THE WEB SEVICES MODELLING ONTOLOGY

2005 OASIS SYMPOSIUM - NEW ORLEANS

CHRISTOPH BUSSLER

ADRIAN MOCAN

MATTHEW MORAN

MICHAEL STOLLBERG

LILIANA CABRAL

MICHAL ZAREMBA

JOHN DOMINGUE

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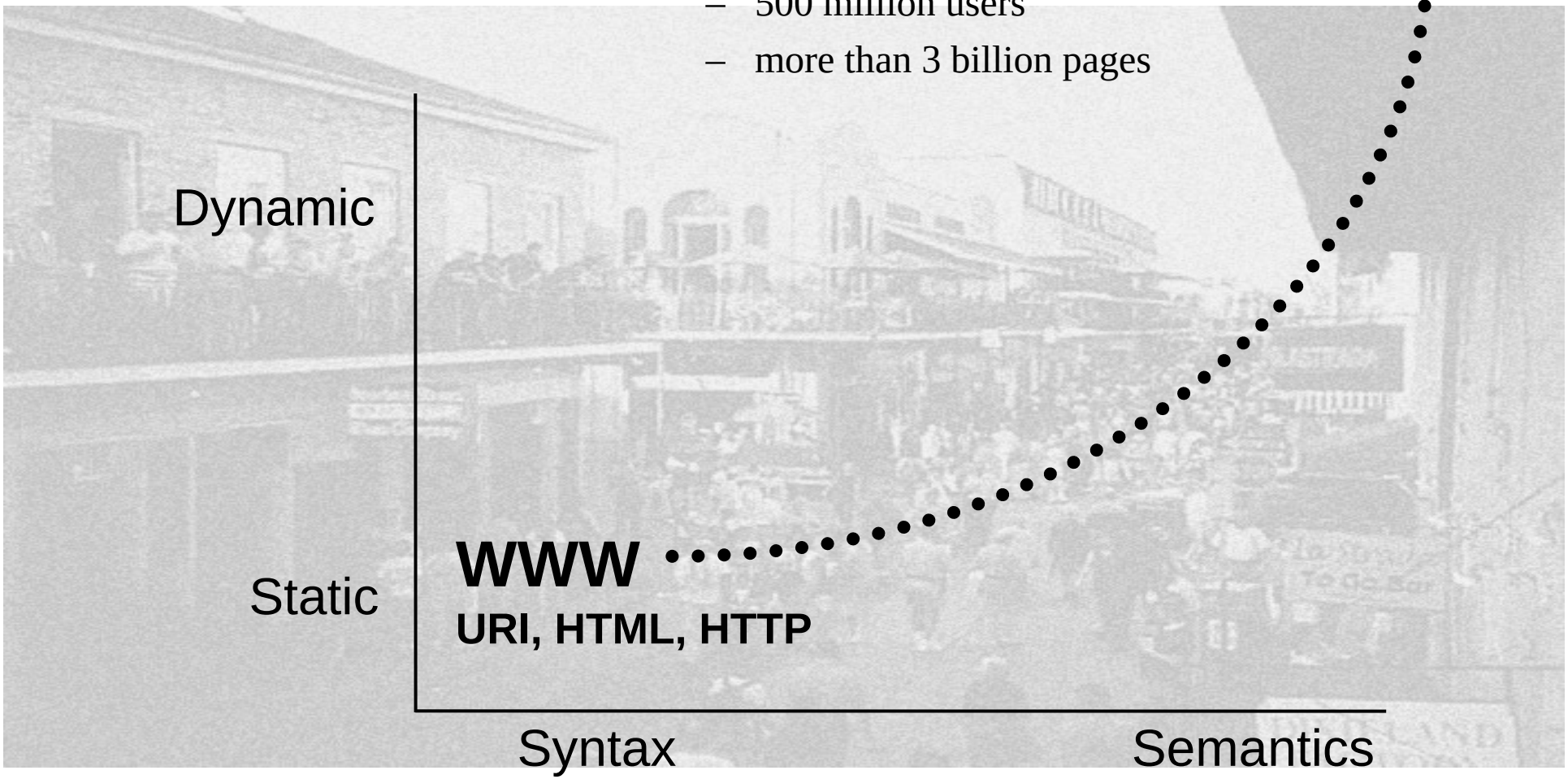
Semantic Web Services

Michal Zaremba

Semantic Web -The Vision

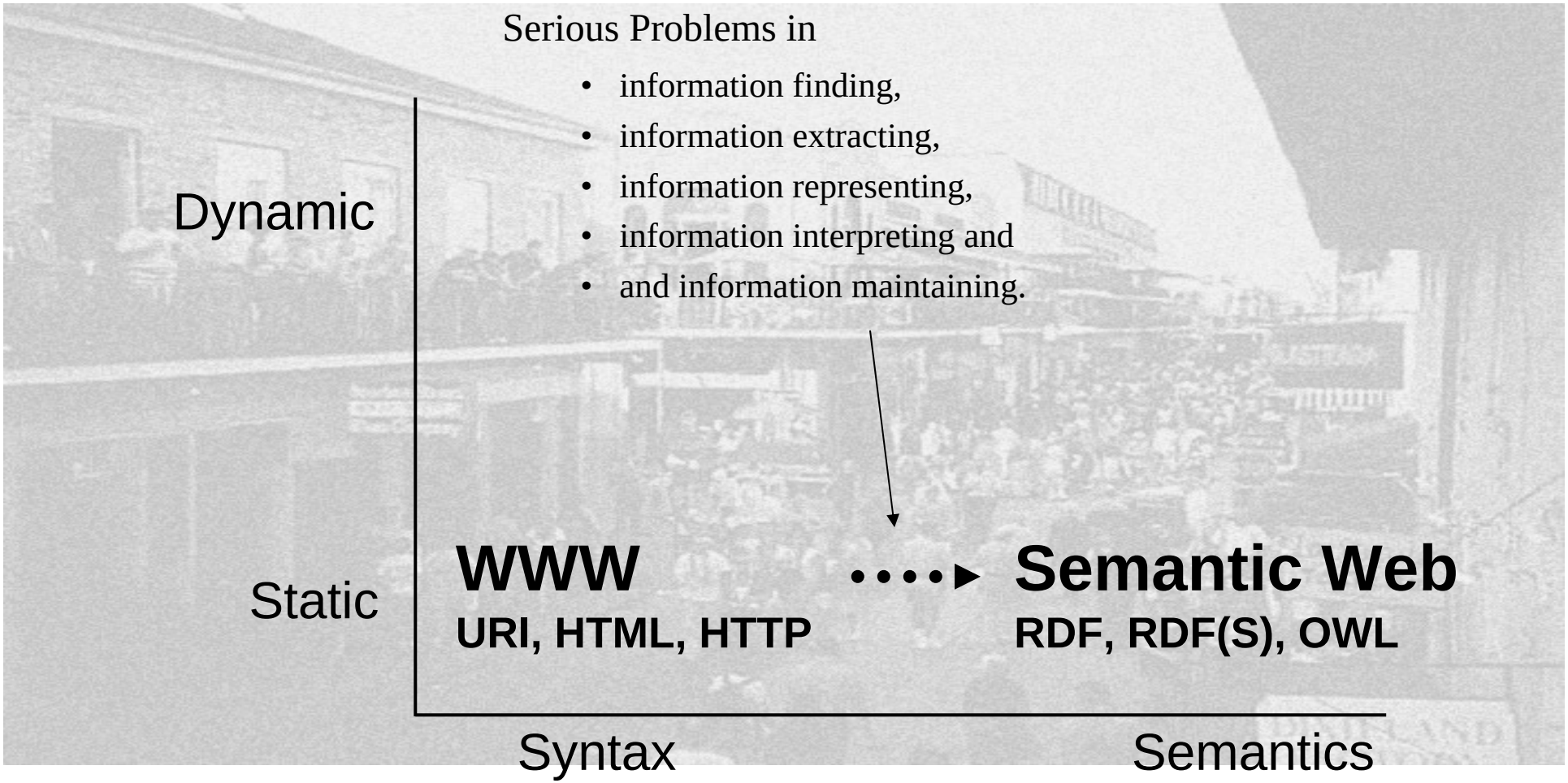
- 500 million users
- more than 3 billion pages



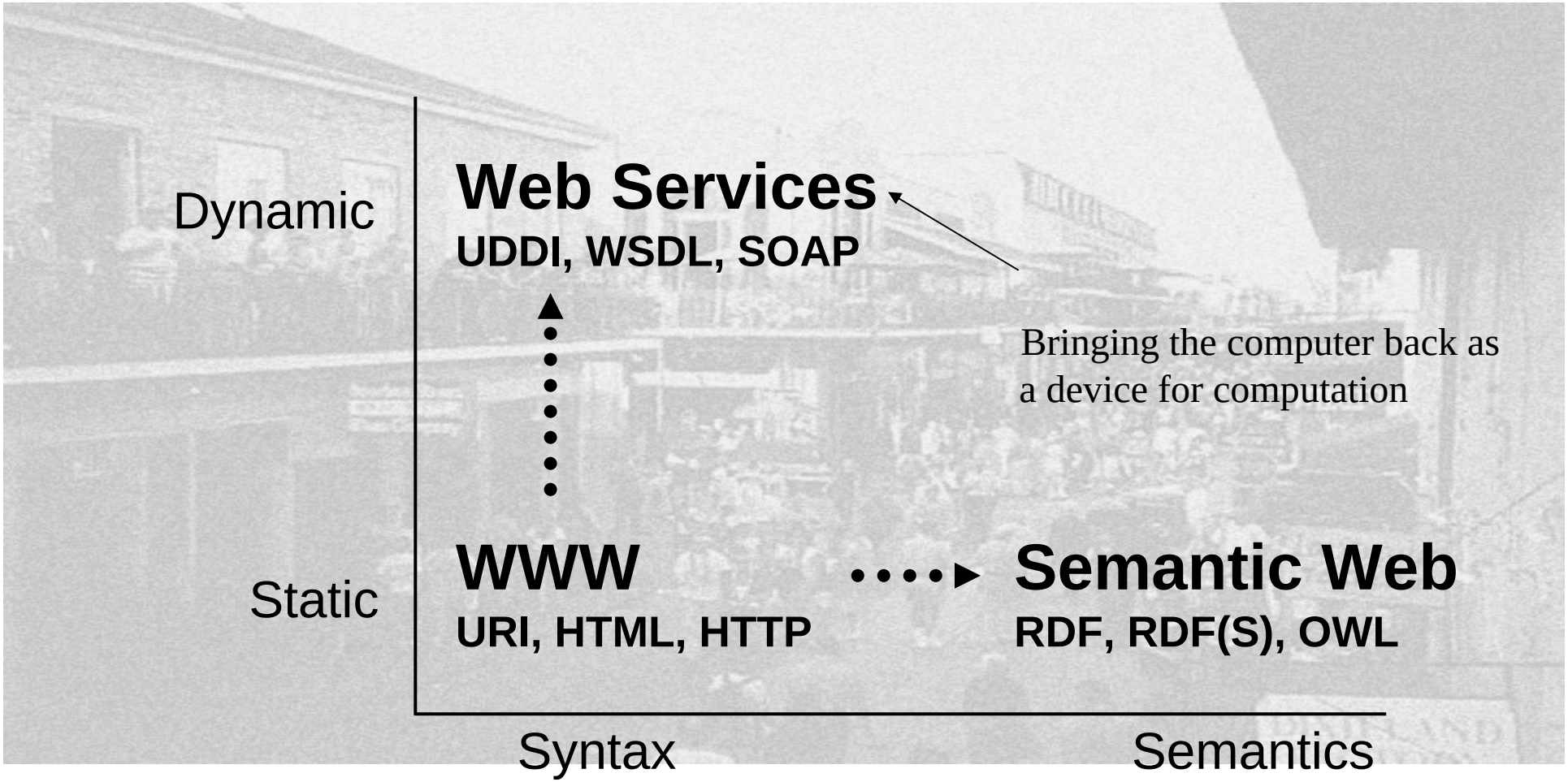
Semantic Web -The Vision

Serious Problems in

- information finding,
- information extracting,
- information representing,
- information interpreting and
- and information maintaining.

