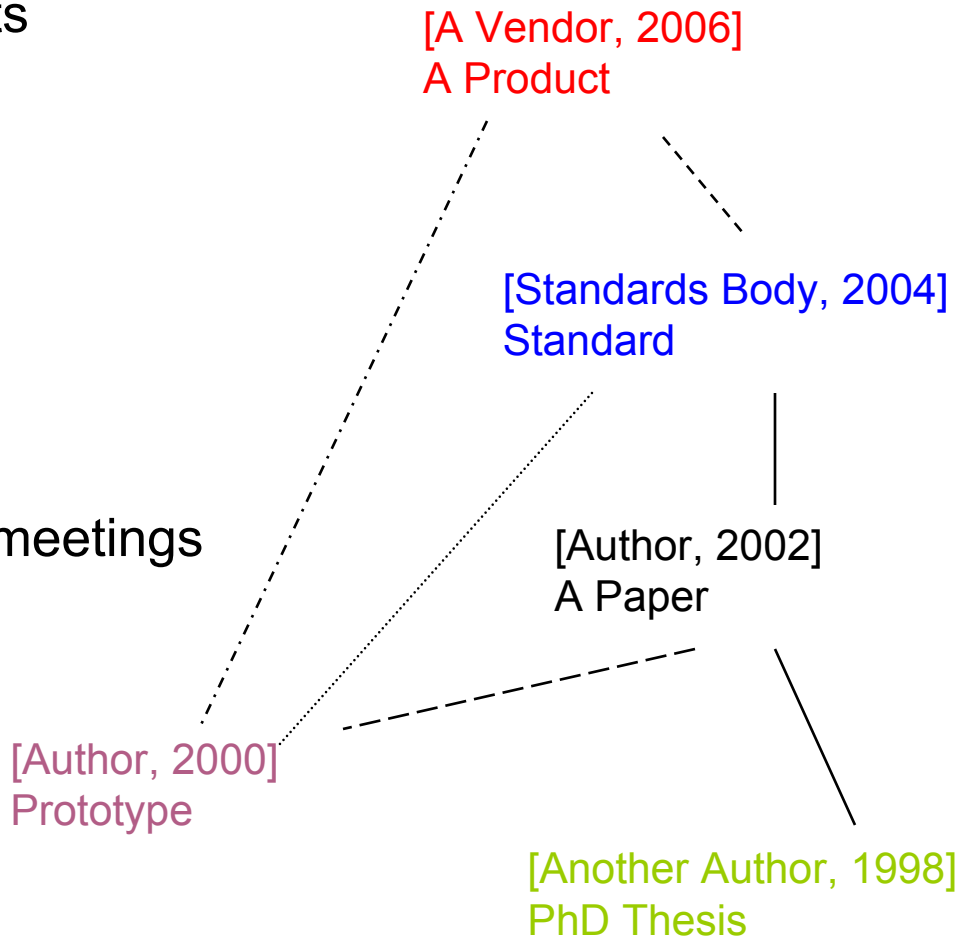
Impact Middleware Report

- Detailed investigation into the research origins of successful middleware technology
  - Web services
  - Application Servers
  - Transaction Monitors
  - Distributed Object Systems
  - Message Queues
  - Remote Procedure Call Systems
- We have documented a dozen impact traces (existence proof)
- To be published in
  - ACM SIGSOFT Software Engineering Notes in Q4 06
  - ACM SIGOPS Operating Systems Review in Q1 07
  - ACM Transactions on Software Engineering Methodology in 07

