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IPDPS 2011
ANCHORAGE

25th IEEE International Parallel &
Distributed Processing Symposium
May 16-20, 2011
Sheraton Anchorage Hotel & Spa
Anchorage (Alaska) USA

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e-Science Infrastructure Integration Invariants to Enable HTC and HPC Interoperability Applications

2011-05-16 Morris Riedel et al.
Jülich Supercomputing Centre, Juelich, Germany

Achim Streit, Karlsruhe Institute of Technology, Karlsruhe, Germany

Dieter Kranzlmüller, Ludwig Maximilians University Munich, Munich, Germany

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Outline

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- Related Work & Reference Model Factors
- Related Work & Transformation Logic & Standards
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  - Academic & Practical Field Studies
  - Invariants in e-Science Application Context
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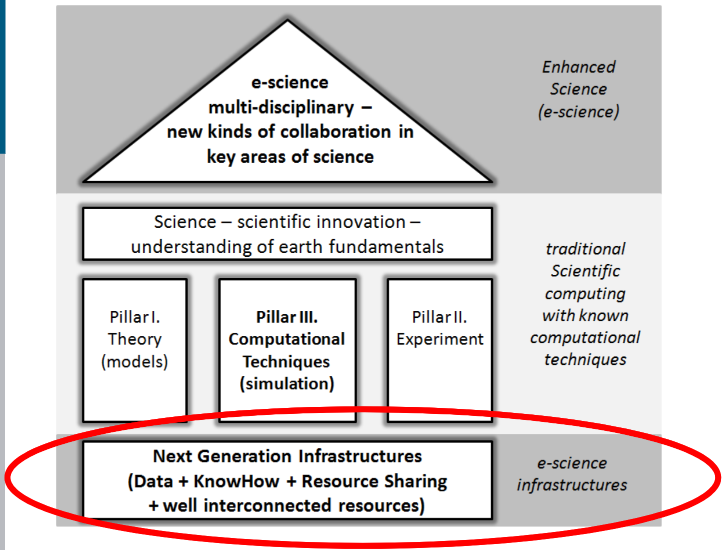
e-Science Infrastructures



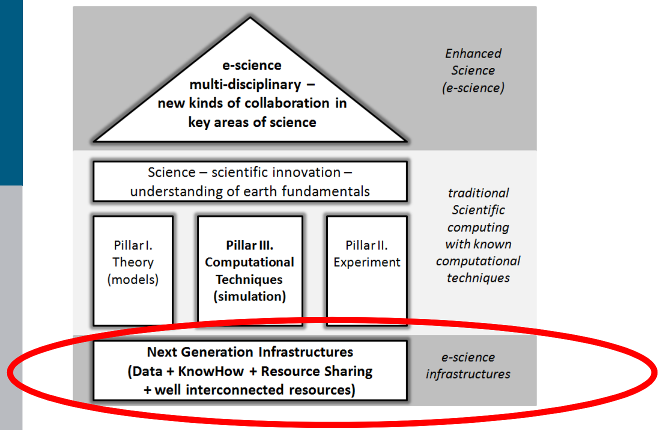
[1] Riedel et al., Research Advances by using Interoperable e-Science Infrastructures, 2009

Name	Country/Continent/Region
APAC	Australia
D-Grid	Germany
DEISA	Europe
EGEE	Europe
NAREGI	Japan
NDGF	Nordic Region
NGS	United Kingdom
OSG	USA
PRAGMA	Pacific Region
TeraGrid	USA

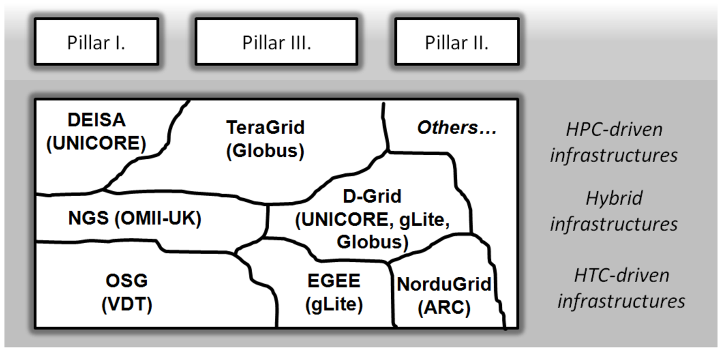
[8] Riedel and E. Laure et al., Interoperation of World-Wide Production e-Science Infrastructures, 2009

-	gLite	Globus Toolkit	UNICORE	ARC	NAREGI	NGS
Security	X.509 VOMS SAML XACML	X.509 VOMS SAML XACML	X.509 VOMS SAML XACML	X.509 VOMS SAML XACML	X.509 VOMS SAML XACML	X.509 VOMS
Information Systems	GLUE XML	GLUE XML	GLUE2 XML	GLUE2 XML	CIM SQL	GLUE XML
Accounting	RUS/UR		RUS/UR	RUS/UR	RUS/UR	RUS/UR
Job Management	BES JSDL DRMAA	BES JSDL DRMAA	BES JSDL DRMAA	BES JSDL DRMAA	JSDL	BES JSDL
Data Managment	GridFTP SRM2.2	GridFTP DAIS	ByteIO	GridFTP SRM2.2	GridFTP GFS	GridFTP DAIS

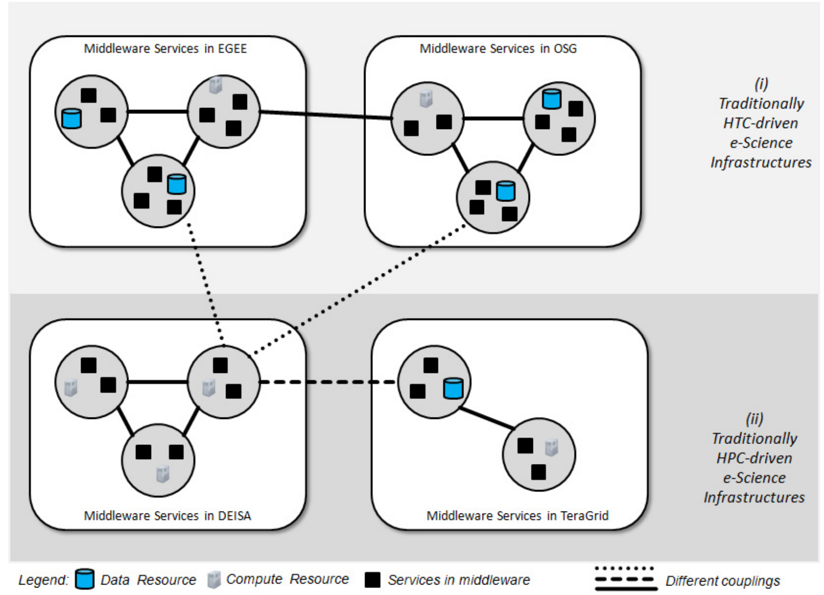
Problem Space & Motivation

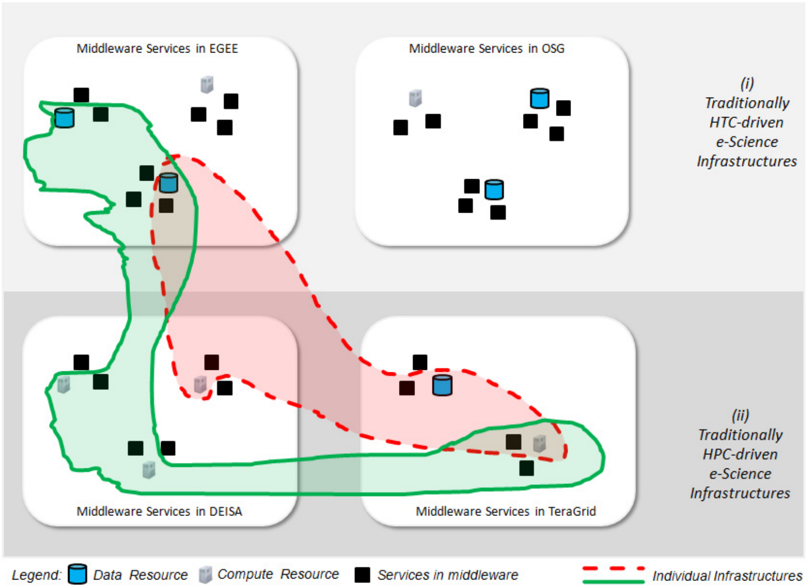


[1] Riedel et al., Research Advances by using Interoperable e-Science Infrastructures, 2009