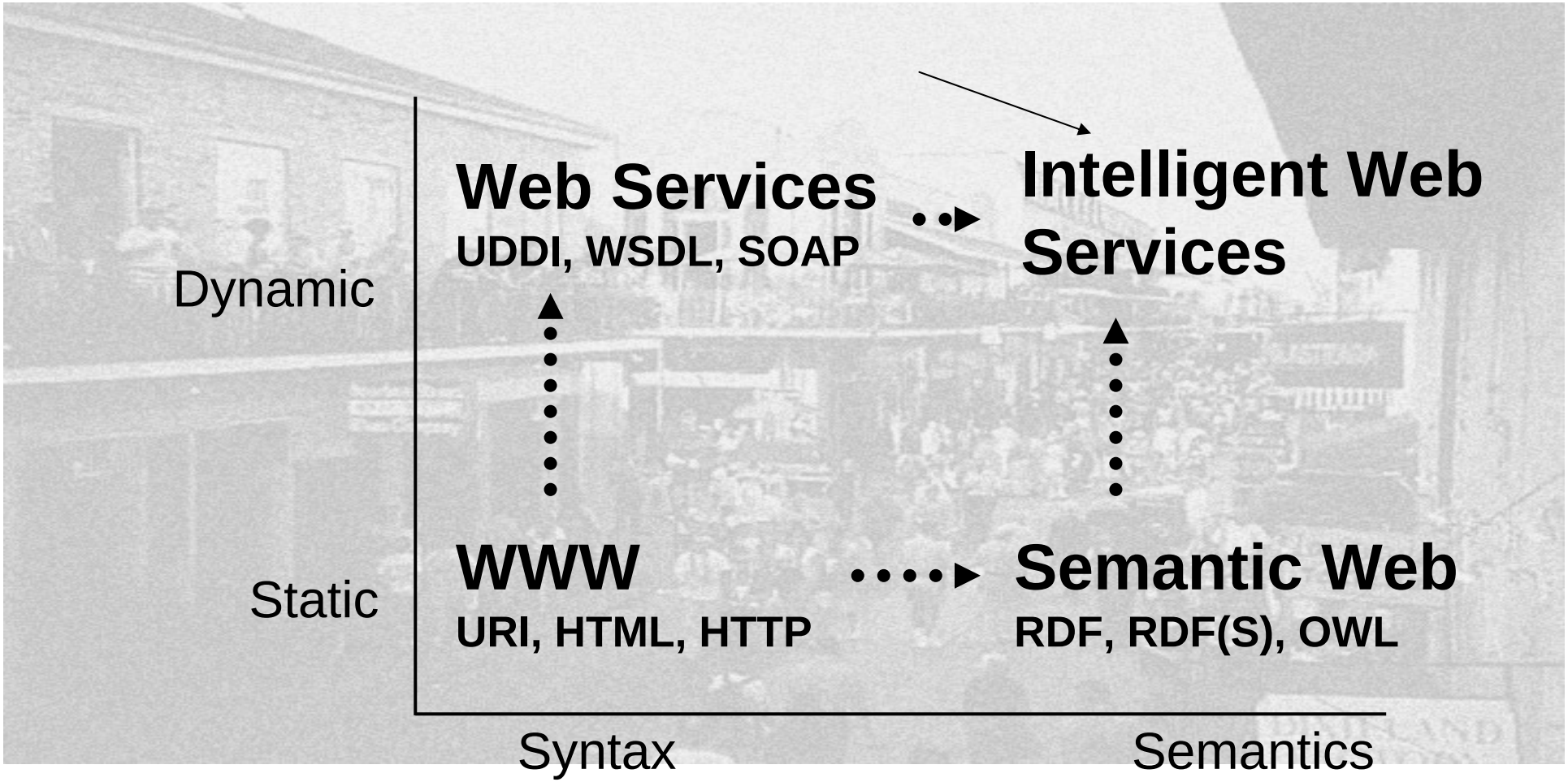


Semantic Web -The Vision

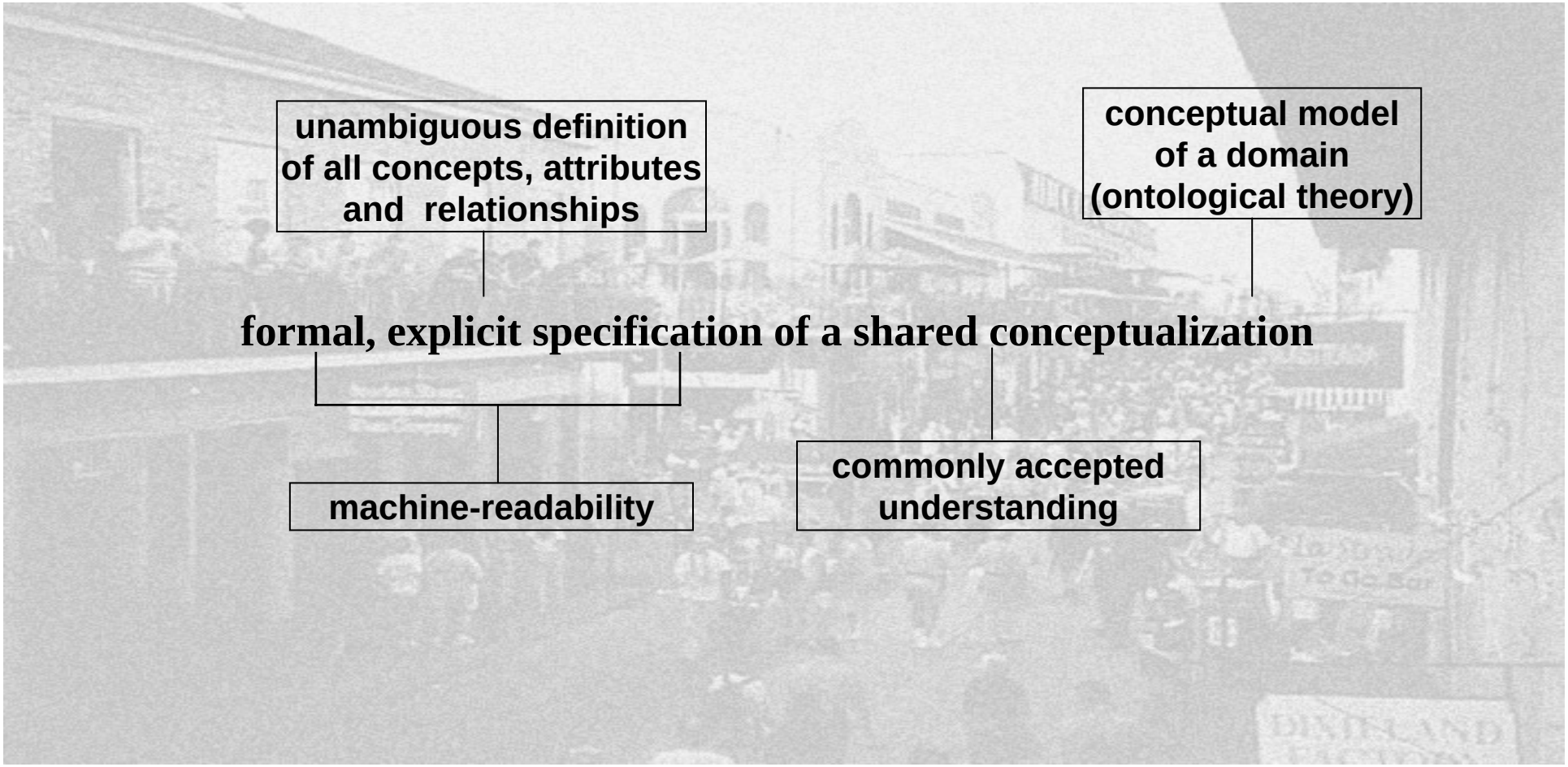


Semantic Web -The Vision

Bringing the web to its full potential



Ontology Definition



Ontology Example

Concept

conceptual entity of the domain

Property

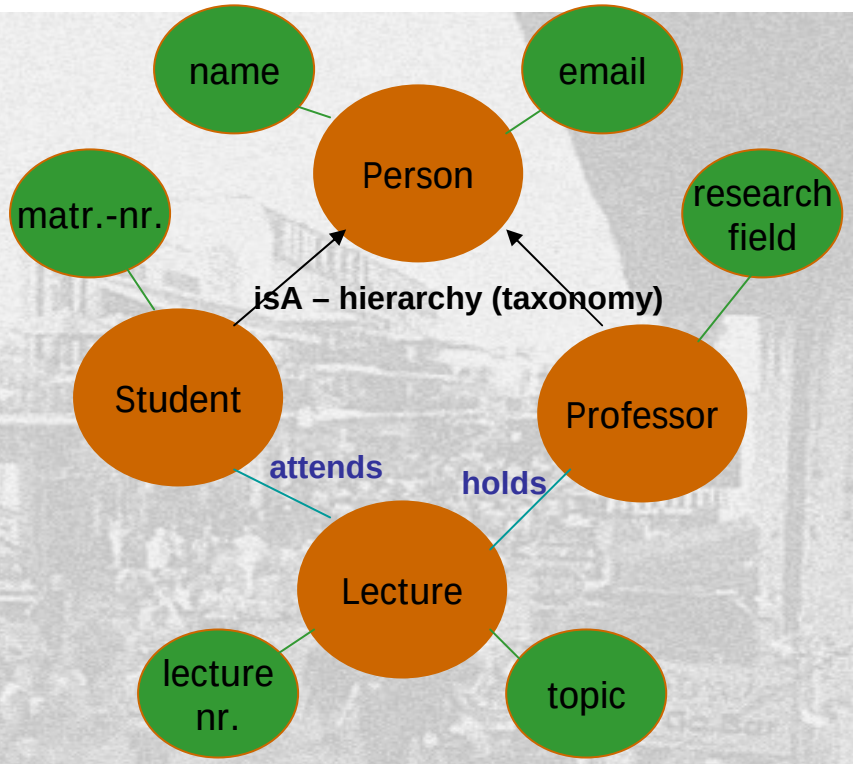
attribte describing a concept

Relation

relationship between concepts or properties

Axiom

coherent description between Concepts / Properties / Relations via logical expressions

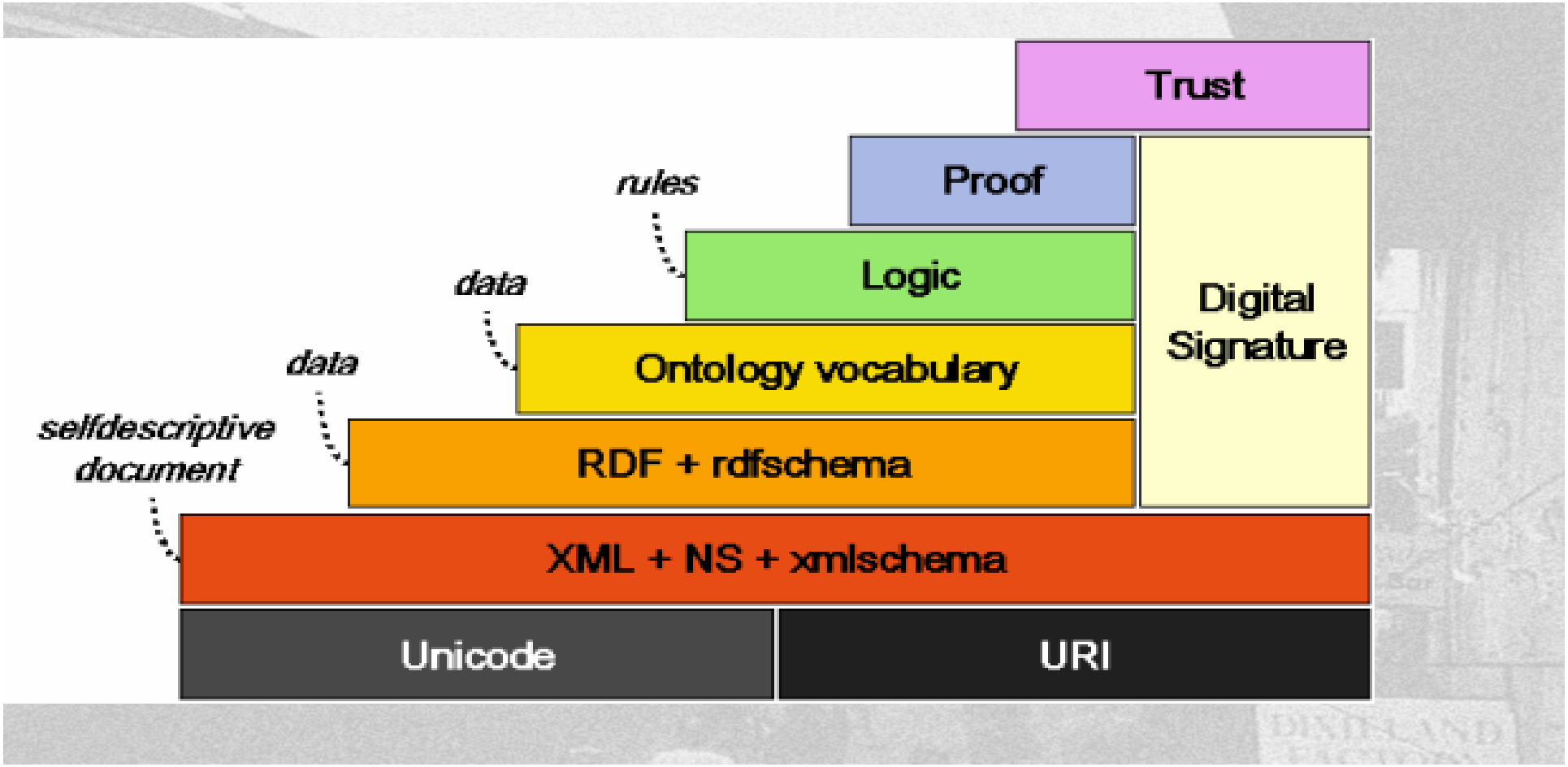



```
holds(Professor, Lecture) :-
Lecture.topic € Professor.researchField
```

Ontology Languages

- Requirements:
  - ”expressivity“
    - **knowledge** representation
    - ontology theory support
  - ”reasoning support“
    - sound (unambiguous, decidable)
    - support reasoners / inference engines
- Semantic Web languages:
  - web compatibility
  - Existing W3C Recommendations:
    - XML, RDF, OWL

“Semantic Web Language Layer Cake”