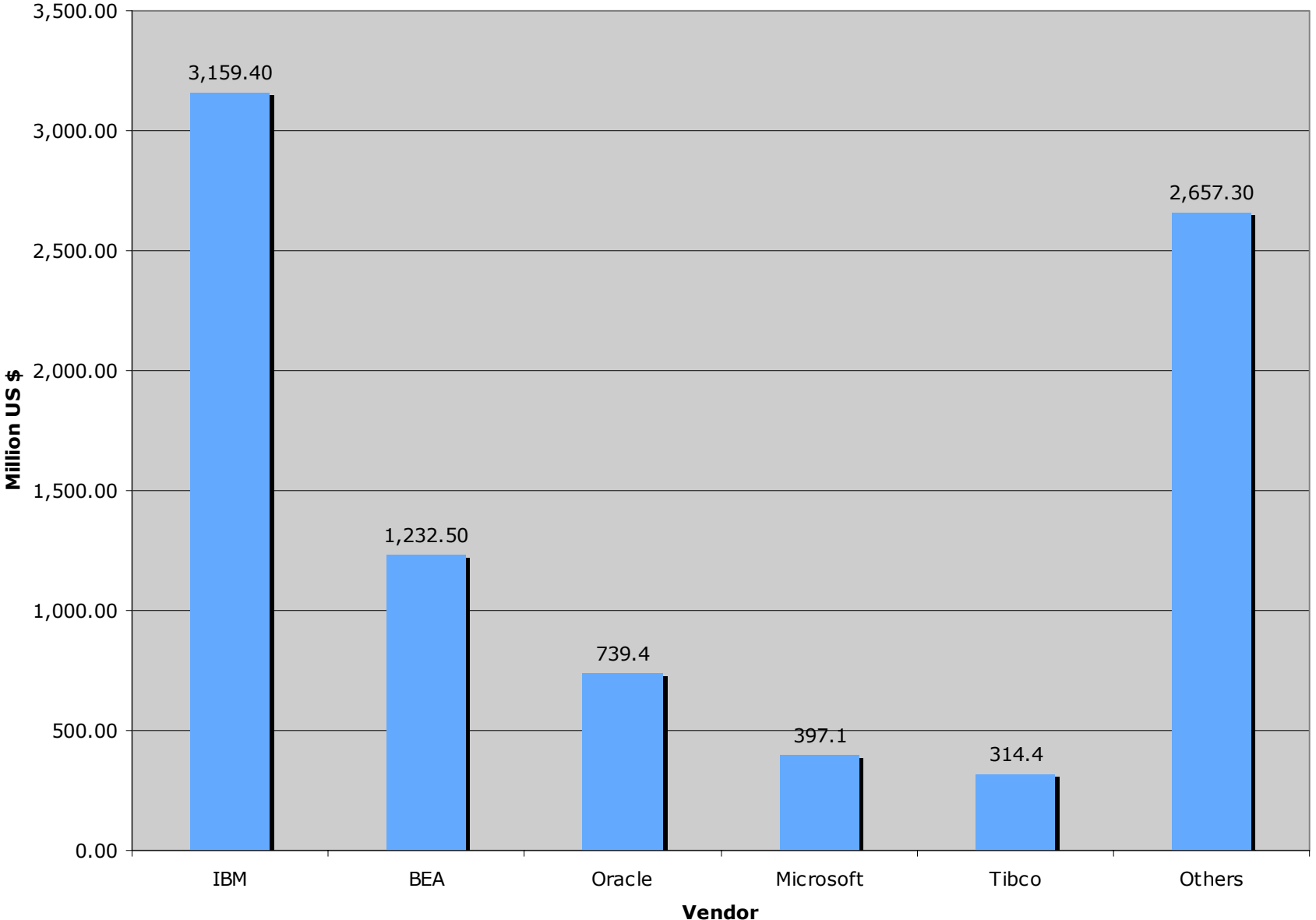
Research Method

- Evidence for impact
  - Market analysis reports
  - Articles in journals & proceedings
  - PhD Theses
  - Technical Reports
  - Software
  - Standards documents
  - Minutes of standards meetings
  - Interviews
  - People movement