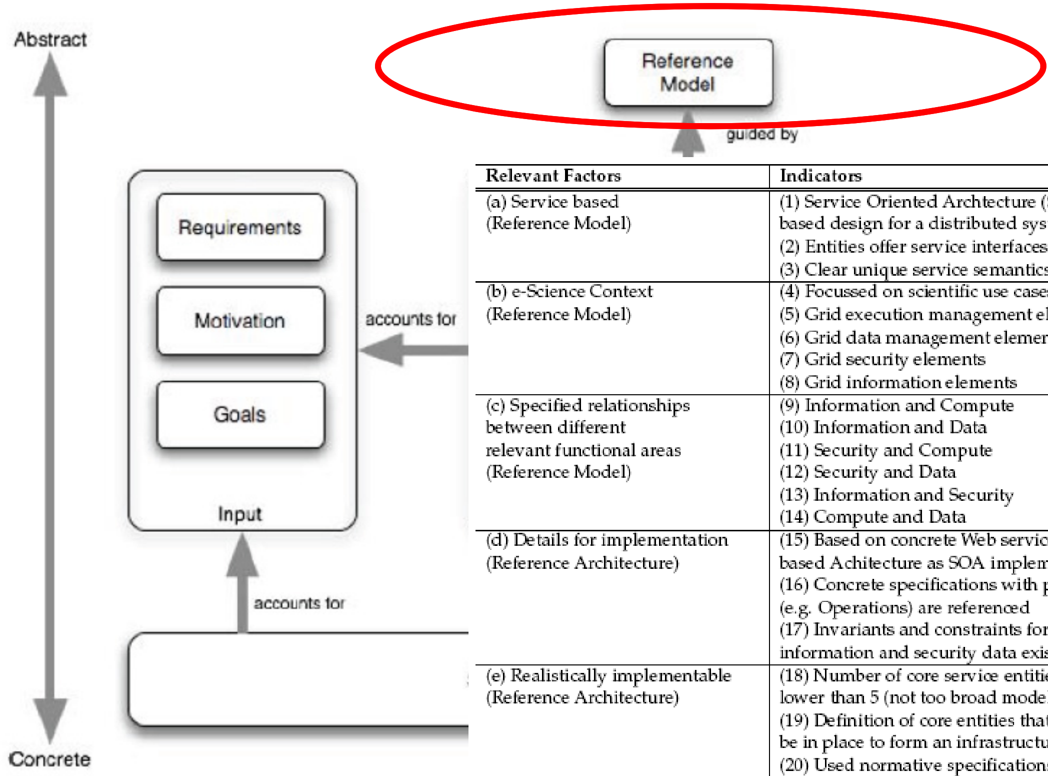


[2] Riedel et al., Towards Individually Formed Computing Infrastructures, 2010





Related Work Approaches and the role of OGSA



Relevant Factors	Indicators	OGSA
(a) Service based (Reference Model)	(1) Service Oriented Archtecture (SOA)-based design for a distributed system	Yes
	(2) Entities offer service interfaces	Yes
	(3) Clear unique service semantics	Yes
(b) e-Science Context (Reference Model)	(4) Focussed on scientific use cases	No
	(5) Grid execution management elements	Yes
	(6) Grid data management elements	Yes
	(7) Grid security elements	Yes
	(8) Grid information elements	Yes
(c) Specified relationships between different relevant functional areas (Reference Model)	(9) Information and Compute	No
	(10) Information and Data	No
	(11) Security and Compute	No
	(12) Security and Data	No
	(13) Information and Security	No
	(14) Compute and Data	No
(d) Details for implementation (Reference Architecture)	(15) Based on concrete Web services (WS)-based Achitecture as SOA implementation	Yes
	(16) Concrete specifications with portTypes (e.g. Operations) are referenced	No
	(17) Invariants and constraints for the use of information and security data exists	No
(e) Realistically implementable (Reference Architecture)	(18) Number of core service entities is lower than 5 (not too broad model)	No
	(19) Definition of core entities that must be in place to form an infrastructure	No
	(20) Used normative specifications are already defined and publicly available	No
	(21) Project that implements core entities and relationships (funding exists)	No
(f) Standards based (Reference Architecture)	(22) Based on normative standard specifications	No
	(23) Specifications from real SDO	No
	(24) No break of existing established standard specifications	No
(g) Adoption in e-Science production technologies (Derived Concrete Architectures)	(25) EGEE / EGI technologies	No
	(26) DEISA / PRACE technologies	No
	(27) Production middleware systems (e.g. ARC, gLite, Globus, UNICORE)	No

[11] OASIS Reference Model for SOAs, 200

[10] Riedel et al., Requirements of an e-Science Infrastructure Interoperability Reference Model, 2011

Lessons learned from ISO/OSI and TCP/IP

ISO / OSI Reference Model…→ huge and rather theoretical impact only

TCP/IP Reference Model…→ Worldwide Internet Success and Impact

• ***‘…the much more succesful history of the TCP/IP model was quite reverse to the ISO OSI model. The protocols came first, and the model was really just a description of the existing Protocols’***

• ***‘… good software engineering practice requires differentiating between the specification and its implementation, something that OSI does very carefully, and TCP/IP does not’***

• ***’… TCP/IP model is not at all general and is poorly suited to desribing any protocol stack other than TCP/IP***

• ***’… first implementations of TCP/IP was part of Berkeley UNIX and was quite good (not to mention, free). People began using it quickly, which led to a large user community, which led to improvements, which led to an even larger community.’***