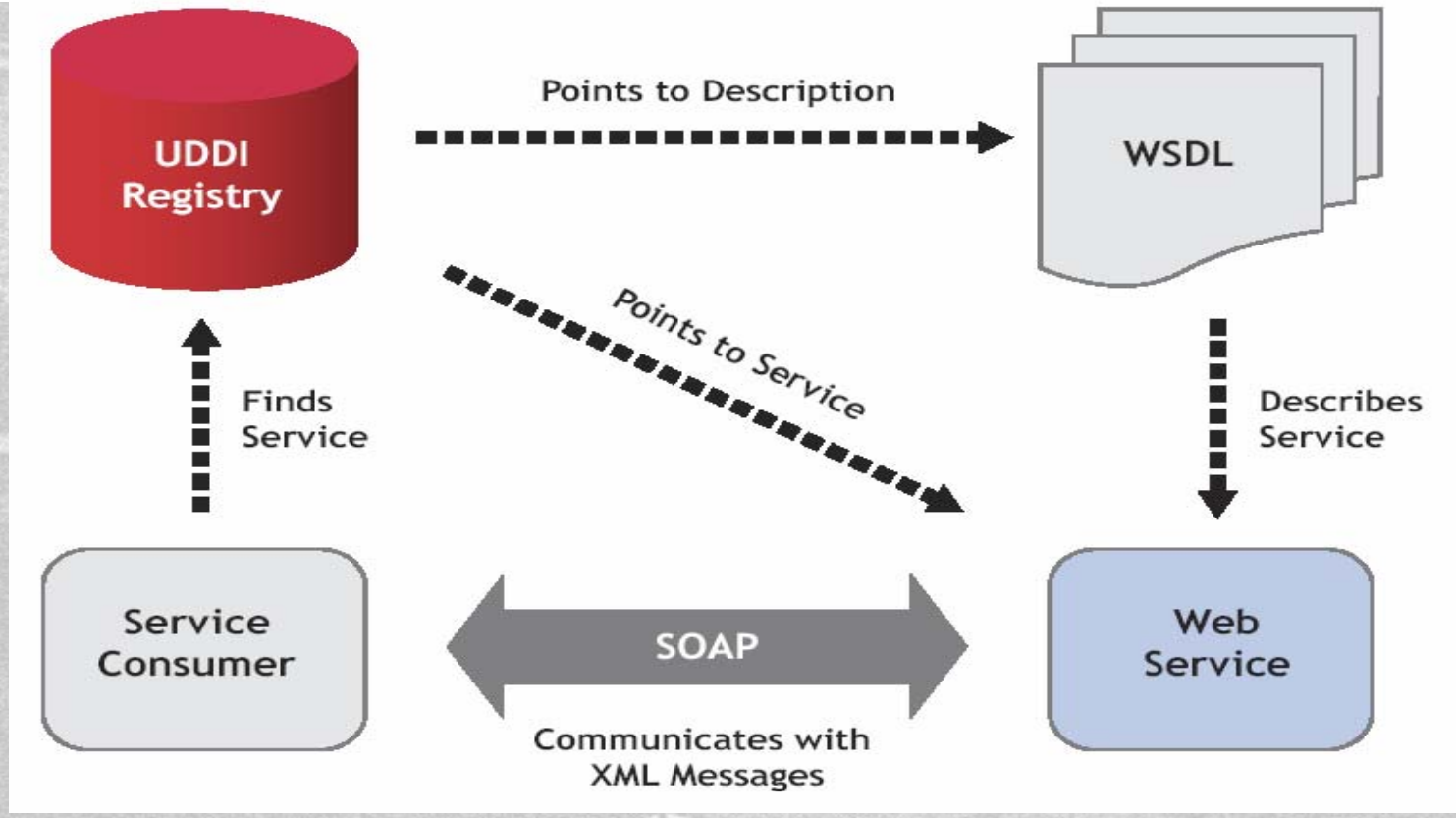


Web Services

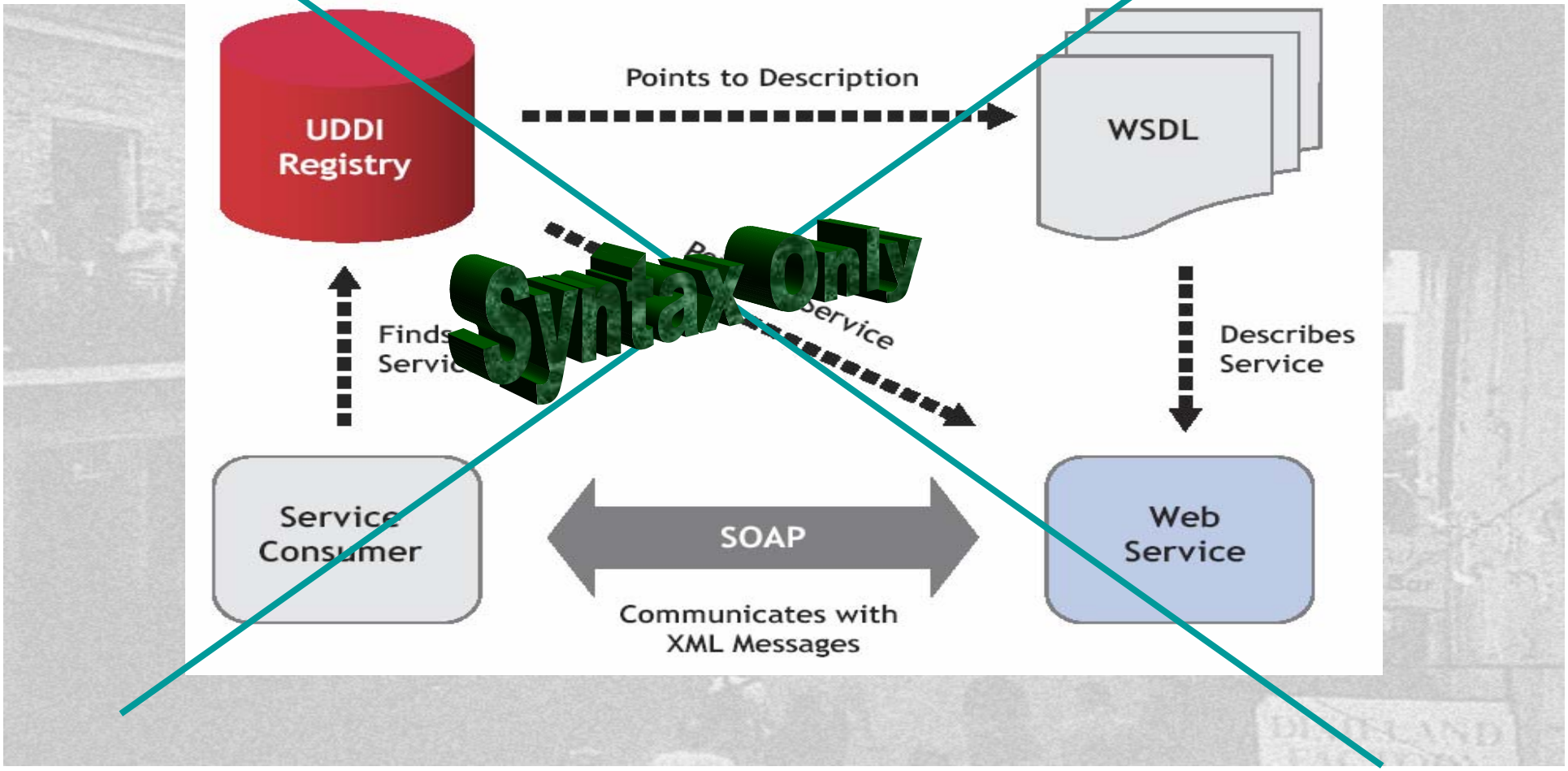
Web Services: [Stencil Group]

- loosely coupled, reusable components
- encapsulate discrete functionality
- distributed
- programmatically accessible over standard internet protocols
- add new level of functionality on top of the current web

Web Services Problems



Web Services Problems



Lack of SWS standards

Current technology does not allow realization of any of the parts of the Web Services' usage process:

- Only syntactical standards available
- Lack of fully developed markup languages
- Lack of marked up content and services
- Lack of semantically enhanced repositories
- Lack of frameworks that facilitate discovery, composition and execution
- Lack of tools and platforms that allow to semantically enrich current Web content

Semantic Web Services

- Define exhaustive description frameworks for describing Web Services and related aspects **(Web Service Description Ontologies)**
- Support ontologies as underlying data model to allow machine supported data interpretation **(Semantic Web aspect)**
- Define semantically driven technologies for automation of the Web Service usage process **(Web Service aspect)**

Semantic Web Services (2)

Usage Process:

- Publication: Make available the description of the capability of a service
- Discovery: Locate different services suitable for a given task
- Selection: Choose the most appropriate services among the available ones
- Composition: Combine services to achieve a goal
- Mediation: Solve mismatches (data, protocol, process) among the combined
- Execution: Invoke services following programmatic conventions

Semantic Web Services (3)

Usage Process – execution support

- Monitoring: Control the execution process
- Compensation: Provide transactional support and undo or mitigate unwanted effects
- Replacement: Facilitate the substitution of services by equivalent ones
- Auditing: Verify that service execution occurred in the expected way

Conclusion

Semantic Web Services

=

Semantic Web Technology

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Web Service Technology

Web Service Modelling Ontology (WSMO)

Adrian Mocan

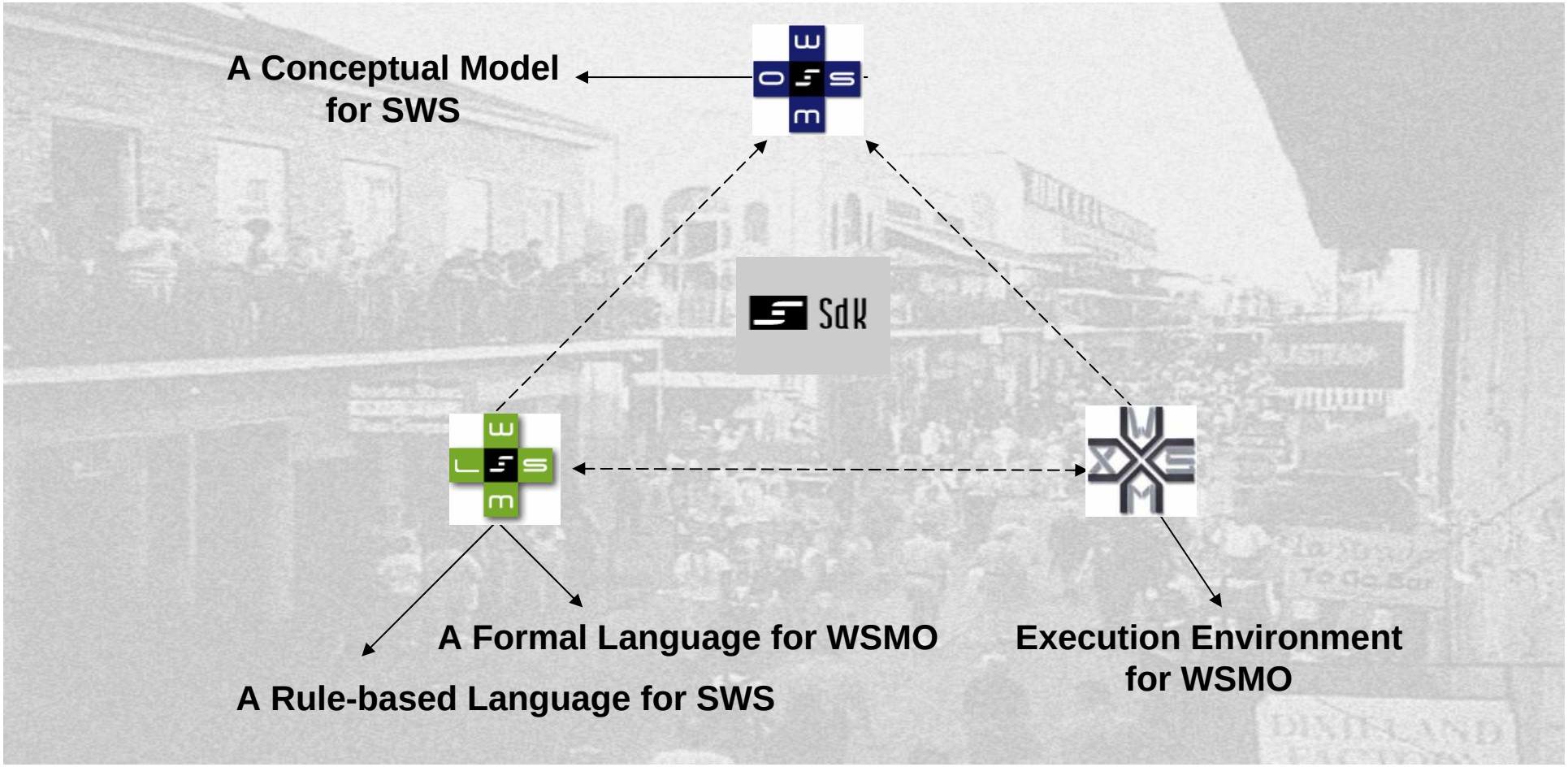
Features

- WSMO is a complete conceptual model for Semantic Web Services and related aspects
- Identifies four main elements: *Web Services*, *Goals*, *Ontologies*, and *Mediators*

Overview

- WSMO Working Groups
- WSMO Design Principles
- WSMO Top Level Notions
  - Ontologies
  - Goals
  - Web Services
  - Mediators
- Basic Notions of WSML
- Using WSMO to address Web Services problems
  - Discovery
  - Composition
  - Grounding

WSMO Working Groups



WSMO Design Principles

Strong Decoupling & Strong Mediation

autonomous components with mediators for interoperability

Interface vs. Implementation

distinguish interface (= description) from implementation (=program)

Peer to Peer

interaction between equal partners (in terms of control)

Execution Semantics

reference implementation (WSMX)

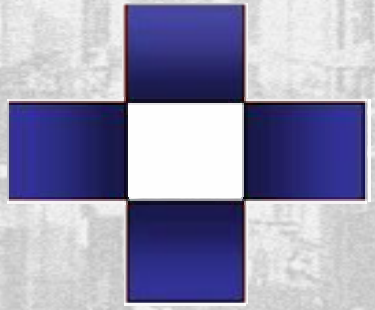
WSMO Top Level Notions

Objectives that a client may have when consulting a Web Service

Goals

Provide the formally specified terminology of the information used by all other components

Ontologies



Web Services

Semantic description of Web Services:
- **Capability** *(functional)*
- **Interfaces** *(usage)*

Mediators

Connectors between components with mediation facilities for handling heterogeneities

Non-Functional Properties

- Every WSMO elements is described by properties that contain relevant, non-functional aspects of the item
- Used for management and element overall description
- **Core Properties:**
  - **Dublin Core Metadata Element Set** plus **version** (evolution support)
  - W3C-recommendations for description type
- **Web Service Specific Properties:**
  - Quality aspects and other non-functional information of Web Services
  - Used for Service Selection

Non-Functional Properties

ontology <http://www.wsmo.org/2004/d3/d3.2/v0.1/20040628/dt.wsml>

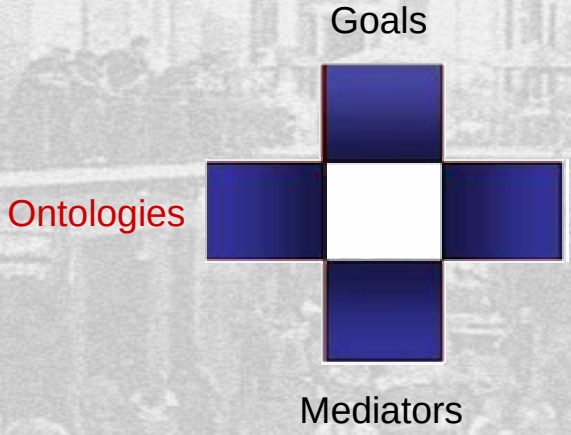
nonFunctionalProperties

dc:title	"Date and Time Ontology"
dc:creator	"DERI International"
dc:subject	"Date", "Time", "Date and Time Algebra"
dc:description	"generic representation of data and time including basic algebra"
dc:publisher	"DERI International"
dc:contributor	"Holger Lausen", "Axel Polleres", "Ruben Lara"
dc:date	2004-06-28
dc:type	http://www.wsmo.org/2004/d2/v0.3/20040329/#ontos
dc:format	"text/plain"
dc:language	"en-US"
dc:relation	<http://www.w3.org/TR/xmlschema-2/>
dc:coverage	"World"
dc:rights	<http://www.deri.org/privacy.html>
version	1.21

WSMO Ontologies

Objectives that a client may have when consulting a Web Service

Provide the formally specified terminology of the information used by all other components



Semantic description of Web Services:
- **Capability** *(functional)*
- **Interfaces** *(usage)*

Connectors between components with mediation facilities for handling heterogeneities

Ontology Specification

- **Non functional properties**
- **Imported Ontologies** Importing existing ontologies where no heterogeneities arise
- **Used mediators:** OO Mediators (ontology import with terminology mismatch handling)
- **'Standard' Ontology Notions:**

Concepts	set of concepts that belong to the ontology
Attributes	set of attributes that belong to a concept
Relations:	define interrelations between several concepts
Functions:	special type of relation (unary range = return value)
Instances:	set of instances that belong to the represented ontology
Axioms	axiomatic expressions in ontology (logical statement)

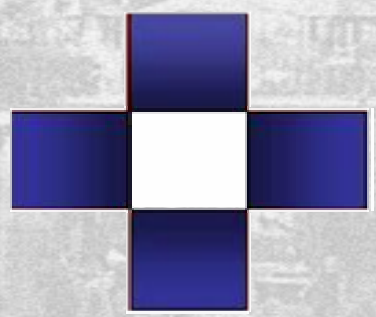
WSMO Goals

Objectives that a client may have when consulting a Web Service

Goals

Provide the formally specified terminology of the information used by all other components

Ontologies



Web Services

Semantic description of Web Services:
- **Capability** *(functional)*
- **Interfaces** *(usage)*

Mediators

Connectors between components with mediation facilities for handling heterogeneities

Goals

- **De-coupling of Request and Service**

  Goal-driven Approach, derived from AI rational agent approach

  - Requester formulates objective independent / without regard to services for resolution
  - 'Intelligent' mechanisms detect suitable services for solving the Goal
  - Allows re-use of Services for different purposes

- **Usage of Goals within Semantic Web Services**
  - A Requester, that is an agent (human or machine), defines a Goal to be resolved
  - Web Service Discovery detects suitable Web Services for solving the Goal automatically
  - Goal Resolution Management is realized in implementations