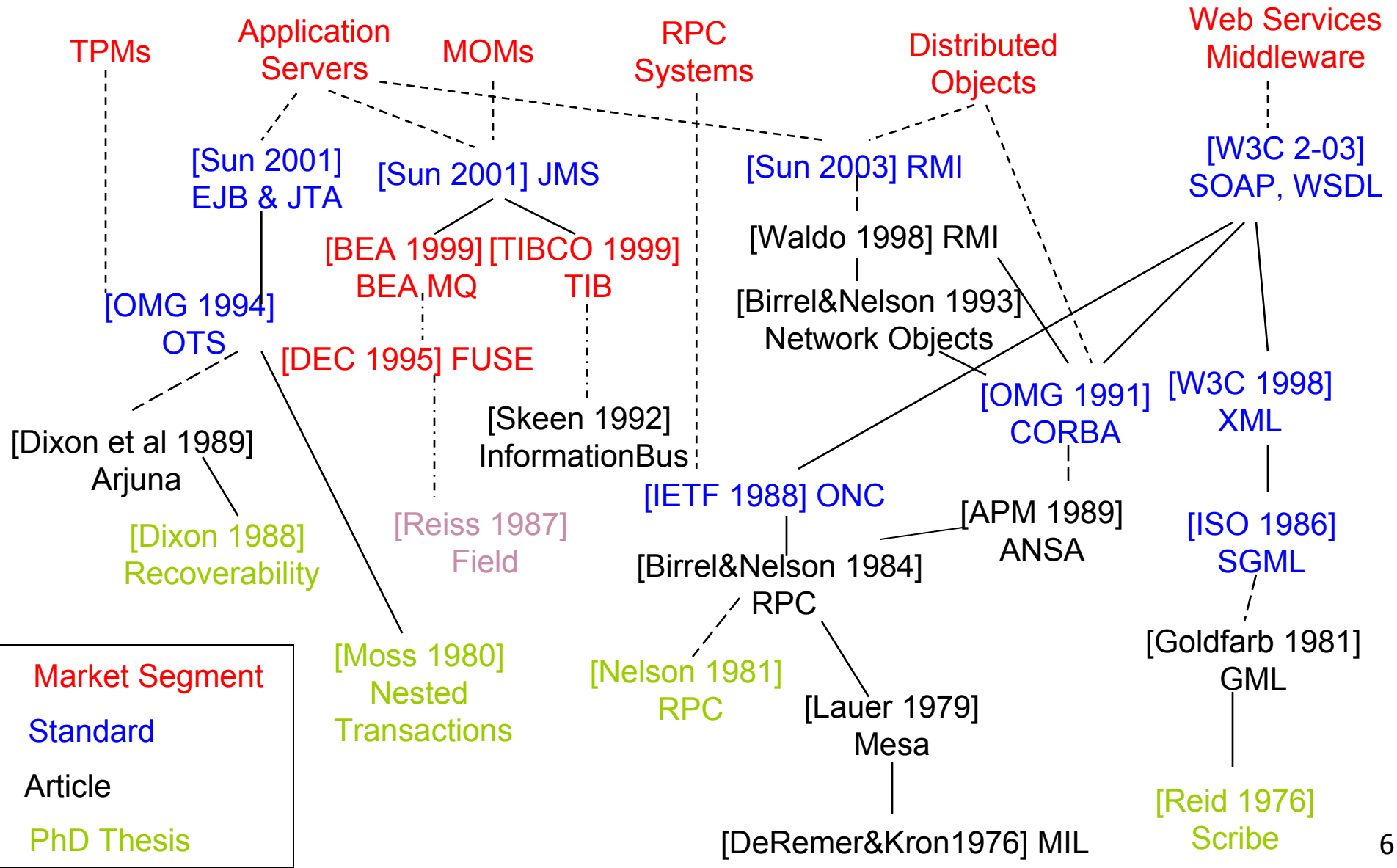
- Impact traces



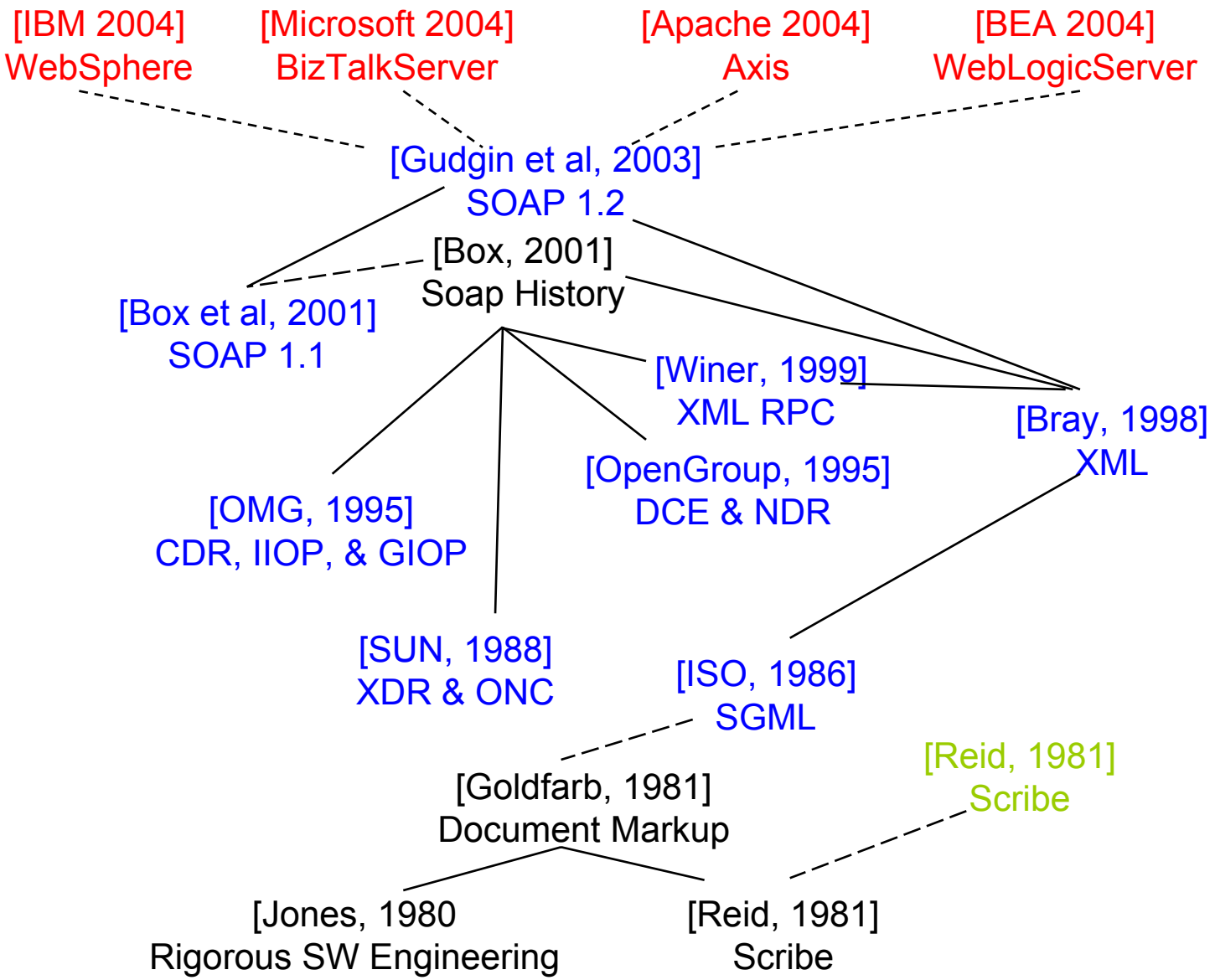
Middleware License Market in 2005 [Gartner 06]