[12] A. S. Tanenbaum. Computer Networks, 2002

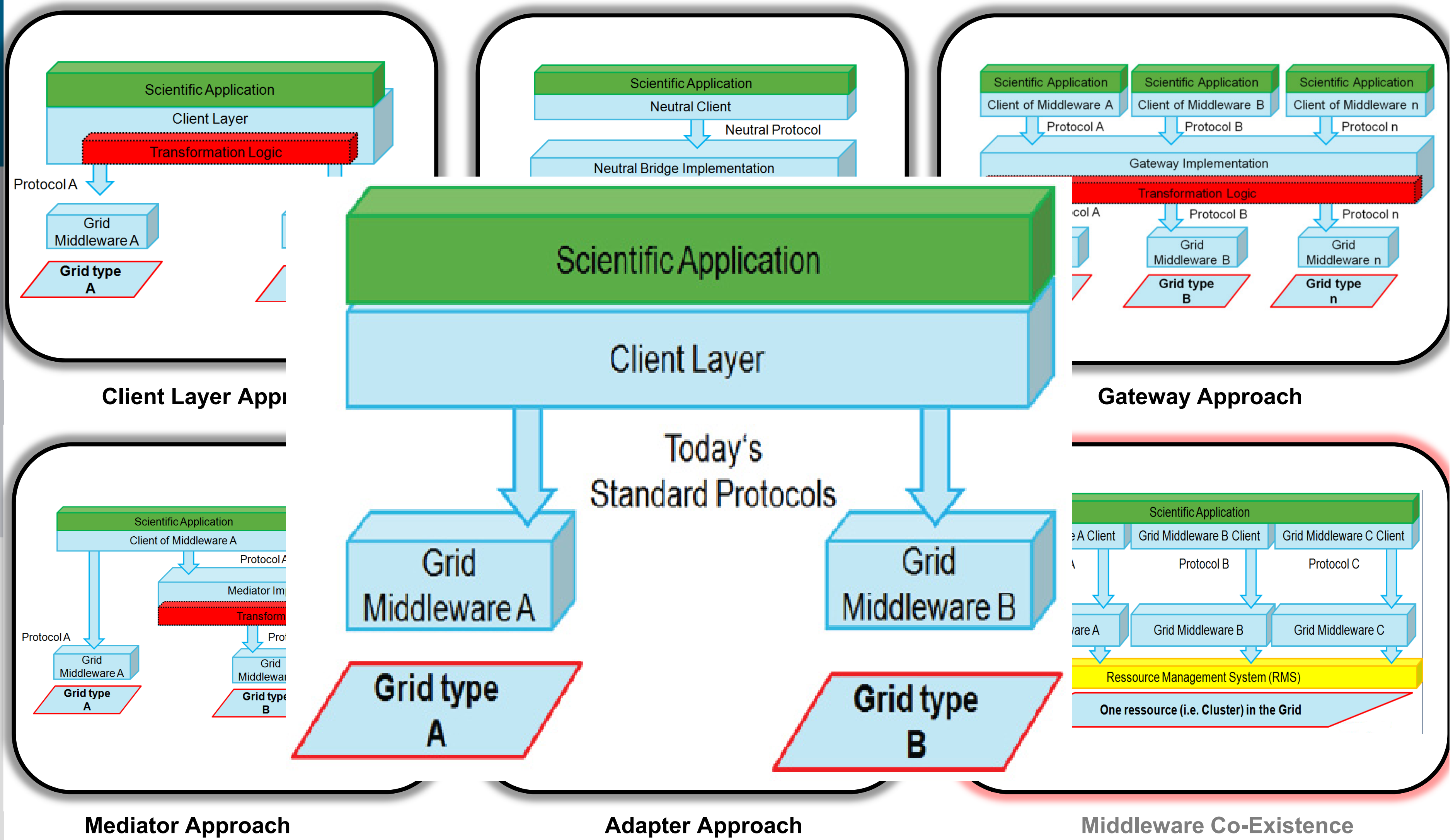
Major Conclusions:
• ***Analogy ISO/OSI model and OGSA***
•***Major design decision for our reference model should be like TCP/IP***

Related Work & Reference Model Factors

Relevant Factors	OGSA	EGA	CSA	RM-ODP	CCA	CPN
(a) Service based (Reference Model)	yes	yes	yes	no	yes	no
(b) e-Science Context (Reference Model)	yes	no	no	no	no	yes
(c) Specified relationships between different relevant functional areas (Reference Model)	no	no	no	no	no	no
(d) Details for implementation (Reference Architecture)	no	no	yes	no	no	no
(e) Realistically implementable (Reference Architecture)	no	no	no	no	yes	no
(f) Standards based (Reference Architecture)	no	no	yes	yes	no	no
(g) Adoption in e-Science production technologies (Derived Concrete Architectures)	no	no	no	no	no	no

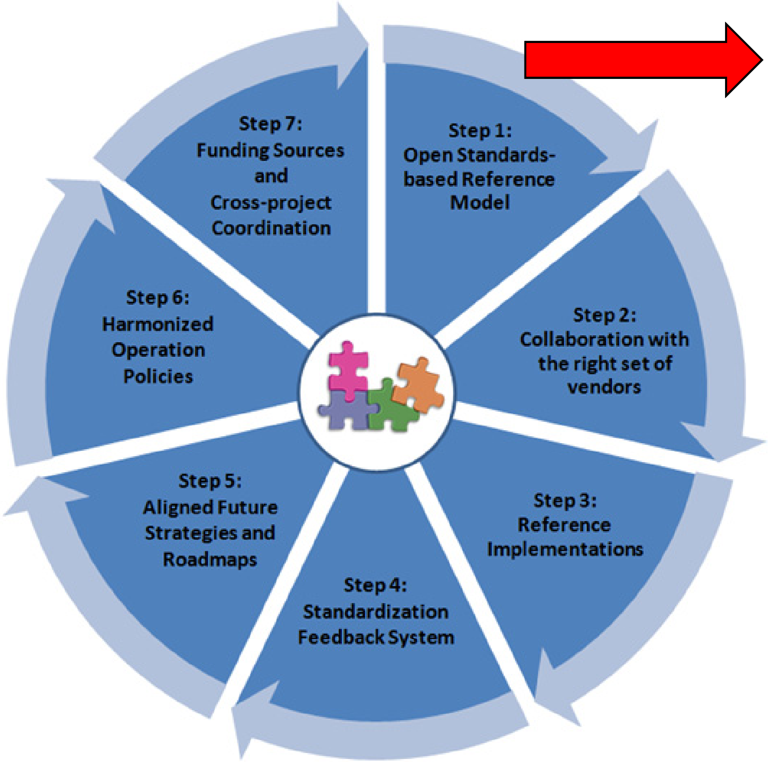
[3] Riedel, e-Science Infrastructure Interoperability Guide – The seven steps towards interoperability in e-science, 2010

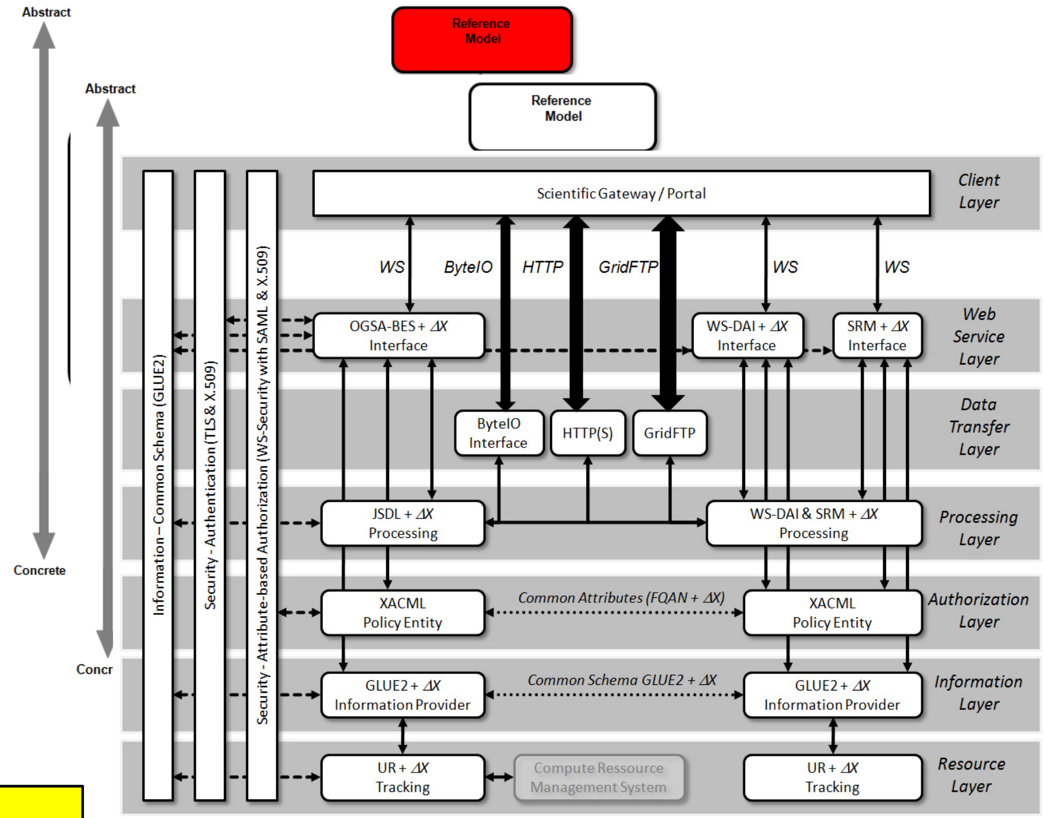
Related Work & Tranformation Logic & Standards