Goal Specification

- **Non functional properties**
- **Imported Ontologies**
- **Used mediators**
  - *OO Mediators:* - import ontologies with integration
  - *GG Mediators:* - allow goal definition by reusing an already existing goal
    - allow specification of **Goal Ontologies**
- **Post-conditions -** the state of the information space that is desired.
  - The result expected from execution a Web Service
  - Expressed as an axiom (unambiguous, based on ontology)
- **Effects -** the state of the world that is desired.
  - Expected changes in the world that should hold after a service execution
  - Expressed as an axiom (unambiguous, based on ontology)

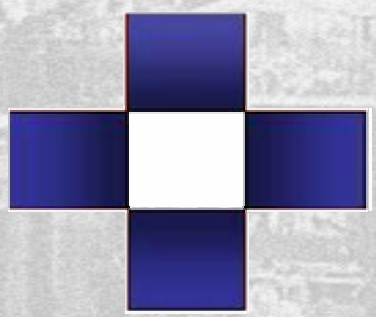
WSMO Web Services

Objectives that a client may have when consulting a Web Service

Goals

Provide the formally specified terminology of the information used by all other components

Ontologies



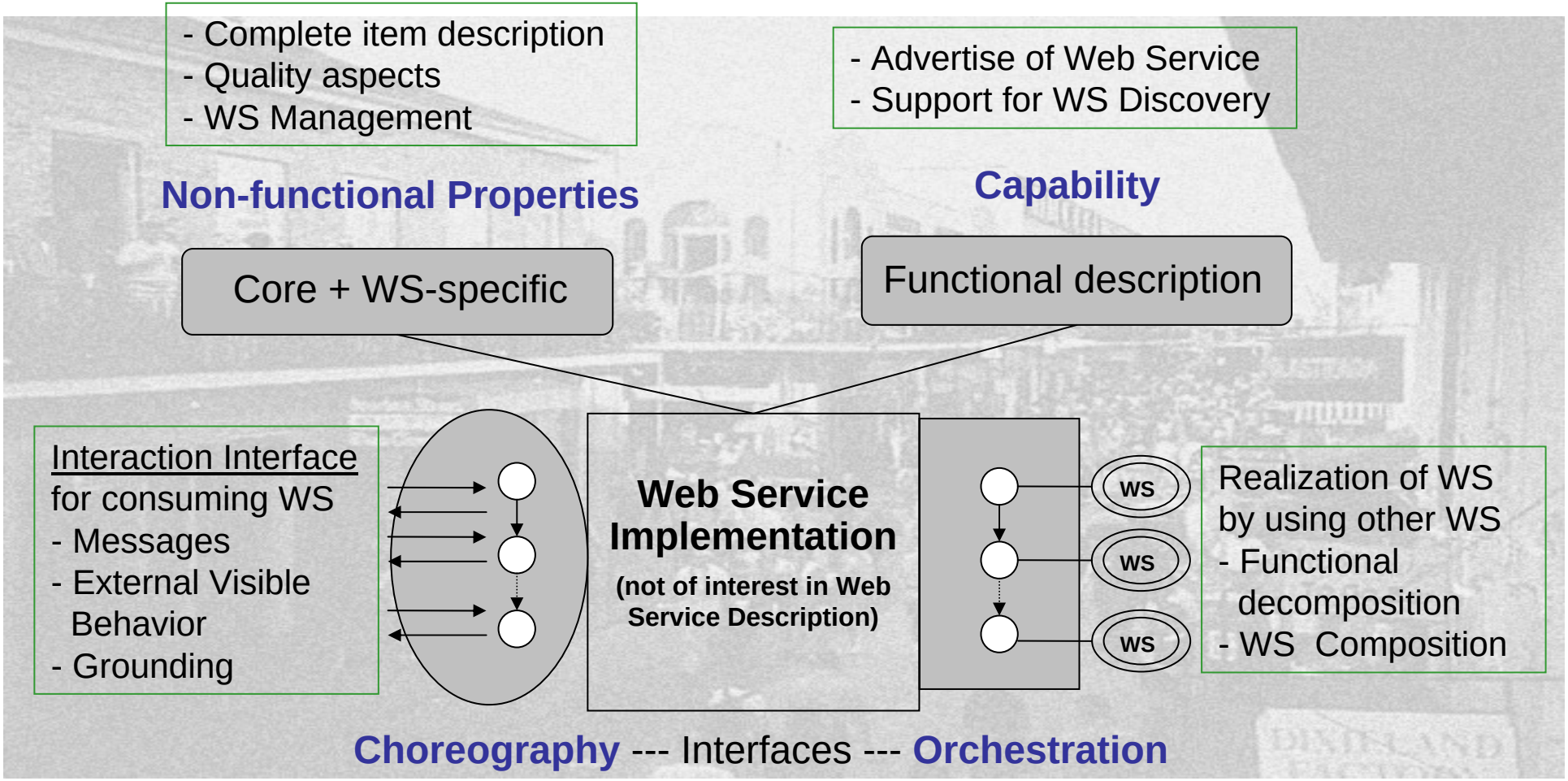
Web Services

Semantic description of Web Services:
- **Capability** *(functional)*
- **Interfaces** *(usage)*

Mediators

Connectors between components with mediation facilities for handling heterogeneities

WSMO Web Service Description



Web Service specific Properties

- Non-functional information of Web Services:

Accuracy
Availability
Financial
Network-related QoS
Performance
Reliability
Robustness
Scalability
Security
Transactional
Trust

Capability Specification

- **Non functional properties**
- **Imported Ontologies**
- **Used mediators**
  - *OO Mediator:* importing ontologies as terminology definition
  - *WG Mediator:* link to a Goal that is solved by the Web Service
- **Pre-conditions**
  - What a web service expects (conditions over the input)
- **Assumptions**
  - Conditions on the state of the world before the WS execution
- **Post-conditions**
  - The result of the WS in relation to the input, and conditions on it
- **Effects**
  - Conditions on the state of the world after the WS execution (i.e. changes in the state of the world)

Choreography in WSMO

"Choreography describes the behavior of the service from a user point of view"

- **External Visible Behavior**
  - those aspects of the workflow of a Web Service where User Interaction is required
  - described by process / workflow constructs
- **Communication Structure**
  - messages sent and received
  - their order (messages are related to activities)

Choreography in WSMO (2)

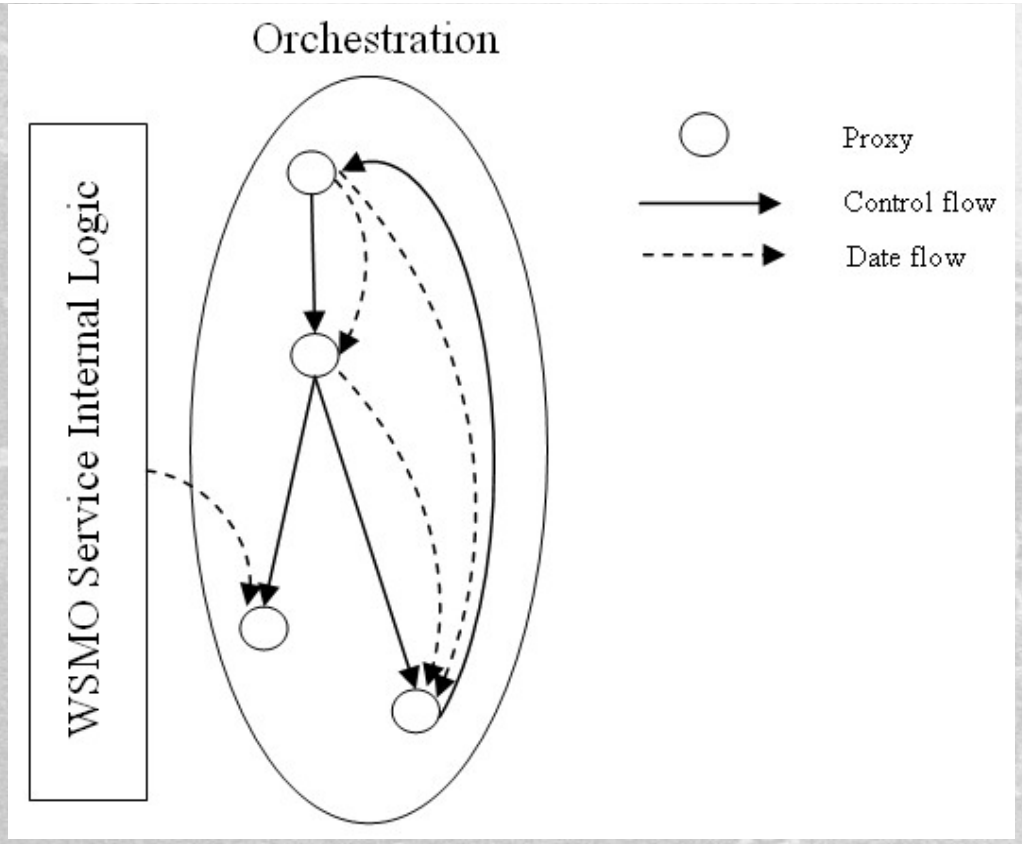
- **Grounding**
  - Concrete communication technology for interaction
  - Choreography related errors (e.g. input wrong, message timeout, etc.)
- **Formal Model**
  - Allow operations / mediation on Choreographies
  - Formal Basis: Abstract State Machines (ASM)

WSMO Orchestration

"…how the overall functionality of the service is achieved by the cooperation of other WSMO service providers "

- **Orchestration Language**
  - Decomposition of Web Service functionality
  - Control structure for aggregation of Web Services
- **Web Service Composition**
  - Combine Web Services into higher-level functionality
  - Resolve mismatches occurring between composed Web Services
- **Proxy Technology**
  - Placeholders for used Web Services
  - Facility for applying the Choreography of used Web Services

WSMO Orchestration Overview



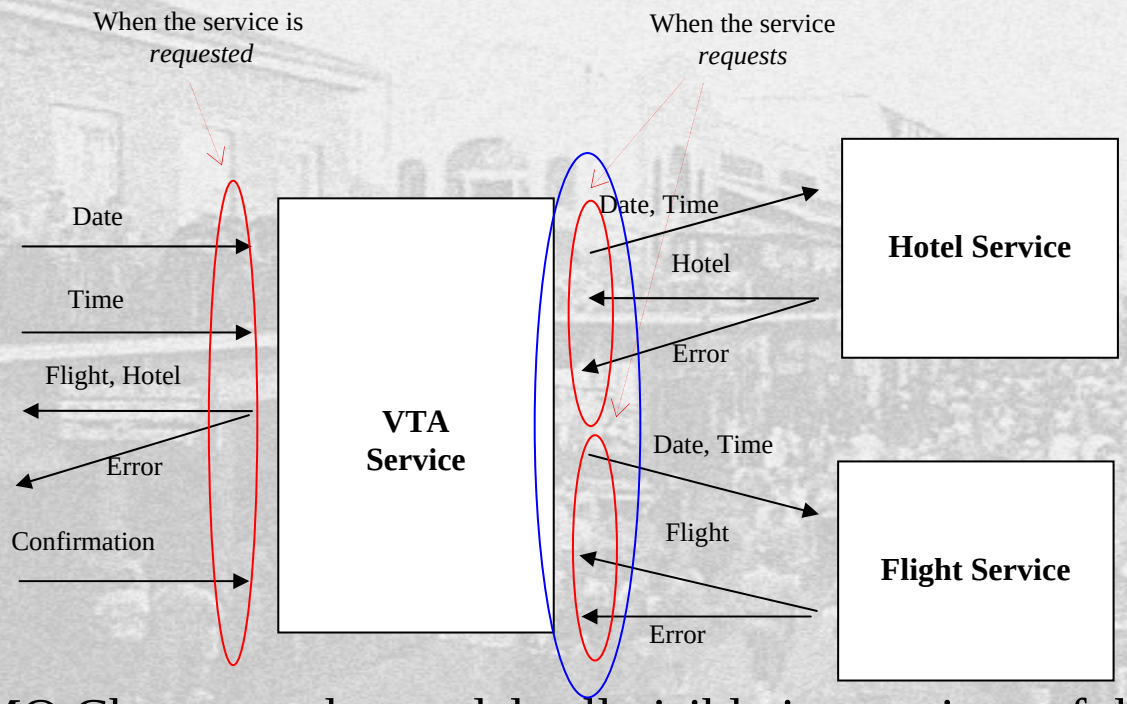
Decomposition of the Web Service functionality into sub-functionalities

Proxies as placeholders for used Web Services

Control Structure for aggregation of other Web Services

Choreography & Orchestration Example

- VTA example:



- WSMO Choreography models all visible interactions of the service (Orchestration shows how all the interaction are related)

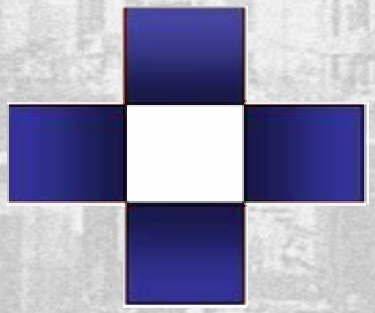
WSMO Mediators

Objectives that a client may have when consulting a Web Service

Goals

Provide the formally specified terminology of the information used by all other components

Ontologies



Web Services

Semantic description of Web Services:
- **Capability** *(functional)*
- **Interfaces** *(usage)*

Mediators

Connectors between components with mediation facilities for handling heterogeneities