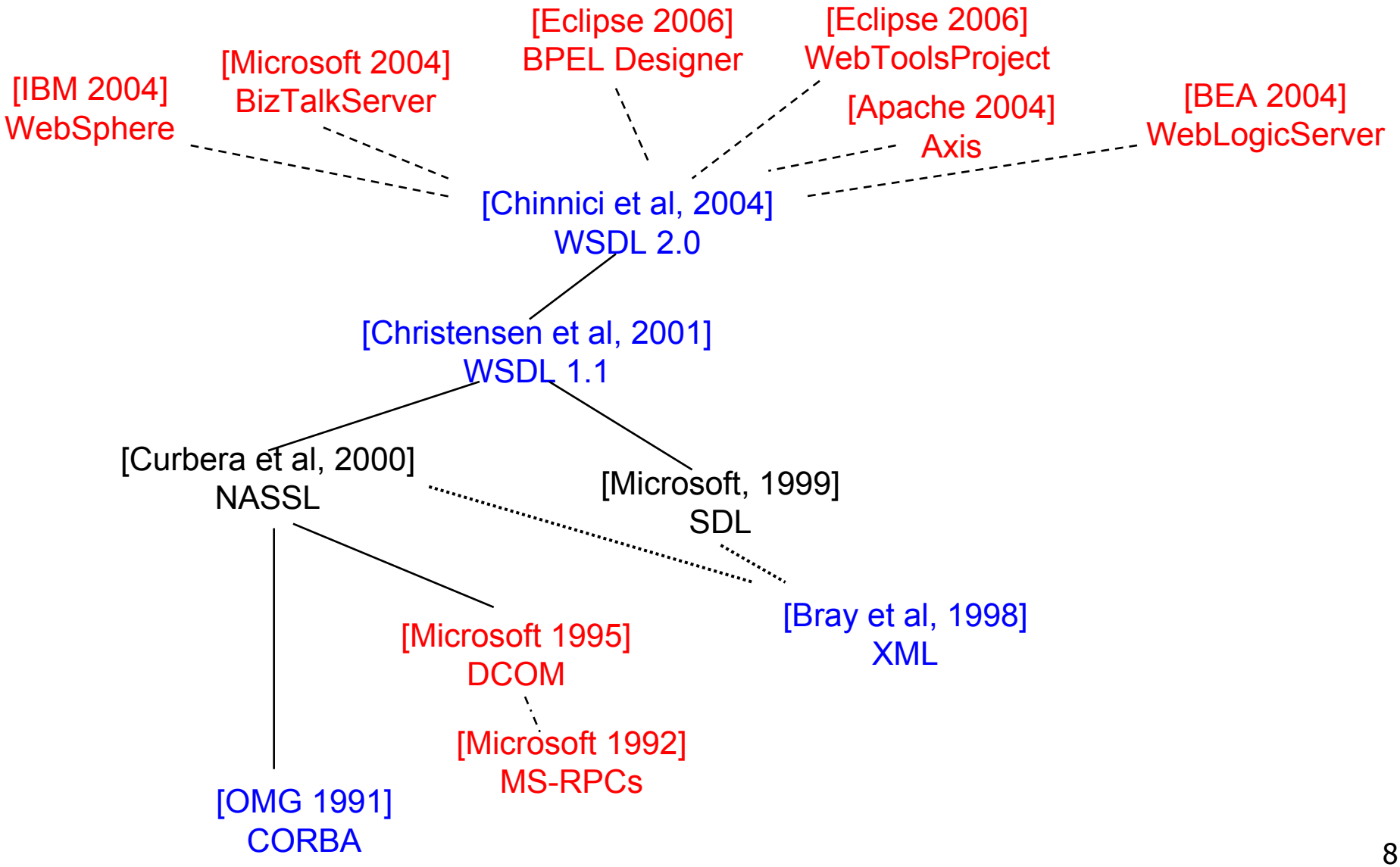
Impact on Middleware: Overview



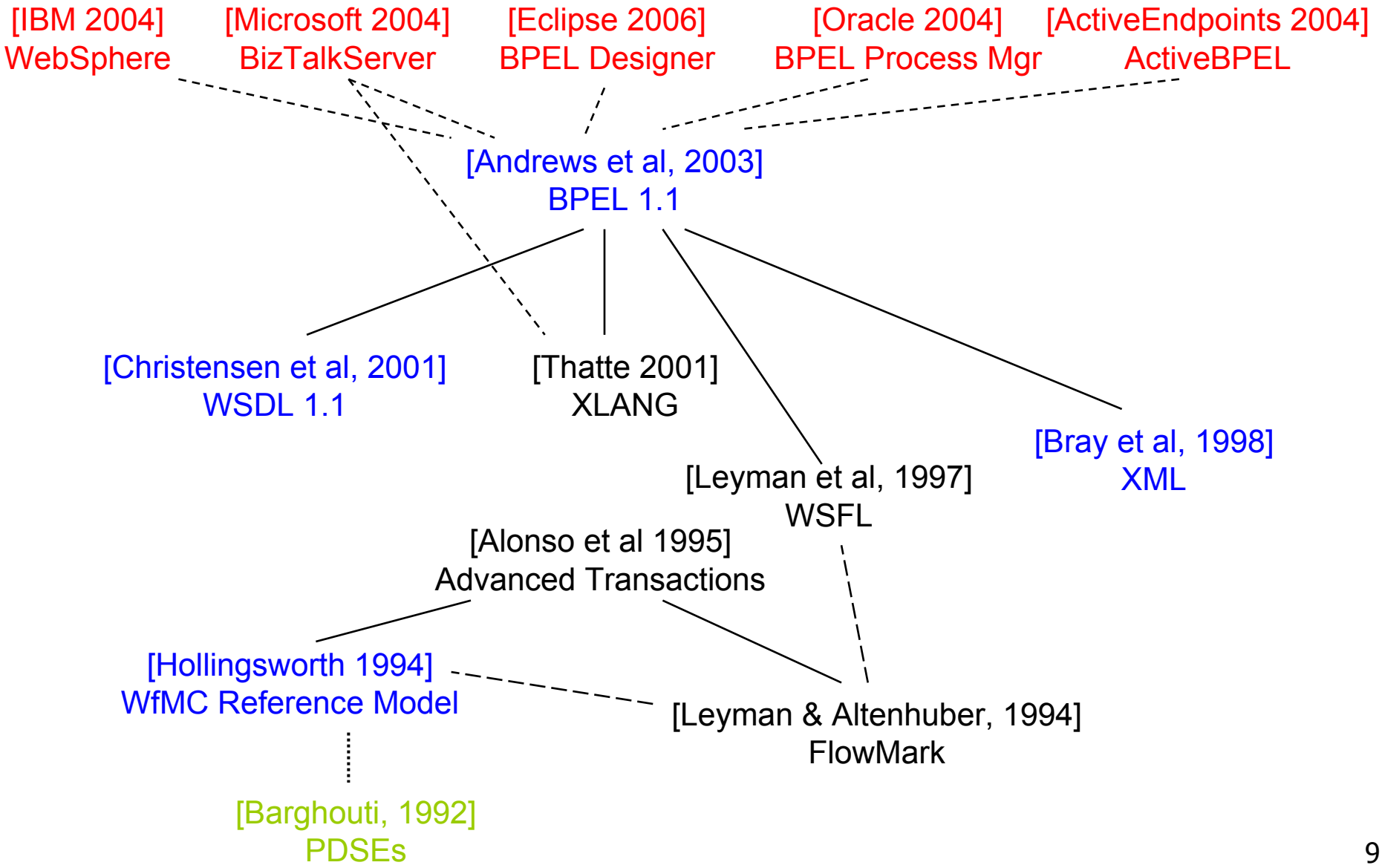