[1] Riedel et al., Research Advances by using Interoperable e-Science Infrastructures, 2009

Seven steps Process and Associated Reference Model



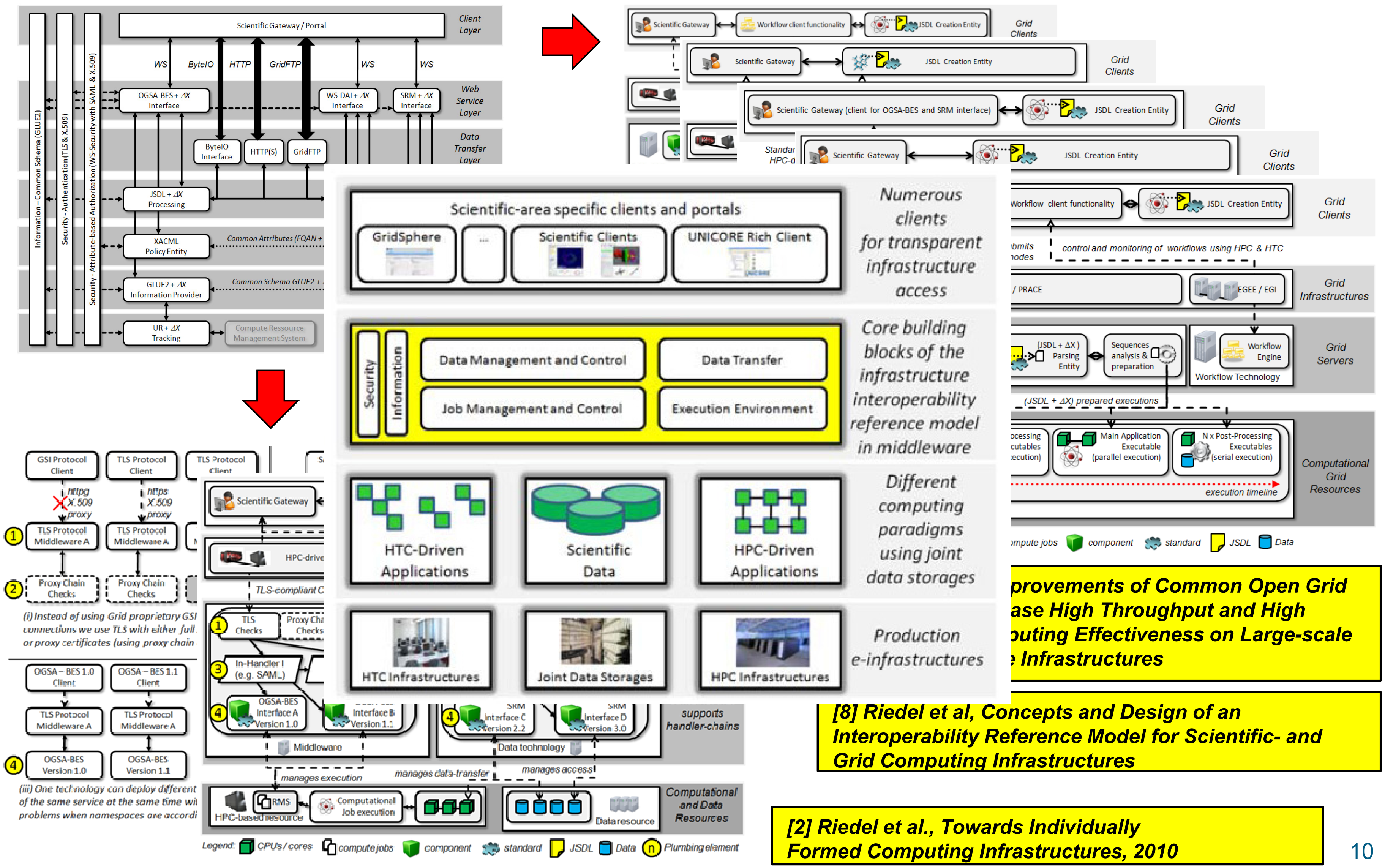


[3] Riedel, e-Science Infrastructure Interoperability Guide – The seven steps towards interoperability in e-science, 2010

European Commission

[1] Riedel et al., Research Advances by using Interoperable e-Science Infrastructures, 2009