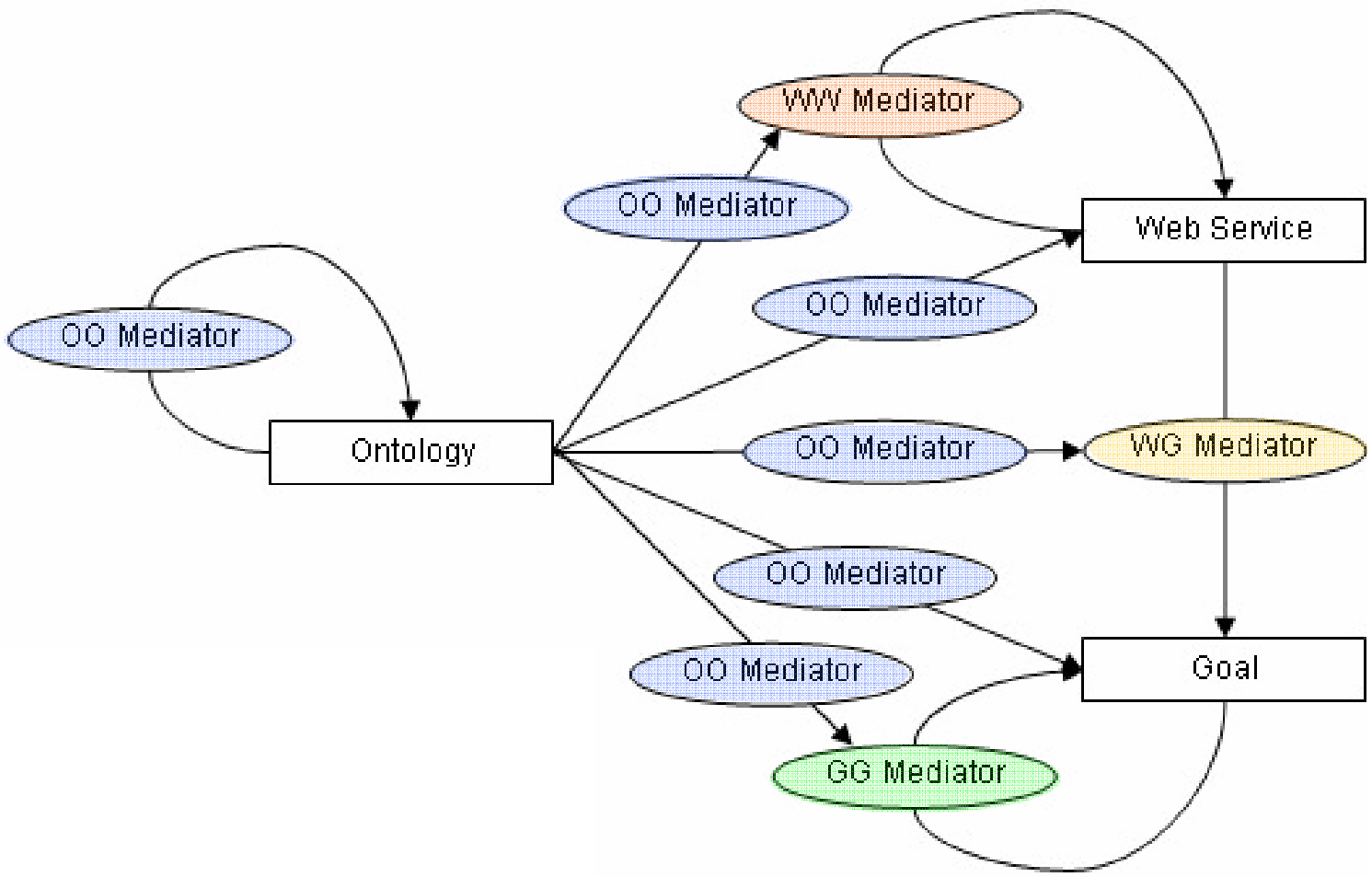
Mediation

- **Heterogeneity …**
  - Mismatches on structural / semantic / conceptual level
  - Occur between different components that shall interoperate
  - Especially in distributed & open environments like the Internet
- **Concept of Mediation** (Wiederhold, 94):
  - ***Mediators*** as components that resolve mismatches
  - Declarative Approach:
    - Semantic description of resources
    - 'Intelligent' mechanisms that resolve mismatches independent of content
  - Mediation cannot be fully automated (integration decision)
- **Levels of Mediation within Semantic Web Services**:

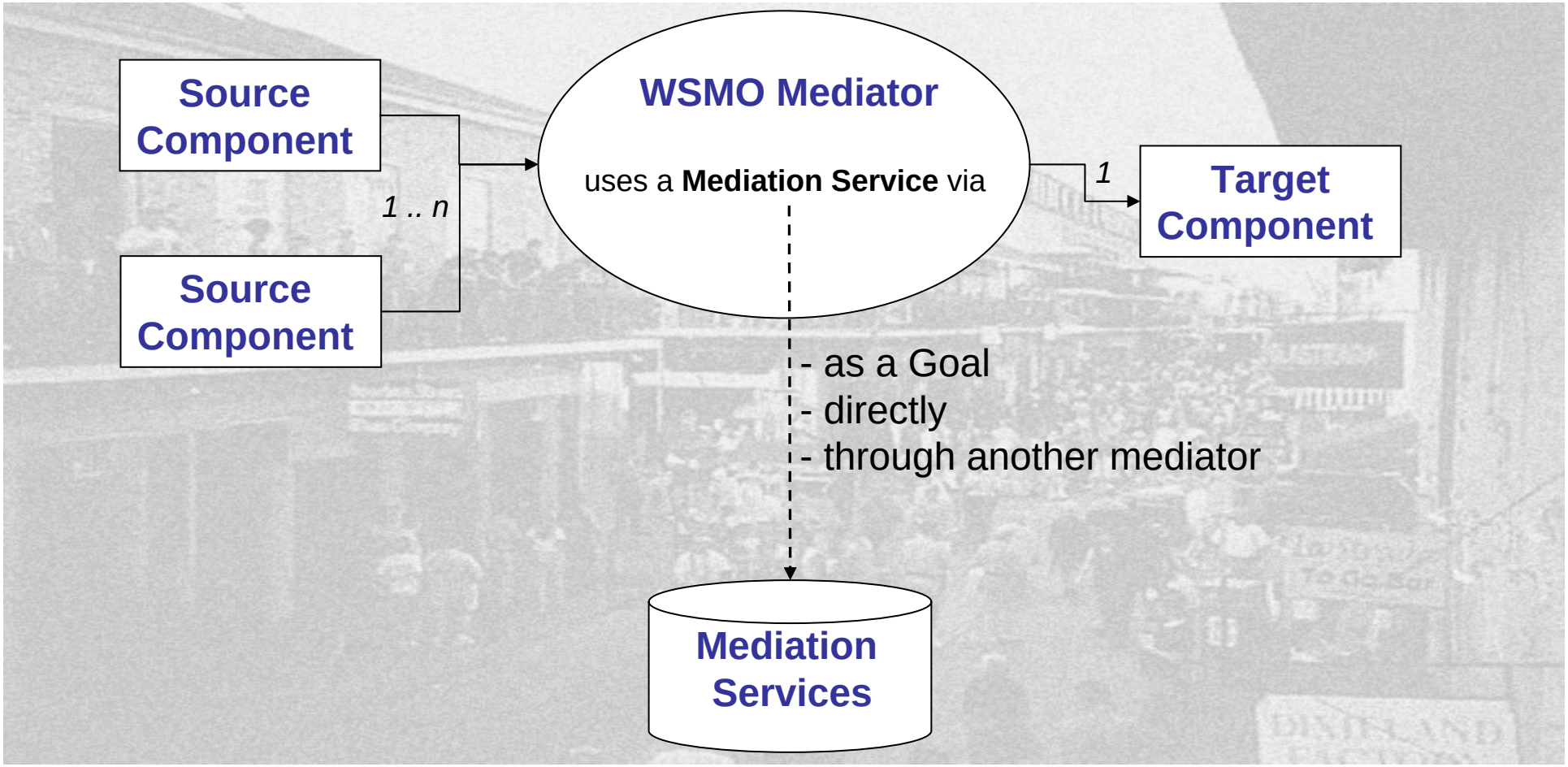
  (1) Data Level: mediate heterogeneous Data Sources

  (2) Process/Protocol Level: mediate heterogeneous Business Processes/Communication Patterns

WSMO Mediators Overview



Mediator Structure



GG Mediators

- **Aim:**
  - Support specification of Goals by re-using existing Goals
  - Allow definition of **Goal Ontologies** (collection of pre-defined Goals)
  - Terminology mismatches handled by OO Mediators

- **Example: Goal Refinement**

WG & WW Mediators

- **WG Mediators:**
  - link a Web Service to a Goal and resolve occurring mismatches
  - match Web Services and Goals that do not match a priori
  - handle terminology mismatches between Web Services and Goals

  $\Rightarrow$ broader range of Goals solvable by a Web Service

- **WW Mediators:**
  - enable interoperability of heterogeneous Web Services
  - handle terminology mismatches between Web Services

  $\Rightarrow$ support automated collaboration between Web Services

  - Data Mediation for resolving terminology mismatches (**OO Mediators**)
  - Process/Protocol Mediation for establishing valid multi-party collaborations and making Business Processes interoperable

Web Services Modelling Language (WSML)

Adrian Mocan

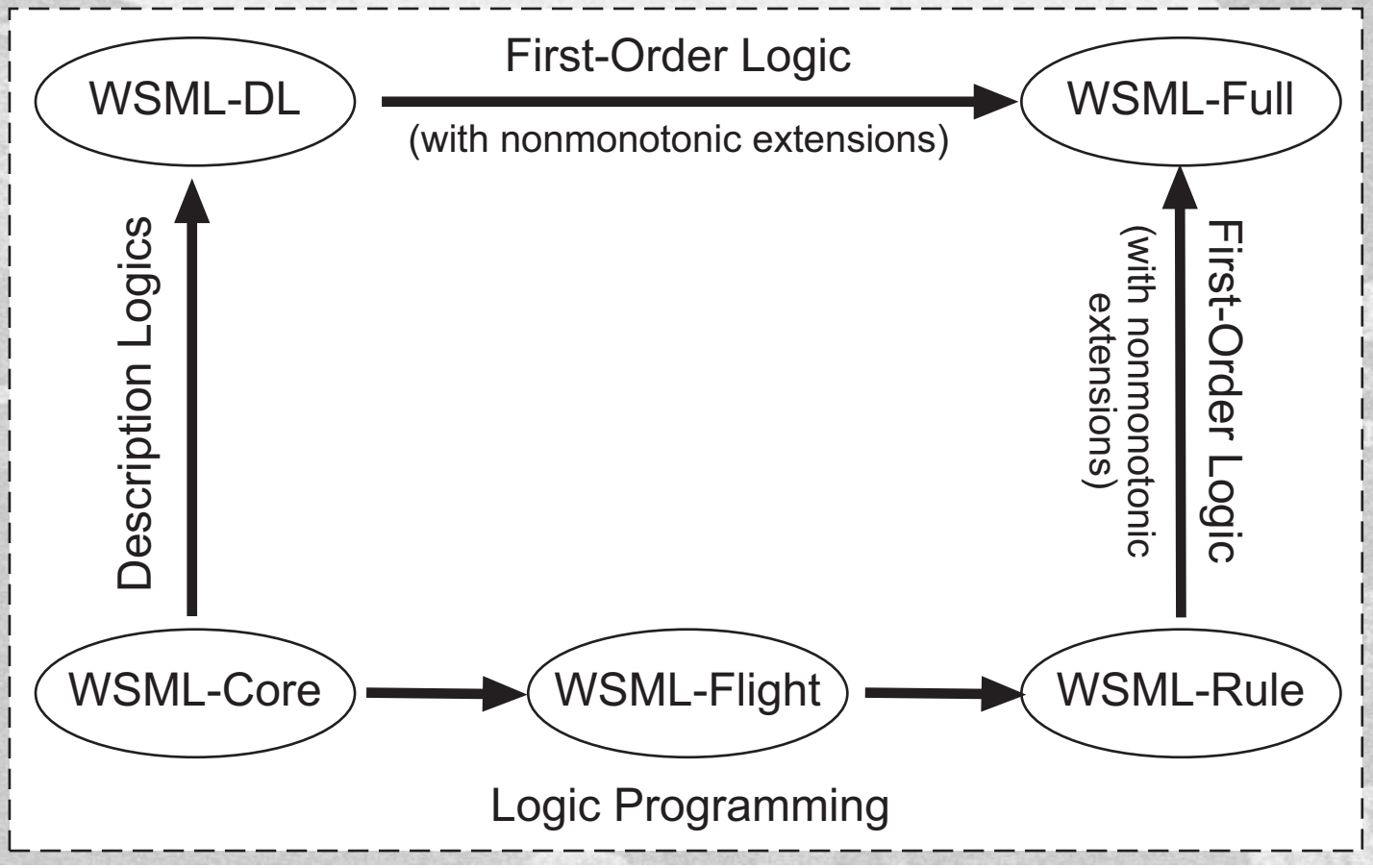
WSML - Web Service Modeling Language

- WSML provides a formal grounding for the conceptual elements of WSMO, based on:
  - Description Logics
  - Rule Languages
  - First-Order Logic

Rationale of WSML

- Provide a Web Service Modeling Language based on the WSMO conceptual model
  - Concrete syntax
  - Semantics
- Provide a Rule Language for the Semantic Web
- Many current Semantic Web languages have
  - undesirable computational properties
  - unintuitive conceptual modeling features
  - inappropriate language layering
    - RDFS/OWL
    - OWL Lite/DL/Full
    - OWL/SWRL

Variants of WSML



WSML Conceptual Syntax for Ontologies

- Ontologies
- Namespaces
- Imported Ontologies
- Used Mediators

Extra-Logical declarations

- Concepts
- Relations
- Functions
  - Special kind of relation
- Instances
  - Explicitly defined in ontology
  - Retrieved from external instance store
- Axioms

Logical Declarations

Non-Functional Properties

WSML Logical Expressions

- Frame- and first-order-based concrete syntax (BNF Grammar in D2, Appendix B)
- Elements:
  - Function symbols (e.g. `f()`)
  - Molecules (e.g. `Human` **`subClassOf`** `Animal`, `John` **`memberOf`** `Human`, `John[name` **`hasValue`** `'John Smith']`).
  - Predicates (e.g. `distance(to:?x, from:?y, distance:?z)`)
  - Logical connectives (**`or`**, **`and`**, **`not`**, **`implies`**, **`equivalent`**, **`impliedBy`**, **`forall`**, **`exists`**)
- Example:

```
    ?x memberOf Human
equivalent
    ?x memberOf Animal and ?x memberOf LegalAgent.
```

WSML Goals and Web Services

- Goal / Web Service
  - assumptions
  - effects
  - pre-conditions
  - post-conditions

  are defined through WSML logical expressions
- Logical expressions are based on ontologies

WSML-Flight - Example

Conceptual Syntax

```
concept ticket
    origin ofType location
    destination ofType location
    departure ofType xsd:dateTime
    arrival ofType xsd:dateTime
    fare ofType price
```

```
axiom validDates
    definedBy
        <- ?x memberOf ticket[arrival hasValue ?y,
                departure hasValue ?z] and ?y < ?z.
```

Logical Expression Syntax

WSML Summary

- Formal languages for WSML
- Variants:
  - WSML-Core
  - WSML-Flight
  - WSML-Rule
  - WSML-DL
  - WSML-Full
- Modular, Frame-based
- Conceptual syntax vs. Logical Expressions
- Syntaxes:
  - Human readable
  - XML
  - OWL/RDF