Trace: Simple Object Access Protocol



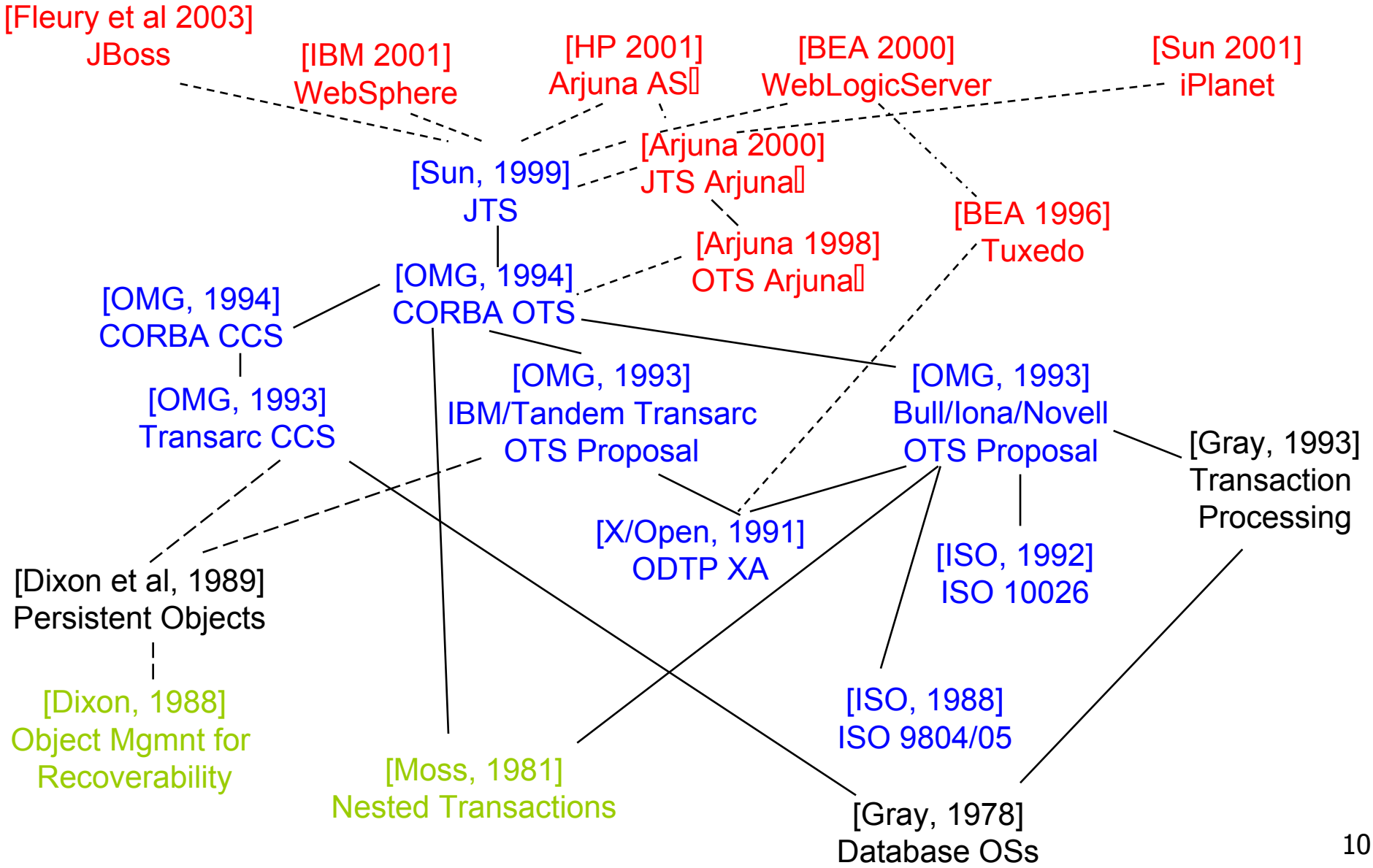
Trace: Web Services Description Language