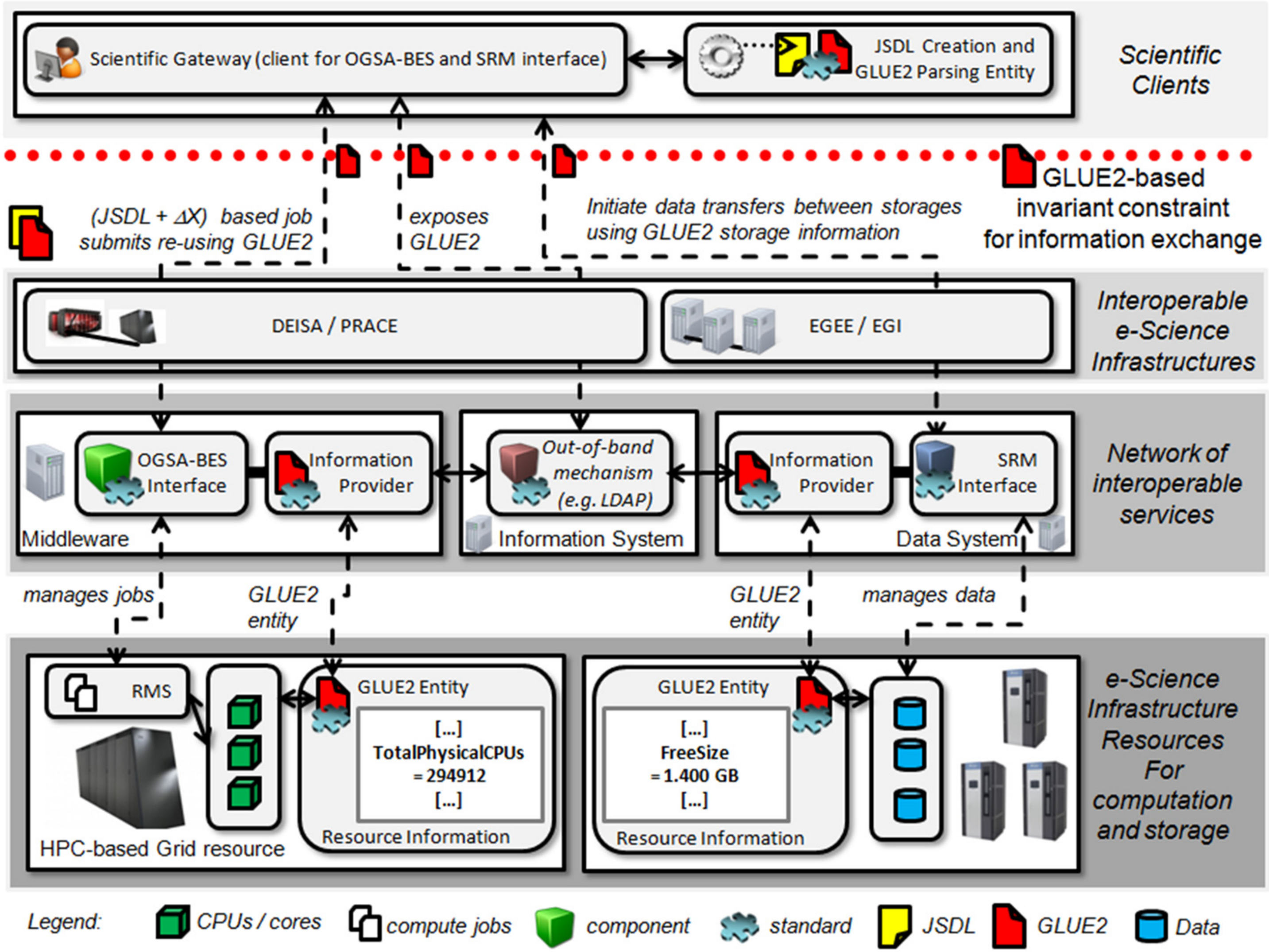
Infrastructure Interoperability Reference Model (IIRM)



[8] Riedel et al, Concepts and Design of an Interoperability Reference Model for Scientific- and Grid Computing Infrastructures

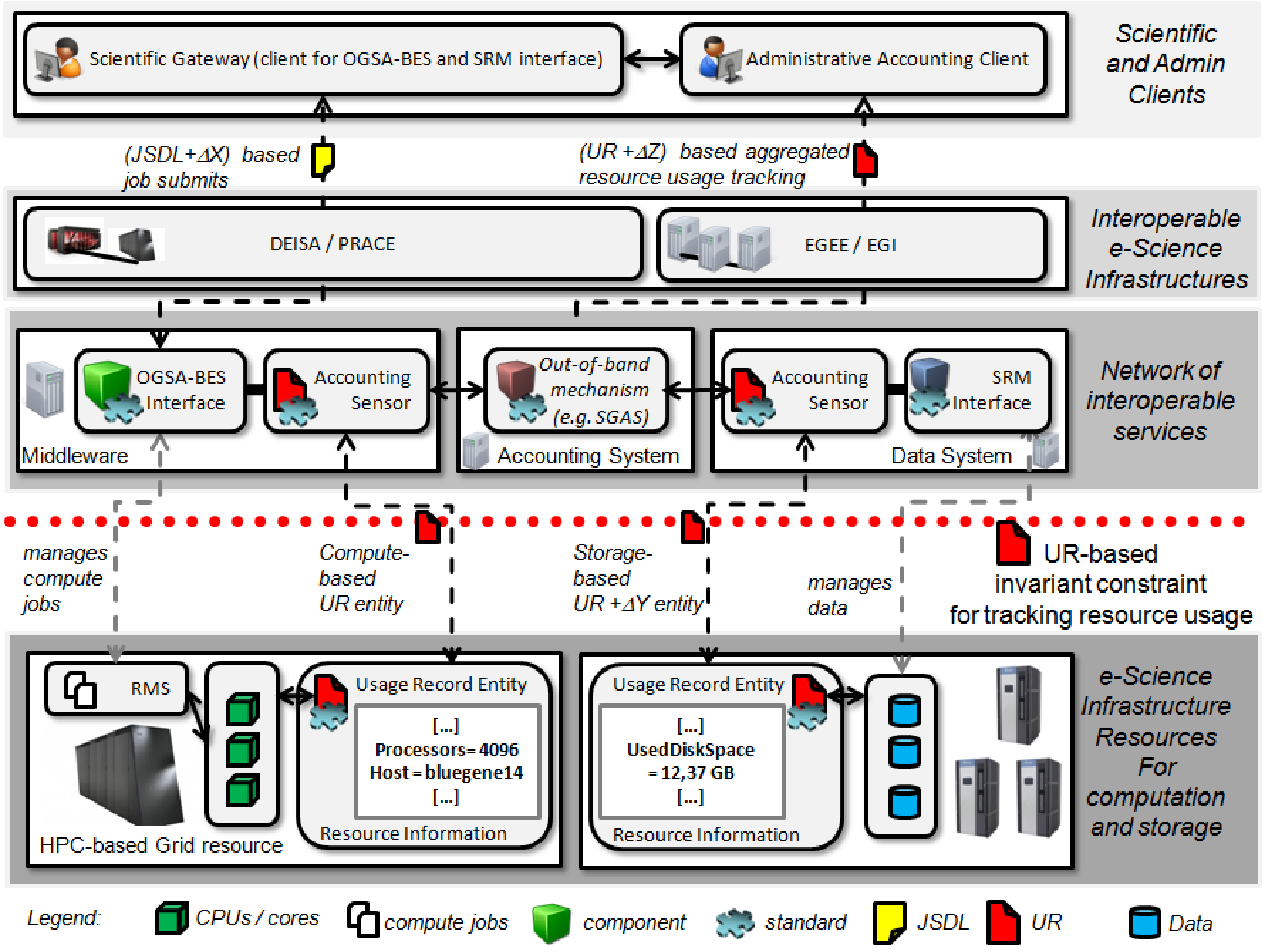
[2] Riedel et al., Towards Individually Formed Computing Infrastructures, 2010