Using WSMO to address Web Services problems

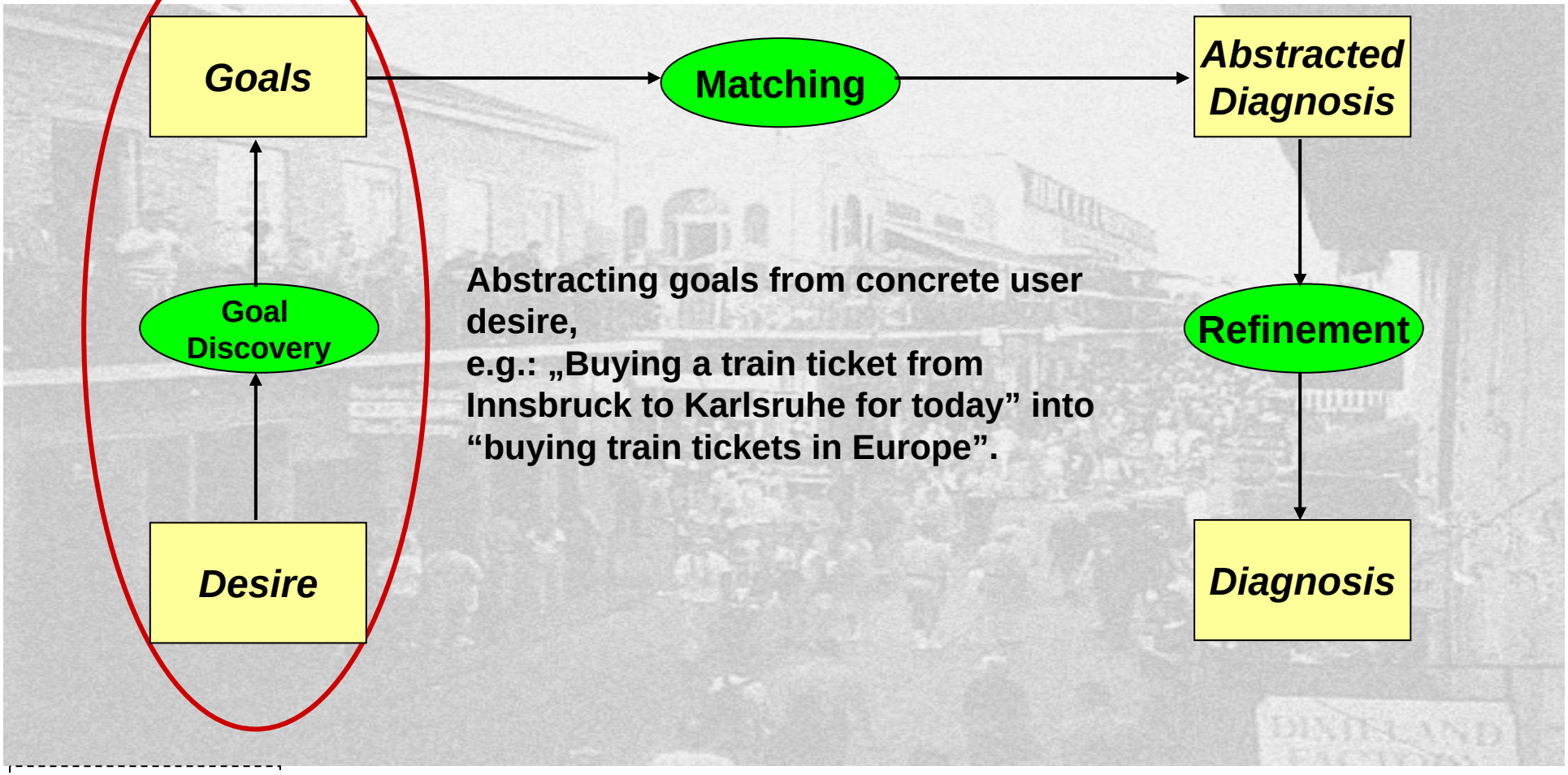
Adrian Mocan

WSMO Discovery - Foundations

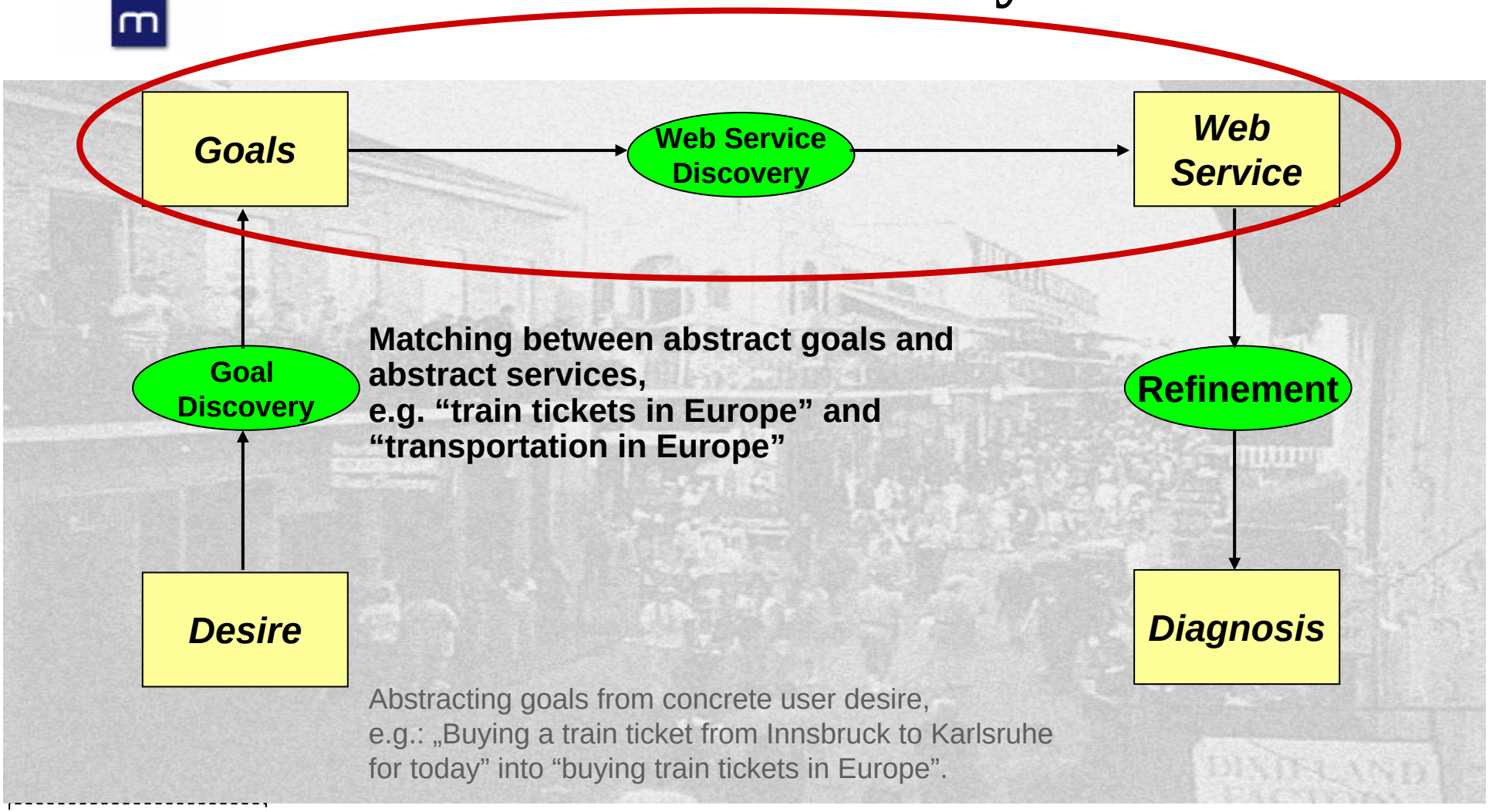
- "Web service" and "service" have to be distinguished:
  - *Web service*: a computational entity able to perform many services, e.g. Amazon Web service
  - *Service*: a concrete invocation of a Web service, e.g. buying „Silver Bullet" for EUR 37,40 with free delivery within 2-3 days.
- Heuristic Classifications (William J. Clancey, 1985)
  - *Abstraction*
    - Process of translating concrete descriptions into features usable for classification, e.g. a concrete body temperature into „lower fever"
  - *Matching*
    - Inferring potential classification or solutions from extracted features
  - *Refinement*
    - Inferring final diagnoses; it may include the acquisition of new features describing the given case

WSMO Discovery

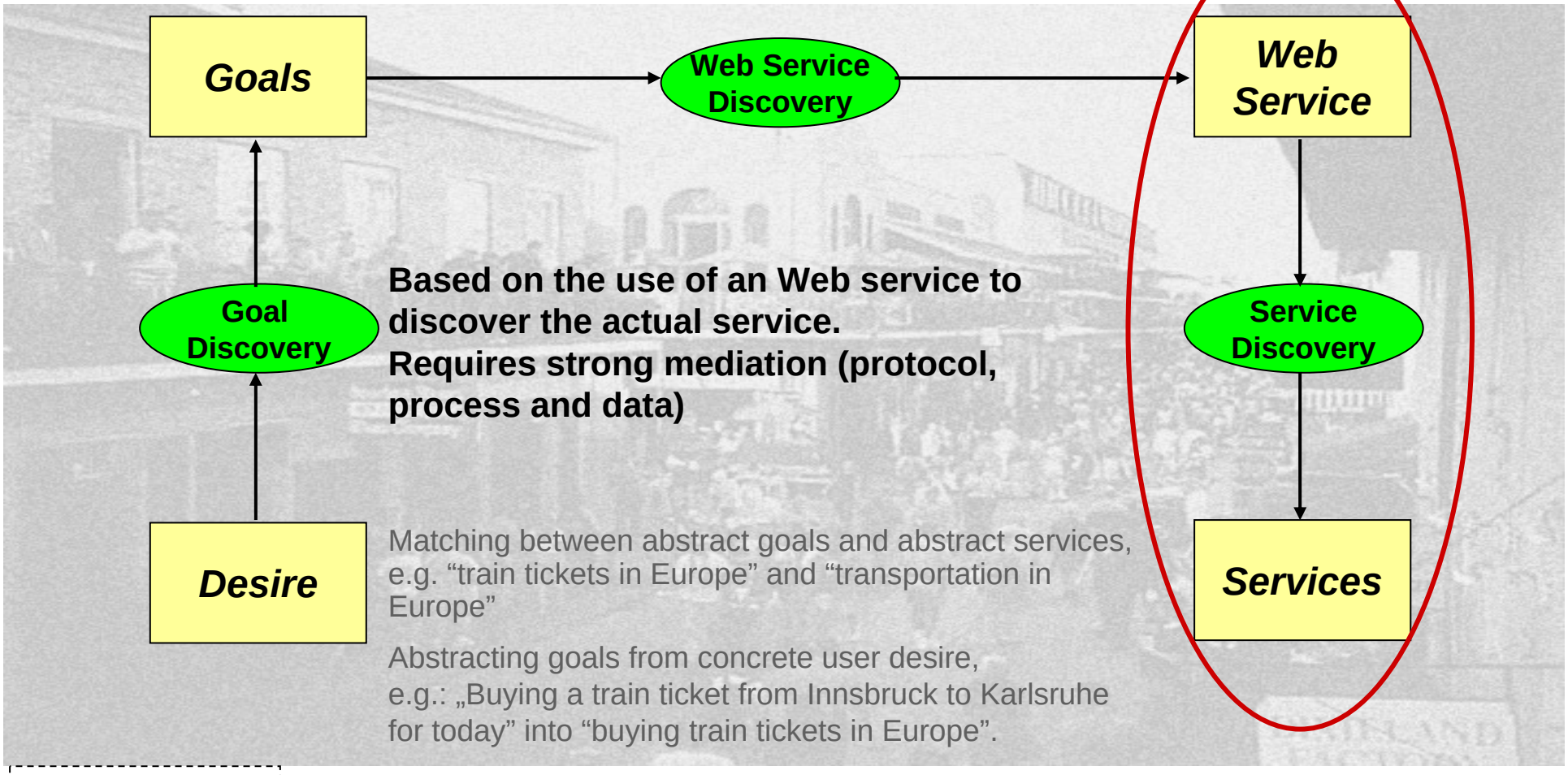
WSMO Discovery



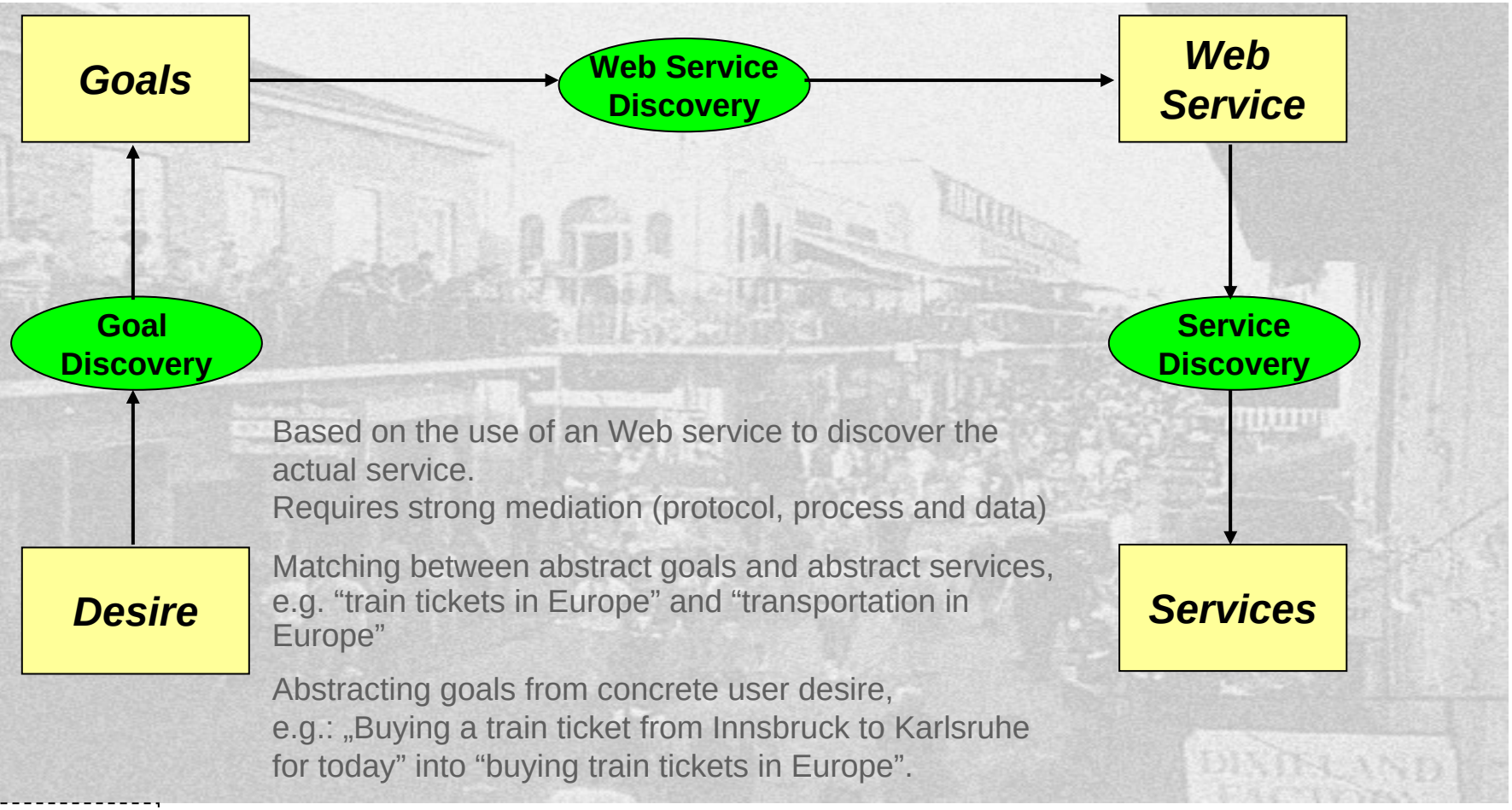
WSMO Discovery



WSMO Discovery



WSMO Discovery



Based on the use of an Web service to discover the actual service.
Requires strong mediation (protocol, process and data)

Matching between abstract goals and abstract services, e.g. “train tickets in Europe” and “transportation in Europe”

Abstracting goals from concrete user desire, e.g.: „Buying a train ticket from Innsbruck to Karlsruhe for today” into “buying train tickets in Europe”.