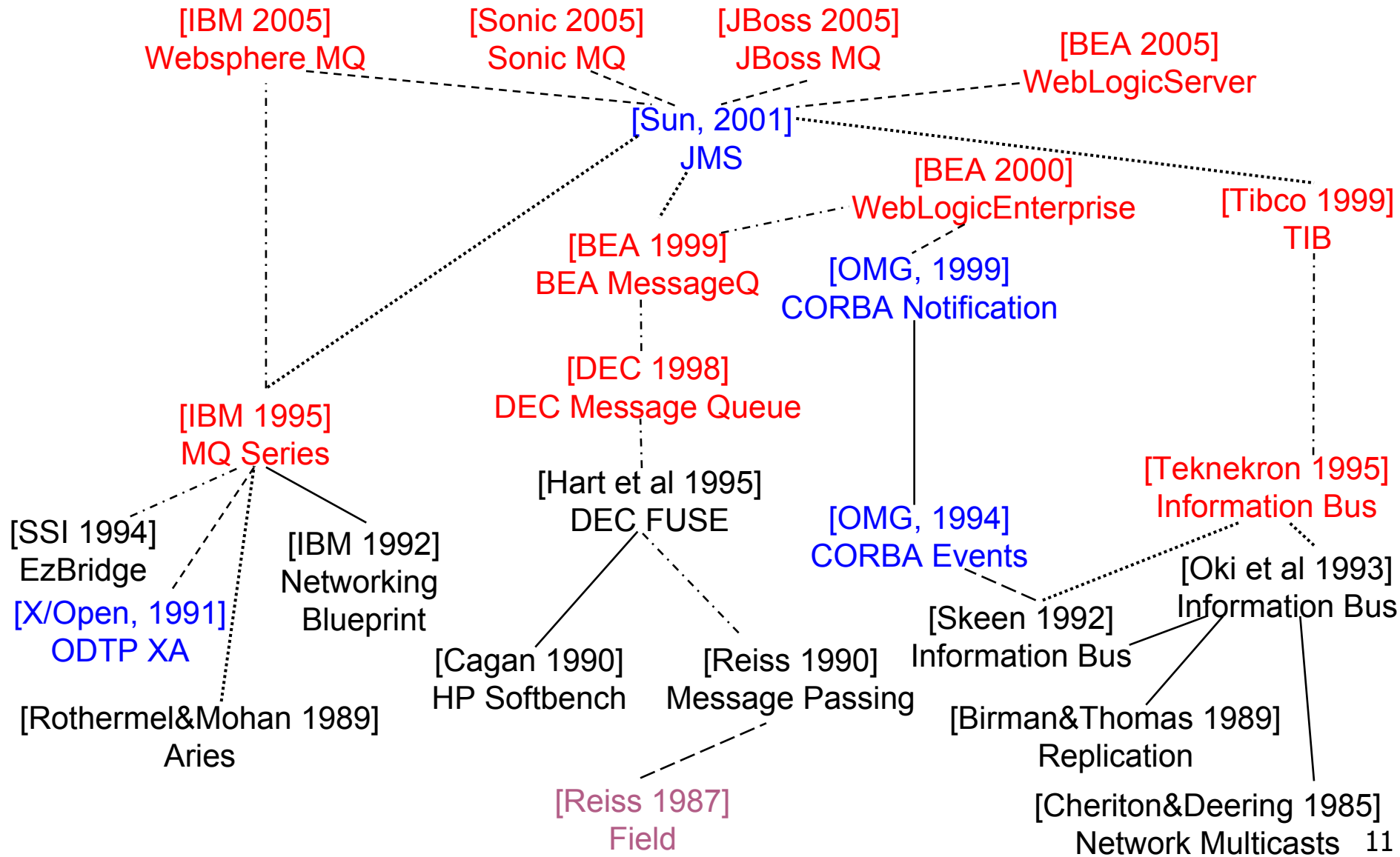
Trace: Business Process Execution Language



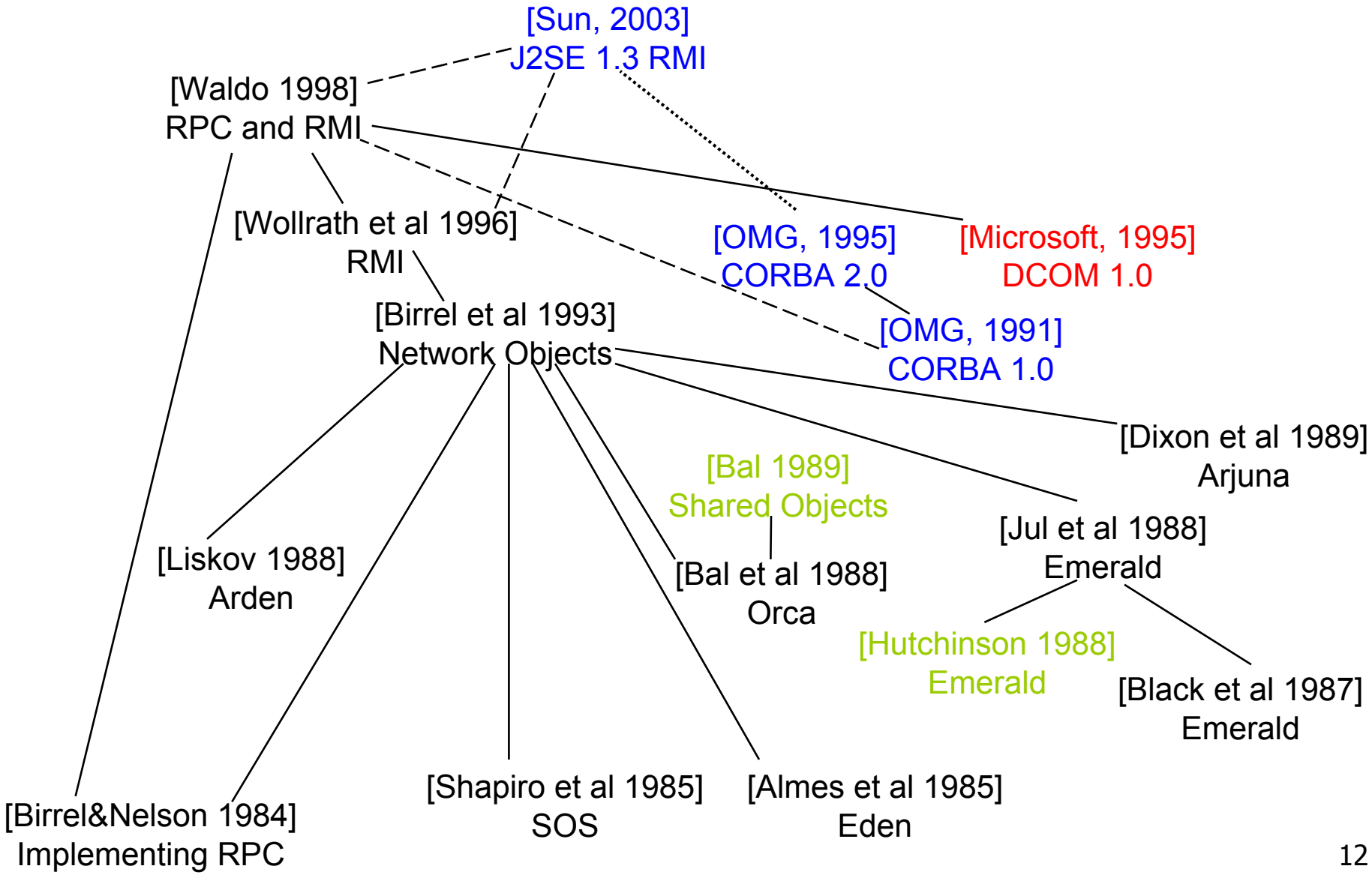
Trace: Transactions in Application Servers