IIRM Global Information Invariant



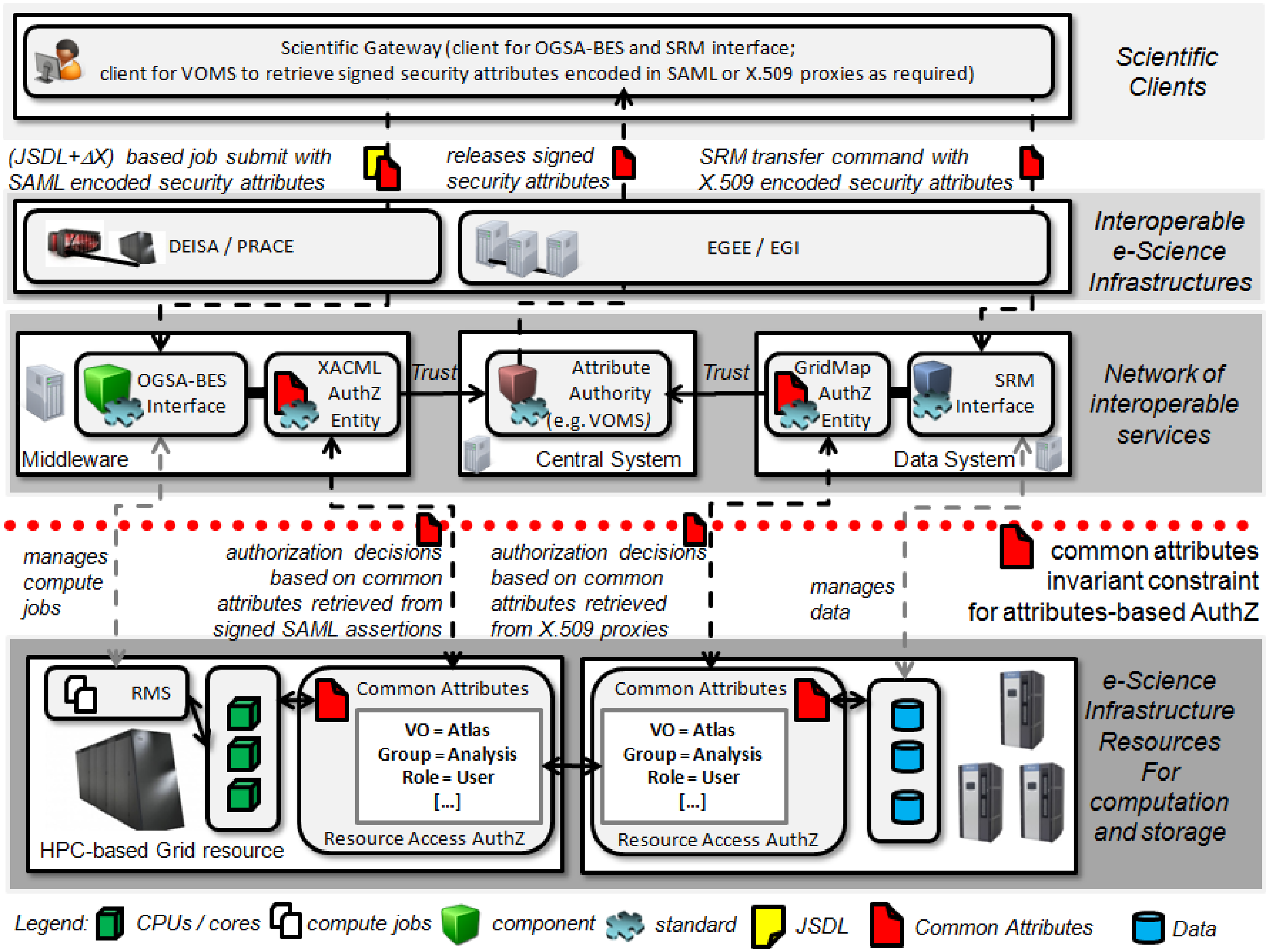
[13] Riedel et al., e-Science Infrastructure Integration Invariants to Enable HTC and HPC Interoperability Applications

IIRM Global Accounting Invariant



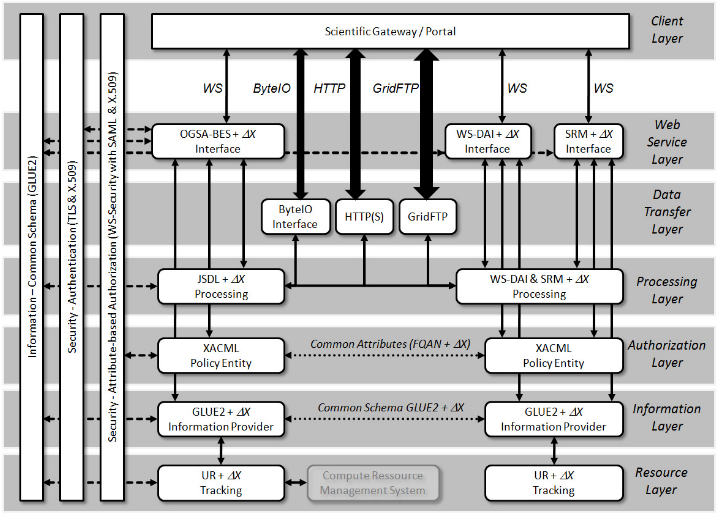
[13] Riedel et al., e-Science Infrastructure Integration Invariants to Enable HTC and HPC Interoperability Applications

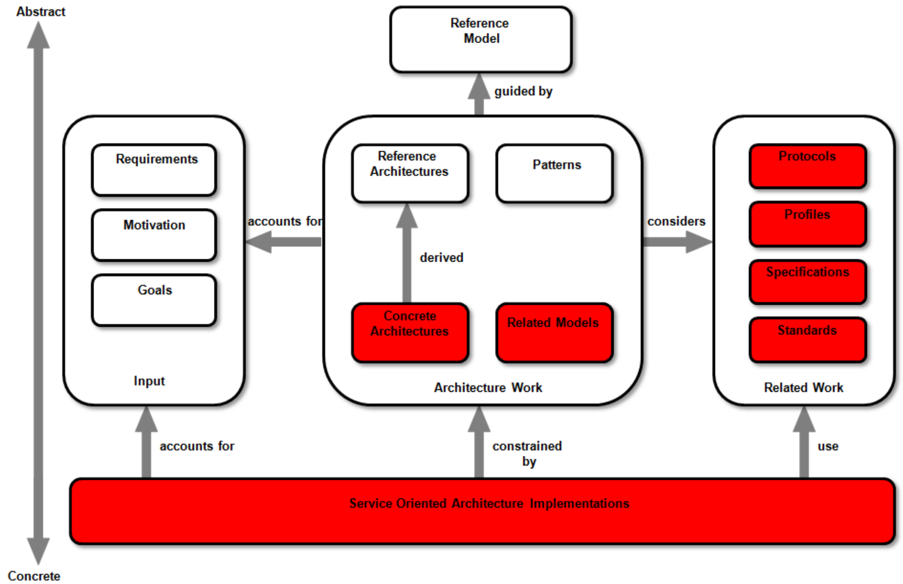
IIRM Global Authorization Attributes Invariant



[13] Riedel et al., e-Science Infrastructure Integration Invariants to Enable HTC and HPC Interoperability Applications

Derived Concrete Architectures and Implementations





[1] Riedel et al., Research Advances by using Interoperable e-Science Infrastructures, 2009