Description and Discovery

Capability descriptions - Levels of abstraction & possible accuracy

What? (Syntactically)

→ Syntactic capability

perhaps complete & perhaps correct

What? (Semantic „Light“)

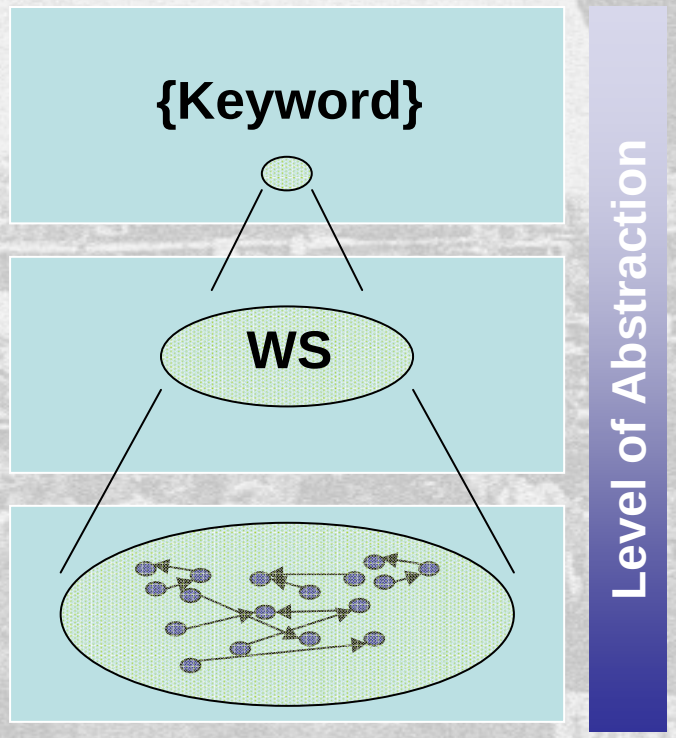
→ Abstract capability

complete & perhaps correct

What & When? (Semantic „Heavy“)

→ Concrete capability

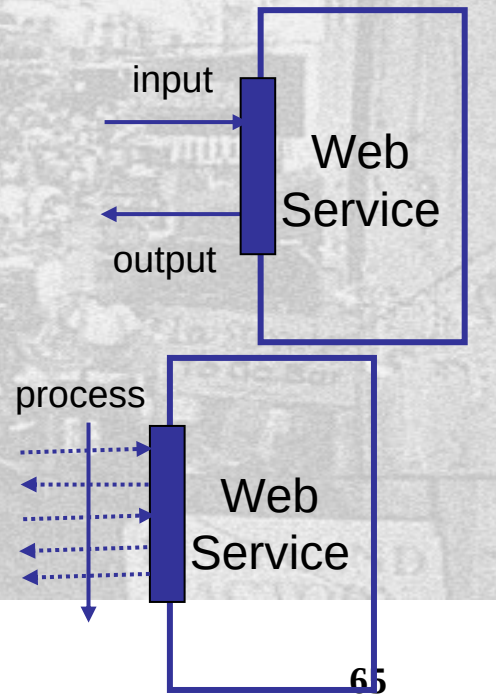
complete & correct
(if user input known & interaction)



Web Service Composition

"Automated selection, composition, and interoperation of [existing] Web services to perform some complex task, given a high-level description of an objective."

- Web services are described at two abstraction levels:
  - functional (or capability) level
    - the focus is on the service inputs, outputs, preconditions, and effects
    - WSMO capability model
  - process level
    - the Web service is defined by an activity flow or an interaction pattern
    - WSMO interface model



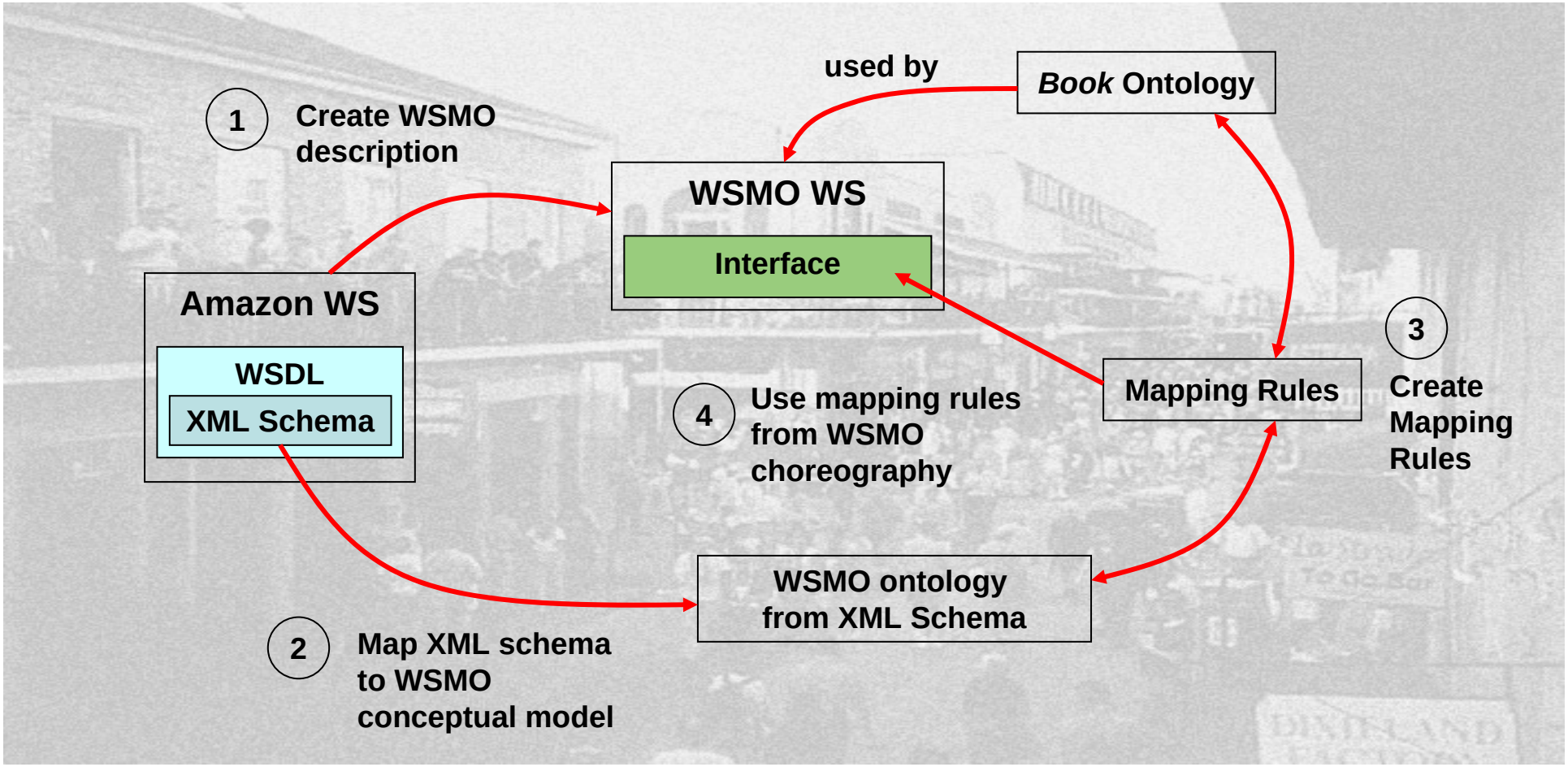
Functional-level vs. process-level - Composition task -

- Functional-level composition
  - select a set of services that, combined in a suitable way, are able to match a given objective:
    - Given the requirements for a trip (destination, duration, budget…), find the services that are necessary to prepare the trip (Deutsche Bahnhof, Hotels@Karlsruhe, Hertz…)
- Process-level composition
  - define an interaction pattern with the selected services, so that an executable implementation of the composition is obtained:
    - Find the correct order for the interactions with the selected services (e.g., interactions with train and hotel have to be interleaved to guarantee consistency of arrival and departure dates)

Service Grounding – WSMO

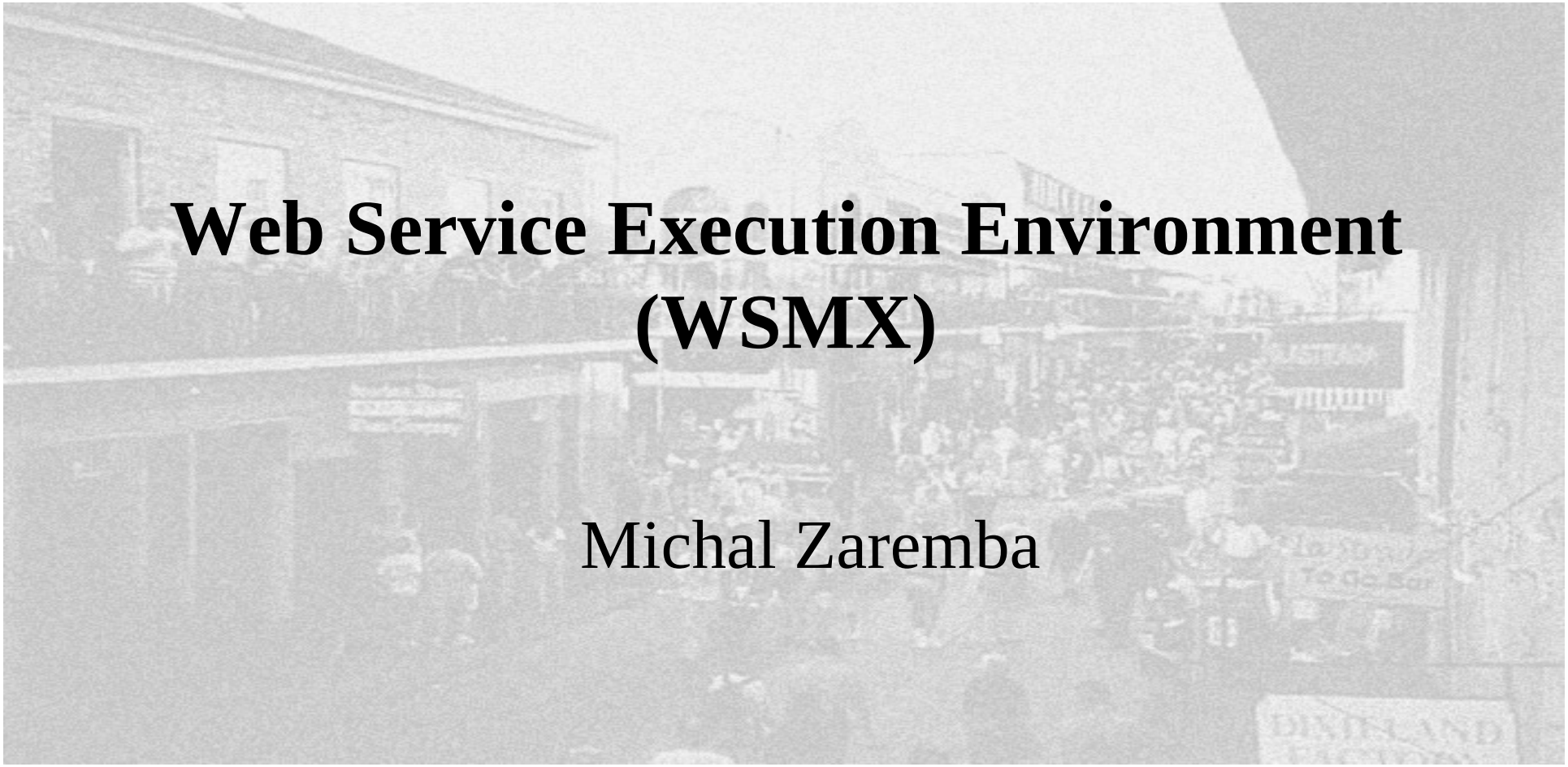
- Deal with existing WSDL services
  - Map from XML Schema used in WSDL to WSMO
  - Use existing tools to mediate from WSMO ontology to WSMO ontology
- Also investigating
  - Using XSLT to map from XML-S of WSDL directly to WSML/XML of ontology used by WSMO description
- Ultimate aim to have **semantic** description of interface grounding in the choreography

Service Grounding – WSMO



Conclusion: **How WSMO Addresses WS problems**

- **Discovery**
  - Provide formal representation of capabilities and goal
  - Conceptual model for service discovery
  - Different levels to Web Service discovery
- **Composition**
  - Provide formal representation of capabilities and choreographies
- **Invocation**
  - Support any type of WS invocation mechanism
  - Clear separation between WS description and implementation
- **Guaranteeing Security and Policies**
  - No explicit policy and security specification yet
  - Proposed solution will interoperate with WS standards
- **Mediation and Interoperation**
  - Mediators as a key conceptual element
  - Mediation mechanism not dictated
  - (Multiple) formal choreographies + mediation enabled interoperation
- The solutions are envisioned maintaining a strong relation with existing WS standards



Web Service Execution Environment (WSMX)

Michal Zaremba

Overview

- WSMX Overview
- Components and System Architecture
- Interrelationship of components
  - Execution semantics
- Component interfaces
  - Data flow between components

WSMX Introduction

- WSMX is a software framework that allows runtime binding of service requesters and service providers
- WSMX interprets service requester goal to
  - Discover matching services
  - Select the service that best fits
  - Provide data mediation if required
  - Make the service invocation
- WSMX is based on the conceptual model provided by WSMO
- WSMX has a formal execution semantics
- WSMX has service oriented and event-based architecture based on microkernel design using such enterprise technologies as J2EE, Hibernate, Spring, JMX, etc.