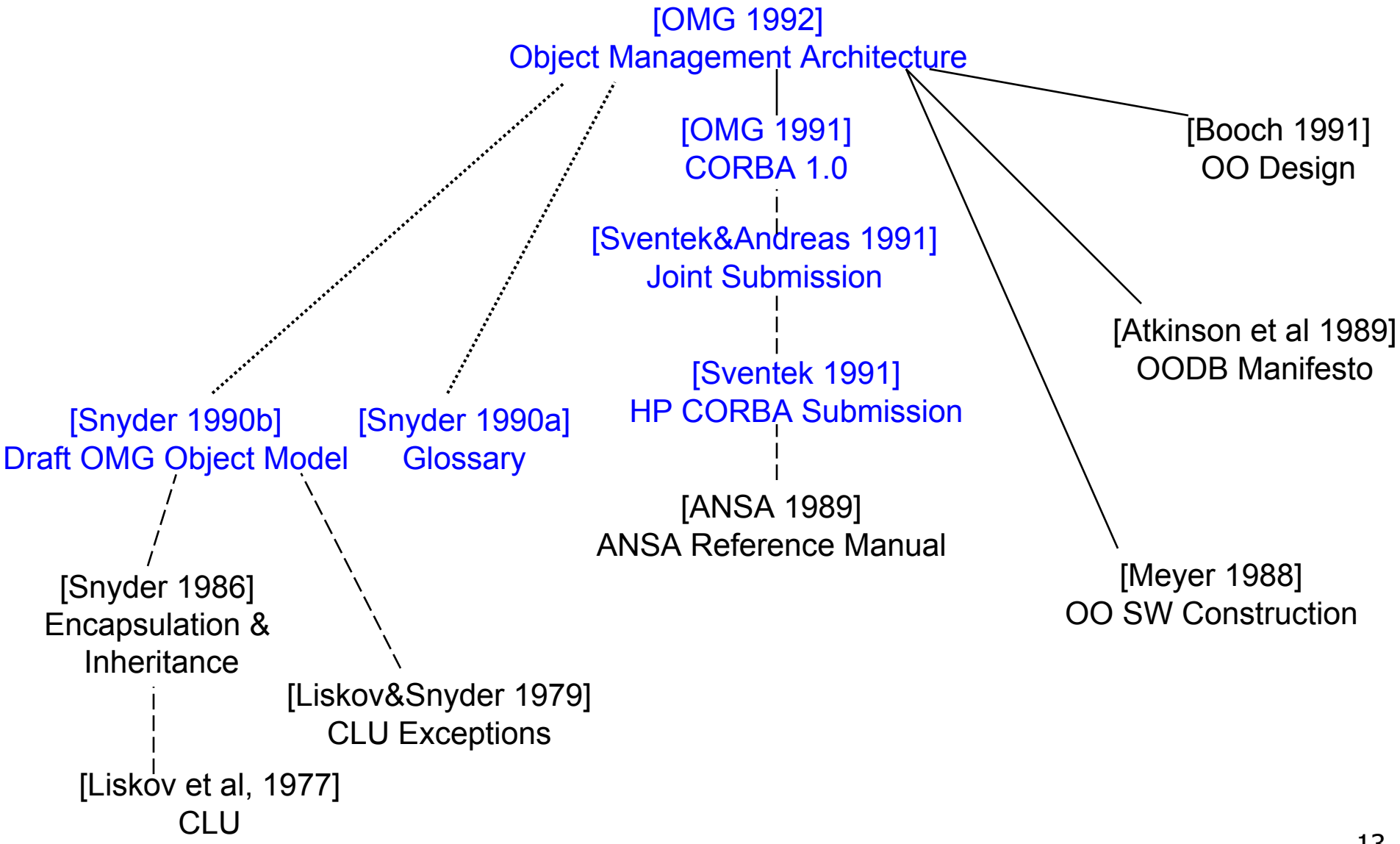
Trace: Messaging in Application Servers



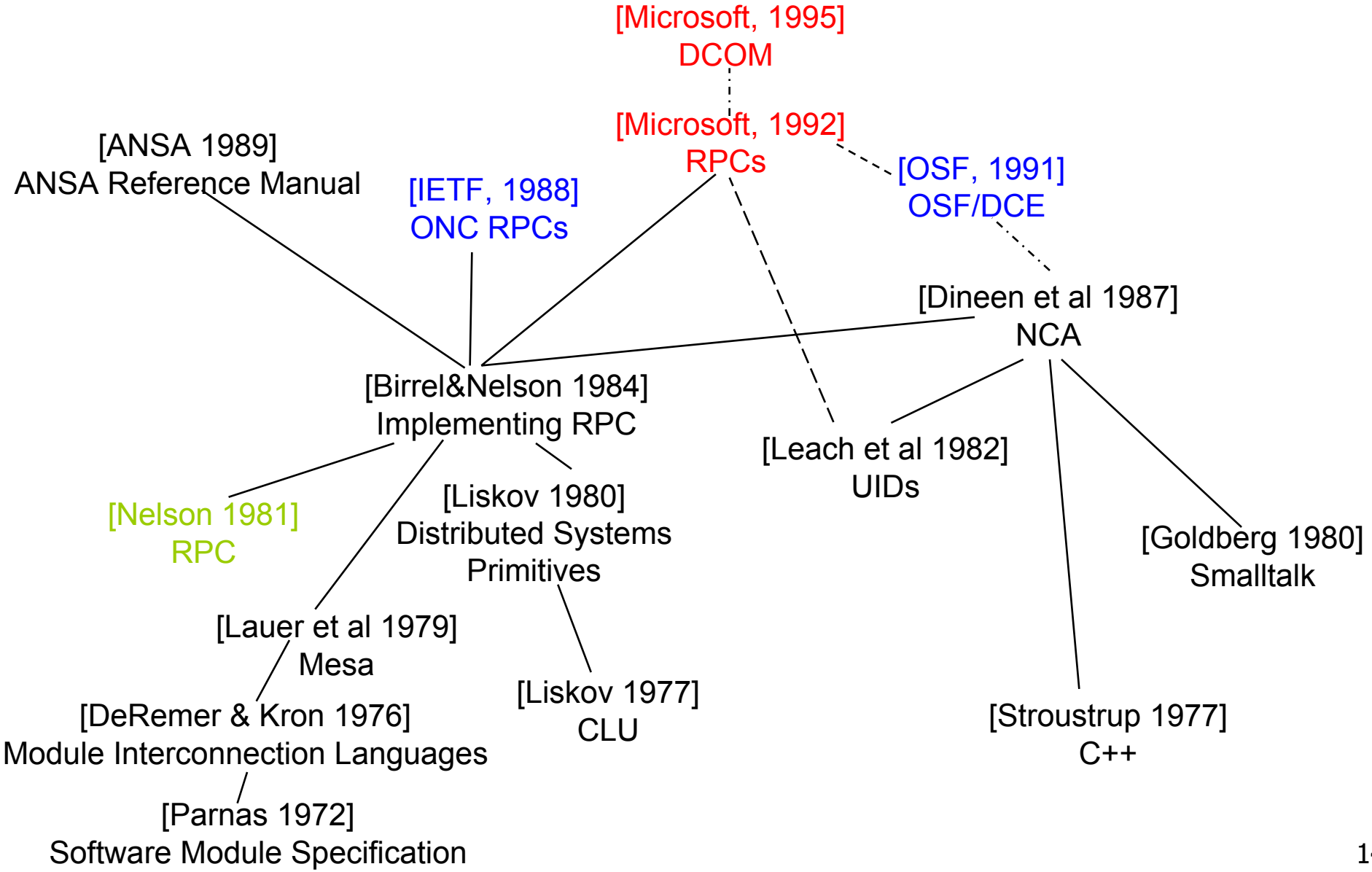
Trace: Distributed Objects in Application Servers



Trace: Distributed Objects in CORBA



Trace: Remote Procedure Calls



Key findings

- Technology Transfer takes time: 15-20 years between first publication of an idea and widespread availability in products
- Inter-disciplinarity: Industry does not care about the ACM CS classification
- On the importance of PhD students: Almost all impact traces lead back to somebody's PhD
- Technology transfer: Most successful form is people movement
- Standardization: Without wide-spread agreements on ideas there is no wide-spread adoption

Tech transfer needs time

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

- RPCs: Key ideas of Module Interconnection Languages in mid 70s, basic research on RPC systems in early 80s, release of RPC into Sun and Apollo OS in late 80s, standardization by IETF and OSF in early 90s.
- Distributed Transactions: Early research into non-standard transactions in early-mid 80s, standardization in mid 90s at OSF and OMG, wide spread use in application servers in late 90s.
- Distributed Objects (RMI): Basic research in mid 80s (Argus, Eden, Emerald), Consolidation in “network objects” in mid 90s, standardization through JCP in late 90s, widespread use in Java and .NET remoting at turn of millenium

Interdisciplinarity

- Impact traces frequently cross boundaries between different CS disciplines.
- For middleware study:
  - Software Engineering
  - Networking
  - Programming Languages
  - Distributed Systems
  - Databases
- Impact sometimes larger in area other than that of first publication (e.g. MQs)

- Example 1: RPC IDLs
  - Information Hiding [CACM 15(5), 1972]
  - MIL [IEEE TSE SE-2(2), 1976],