[11] OASIS Reference Model for SOAs, 2006

European Middleware Initiative

UNICORE

dCache.ORG

KnowARC

gLite

Distributed European Infrastructure for Supercomputing Applications

egee Enabling Grids for E-sciencE

EGI

PRACE

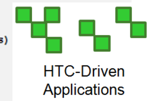
HTC-Driven Applications

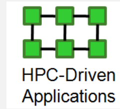
HPC-Driven Applications

Academic & Practical Field Studies

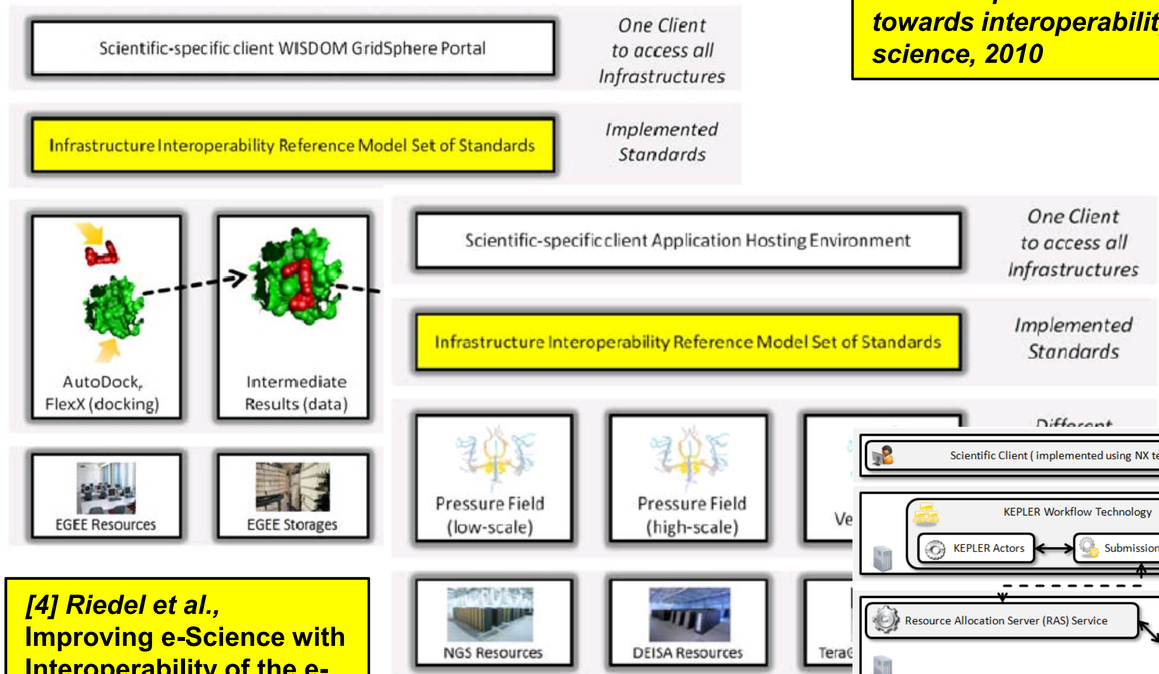
[3] Riedel, *e-Science Infrastructure Interoperability Guide – The seven steps towards interoperability in e-science*, 2010

```
Begin

  Begin GridInformationProvisioning
    Grid Information Providers (GIPs) publish pieces of
    information about infrastructures (HPC and HTC resources)
  End

  scienceworkflowfinished = false

  WHILE (scienceworkflowfinished)
    Begin Brokering
      End-user uses client technology (CT) and performs application setup
        and defines HPC or HTC requirements for next scientific workflow step
      Compute resource (CR) of corresponding HPC and HTC infrastructure is
        found based on the information exposed by GIPs
    End

    Begin JobSubmitToResource
      If CR.type is HTC then
        End-user of CT submits HTC job to a HTC resource
        using middleware MA of the corresponding infrastructure IA
      End If
      If CR.type is HPC then
        End-user of CT submits HPC job to a HPC resource
        using middleware MB of the corresponding infrastructure IB
      End If
    End

    Begin AnalysisScienceComplete
      If end-user need no further computing then
        scienceworkflowfinished = true
    End

  End While

End
```



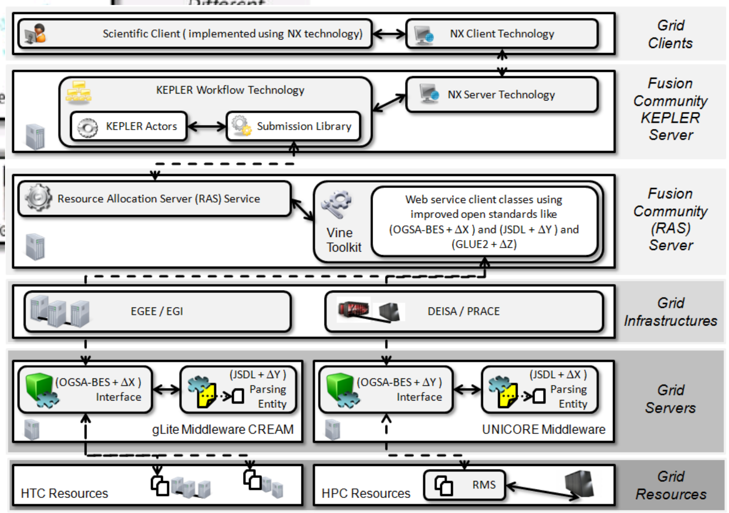


‚Design Pattern‘



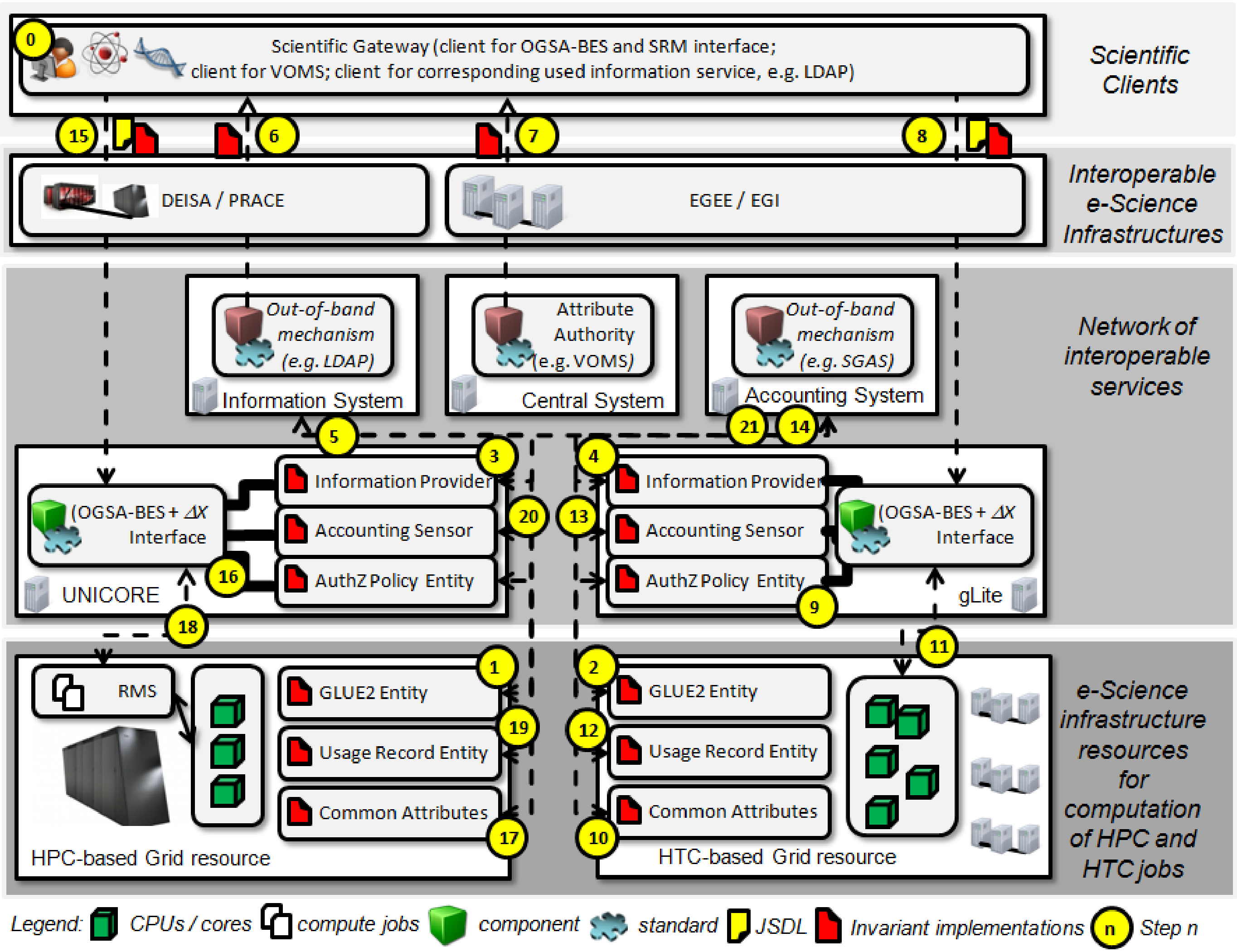
[4] Riedel et al., Improving e-Science with Interoperability of the e-Infrastructures EGEE and DEISA, *2008*