  - Mesa [ICSE-4, 1977]
  - Cedar RPCs [ACM ToCS (2(1), 1984]
  - Sun RPC [IETF RFC 1057, 1987]
- Example 2: Transactions
  - OS - Gray 1976
  - Nested Transactions, Moss 1981
  - Concurrency Ctrl Bernstein et al 1987
  - Arjuna Dixon, 1989
  - OSF ODTP/XA, 1991
  - CORBA CCS, OTS 1994
  - J2EE JTS, JTA, 2001

Traces often lead back to PhDs

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- RPCs:
  - Failure semantics & architecture: Nelson, (CMU 1981)
  - Orphan detection: Panzieri (Newcastle University 1985)
- Distributed Transactions:
  - Nested transactions: Moss (MIT 1981)
  - Object transactions: Dixon (Newcastle University, 1987)
- Object Models for distributed computing:
  - CORBA object model: Snyder (MIT, 1978)
  - RMI object model: Bal (Vrije, 1989) & Hutchinson (Washington 1987)
- Web services:
  - Scribe: Reid (CMU, 1981)

People movement: The real enabler of technology transfer

- A. Herbert from U Cambridge to APM where he devised ANSA
- B. Nelson from CMU to Xerox PARC where he wrote the definitive paper on RPCs with A. Birrel
- B. Nelson and A. Birrel to DEC Research where they wrote the Network Object paper providing the basis for Java RMI.
- A. Watson from APM to OMG where he controlled CORBA standardization
- J. Waldo from UMass to HP and J. Sventek from APM to HP where they wrote CORBA 1.0 spec
- J. Waldo from HP to Sun where he wrote RMI specification
- G. Dixon from NCL to Transarc where he wrote OMG CORBA OTS and CCS service specs

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Conclusions

- Be patient about exploitation of results!
- Support PhD students!
- Fund mobility not just between member states but between academia and industry!
- Facilitate out of area dissemination!
- Find ways to incentivize software engineering academics to take part in standardization!