[5] Riedel et al., *Exploring the Potential of Using Multiple e-Science Infrastructures with Emerging Open Standards-based e-Health Research Tools*



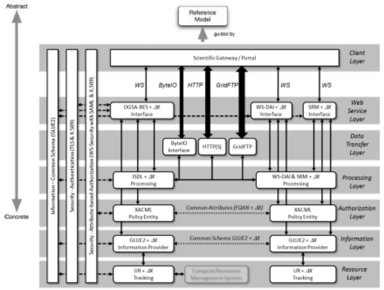
[6] *M.S. Memon & Riedel et al.,* Lessons learned from jointly using HTC- and HPC-driven e-science infrastructures in Fusion Science

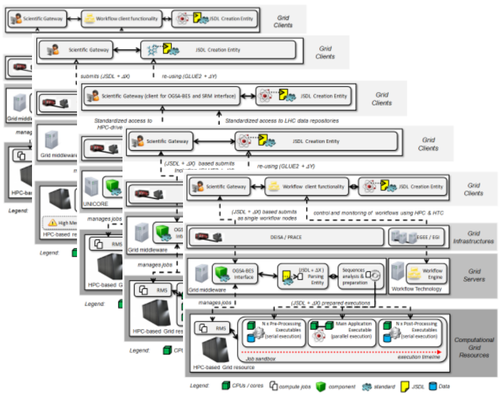
Invariants in e-Science Application Context

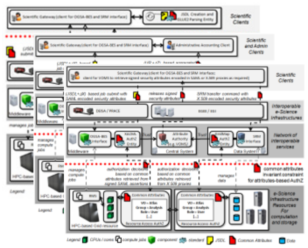


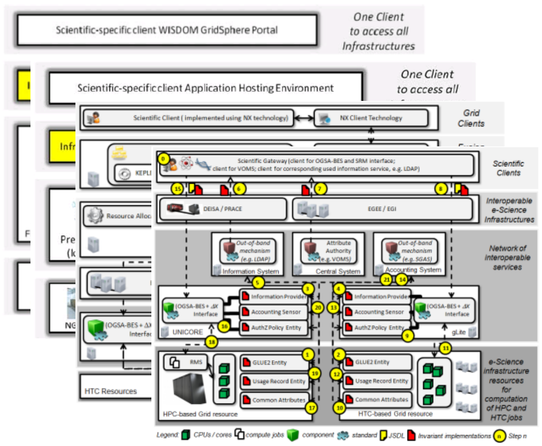
[13] Riedel et al., e-Science Infrastructure Integration Invariants to Enable HTC and HPC Interoperability Applications

Summary & Conclusions









- Infrastructure Interop Reference Model
  - Standards-based entities and relationships with ‘required refinements’
  - Cp: ISO/OSI → TCP/IP, SGML → XML
  - Bottom line: OGSA → IIRM
  - Applied research and impact on real e-science Infrastructures (EGI/PRACE)
  - Roadmap of EMI developments
  - Numerous standards improvements based on lessons learned & experience
- Seven steps process towards e-Science Infrastructure Interoperability
  - Addresses ‘operational interoperability’ and ‘sustained interoperation’ issues
- Accompanying Case Studies
  - Practical field tests & reference implementations of IIRM concepts

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References

[1] M. Riedel, F. Wolf, D. Kranzlmüller, A. Streit, T. Lippert - *Research Advances by using Interoperable e-Science Infrastructures - The Infrastructure Interoperability Reference Model applied in e-Science,* Journal of Cluster Computing, Special Issue Recent Advances in e-Science, Cluster Computing (2009) Vol. 12, No. 4, pp. 357-372, DOI 10.1007/s10586-009-0102-2, December 2009

[2] M. Riedel, A. Streit, Th. Lippert, F. Wolf, D. Kranzlmüller - Towards Individually Formed Computing Infrastructures with High Throughput and High Performance Computing Resources of Large-scale Grid and e-Science Infrastructures, Proceedings of MIPRO Conference, GVS Workshop, 2010

[3] M. Riedel, „E-Science Infrastructure Interoperability Guide – The Seven Steps towards Interoperability for e-Science“, book „Guide to e-Science: Next Generation Scientific Research and Discovery“, Editors: X. Yang and L. Wang Springer, to be published in 2010

[4] M. Riedel et al. “Improving e-Science with Interoperability of the e-Infrastructures EGEE and DEISA”; Proceedings of the 31st International Convention MIPRO, Conference on Grid and Visualization Systems (GVS), May 2008, Opatija, Croatia, Croatian Society for Information and Communication Technology, Electronics and Microelectronics, ISBN 978-953-233-036-6, pages 225 – 231

[5] M. Riedel, B. Schuller, M. Rambadt, M.S. Memon, A.S. Memon, A. Streit, F. Wolf, Th. Lippert, S.J. Zasada, S. Manos, P.V. Coveney, F. Wolf, D. Kranzlmüller - *Exploring the Potential of Using Multiple e-Science Infrastructures with Emerging Open Standards-based e-Health Research Tools,* Proceedings of the The 10th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGrid 2010), May 17-20, 2010

[6] M. S. Memon, M. Riedel, A. S. Memon, F. Wolf, A. Streit, Th. Lippert, Marcin Plociennik, Michal Owsiak, David Tskhakaya, Christian Konz, Lessons learned from jointly using HTC- and HPC-driven e-science infrastructures in Fusion Science, proceedings of the IEEE ICIET 2010 Conference, Pakistan

[7] M. Riedel et al. „*Improvements of Common Open Grid Standards to Increase High Throughput and High Performance Computing Effectiveness on Large-scale Grid and e-Science Infrastructures „* Seventh High-Performance Grid Computing (HPGC) Workshop at International Parallel and Distributed Processing Symposium (IPDPS) 2010, April 19-23, 2010, Atlanta, USA

[8] M. Riedel, A. Streit, Th. Lippert, F. Wolf, D. Kranzlmueller - *Concepts and Design of an Interoperability Reference Model for Scientific- and Grid Computing Infrastructures,* Proceedings of the Applied Computing Conference, in Mathematical Methods and Applied Computing, Volume II, WSEAS Press 2009, ISBN 978-960-474-124-3, Pages 691 - 698

[9] M. Riedel and E. Laure et al. - *Interoperation of World-Wide Production e-Science Infrastructures*, Concurrency and Computation: Practice and Experience, 21 (2009) 8, 961 - 990

[10] M. Riedel, A. Streit, D. Kranzlmueller, D. Mallmann, and T. Lippert. Requirements of an e-Science Infrastructure Interoperability Reference Model. In Proceedings of the MIPRO 2011, 2011.

[11] OASIS Reference Model for Service-Oriented Architectures, OASIS Document, 2006

[12] A. S. Tanenbaum, Computer Networks. 2002. ISBN-10 9780130661029.

[13] Riedel et al., e-Science Infrastructure Integration Invariants to Enable HTC and HPC Interoperability Applications, HPGC 2011