WSMX Design Principles

Strong Decoupling & Strong Mediation

autonomous components with mediators for interoperability

Interface vs. Implementation

distinguish interface (= description) from implementation (=program)

Peer to Peer

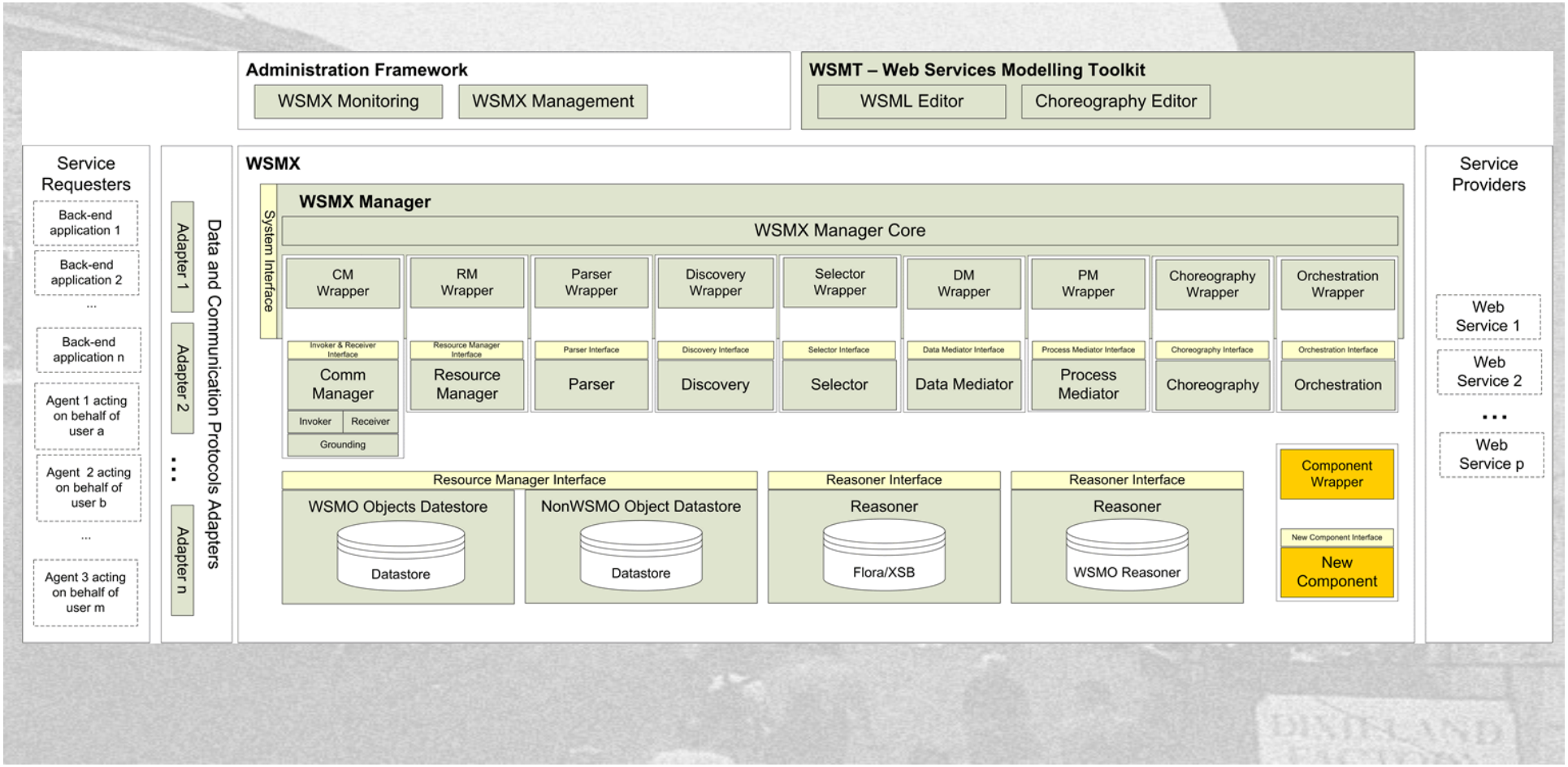
interaction between equal partners (in terms of control)

WSMO Design Principles == WSMX Design Principles == SOA Design Principles

Scope of WSMX Development

- Reference implementation for WSMO
- Complete architecture for SWS discovery, mediation, selection and invocation
- Example of implemented functionality - achieving a user-specified goal by invoking WS described with the semantic markup

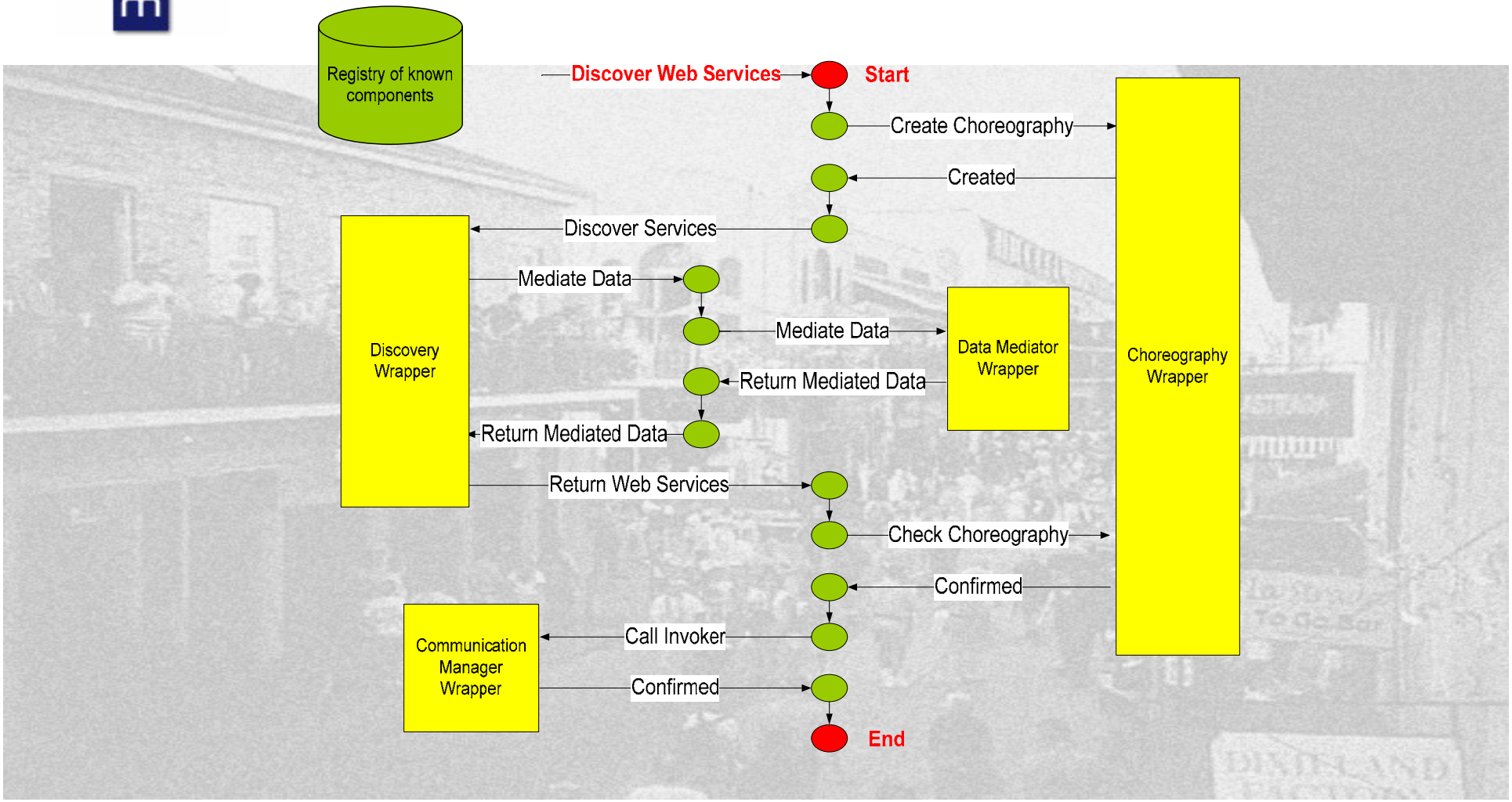
System Architecture



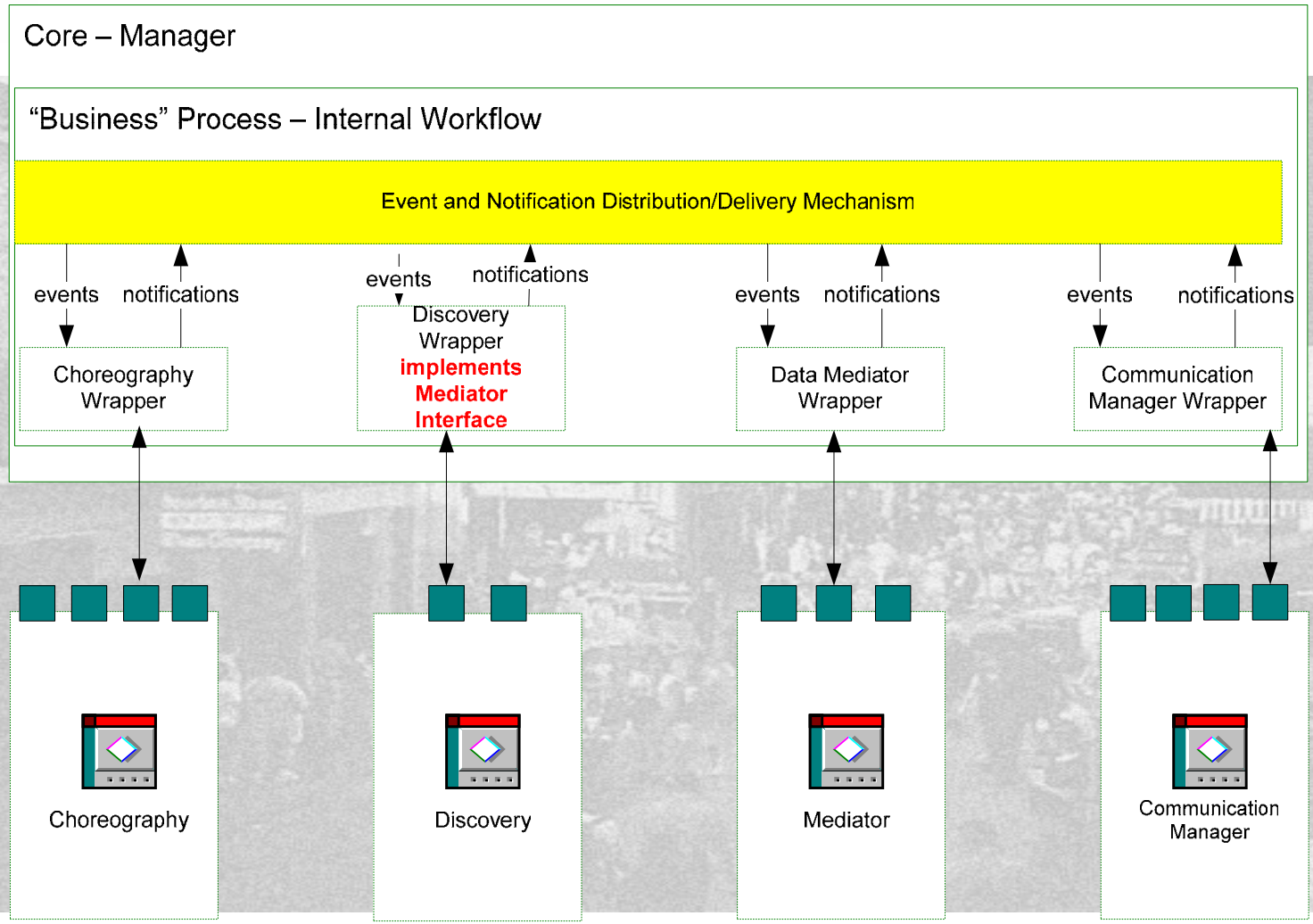
Dynamic Execution Semantics

- WSMX consists of loosely coupled components
- Components might be dynamically plug-in or plug-out
- Execution Semantics - invocation order of components
- Event-based implementation
- New execution semantics can appear in the future including new components
- We need a flexible way to create new execution semantics and deploy them in the system
- Ultimate goal is to execute workflow definition describing interactions between system components

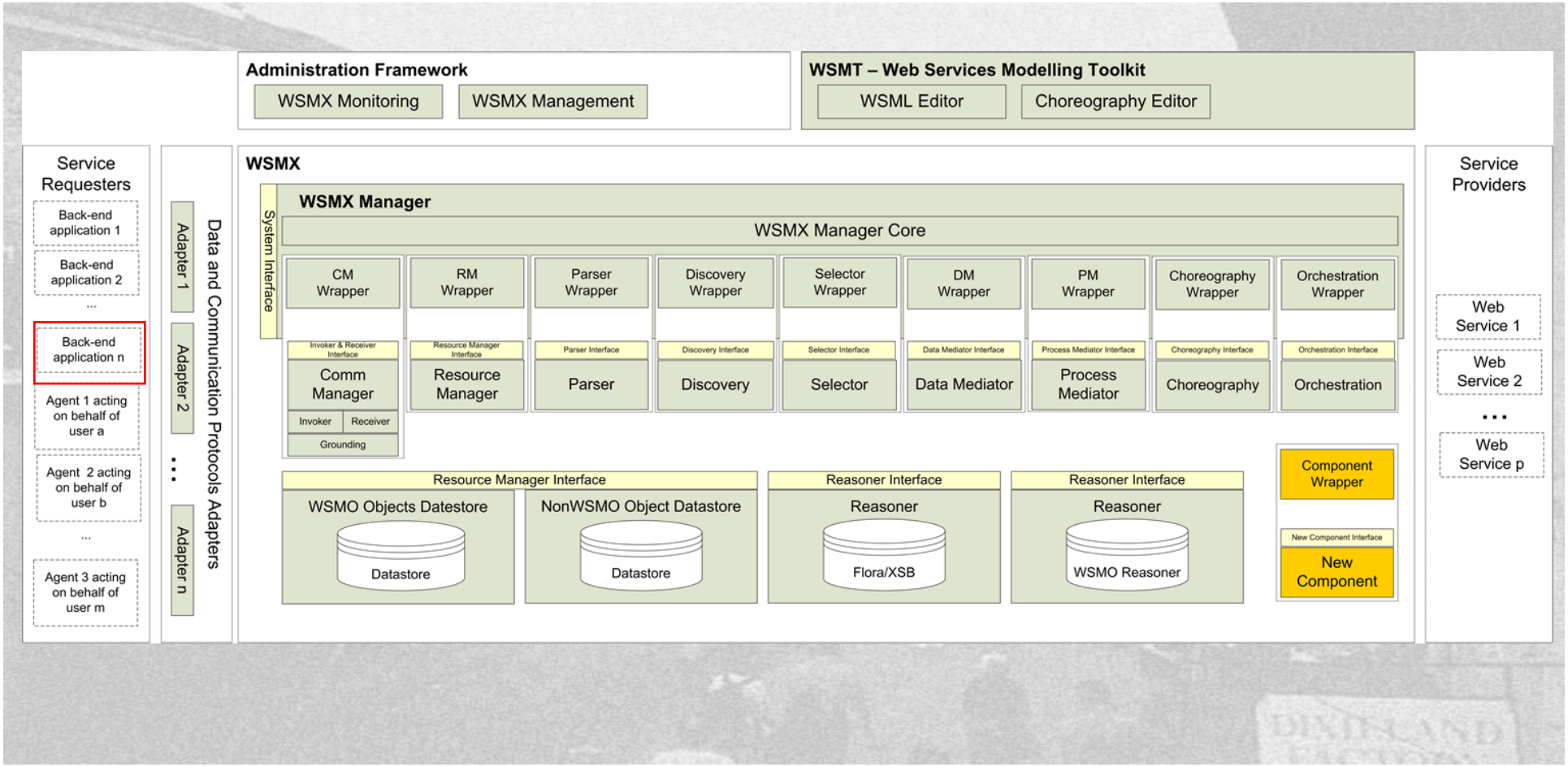
Define “Business” Process



Event-based Implementation



System Architecture



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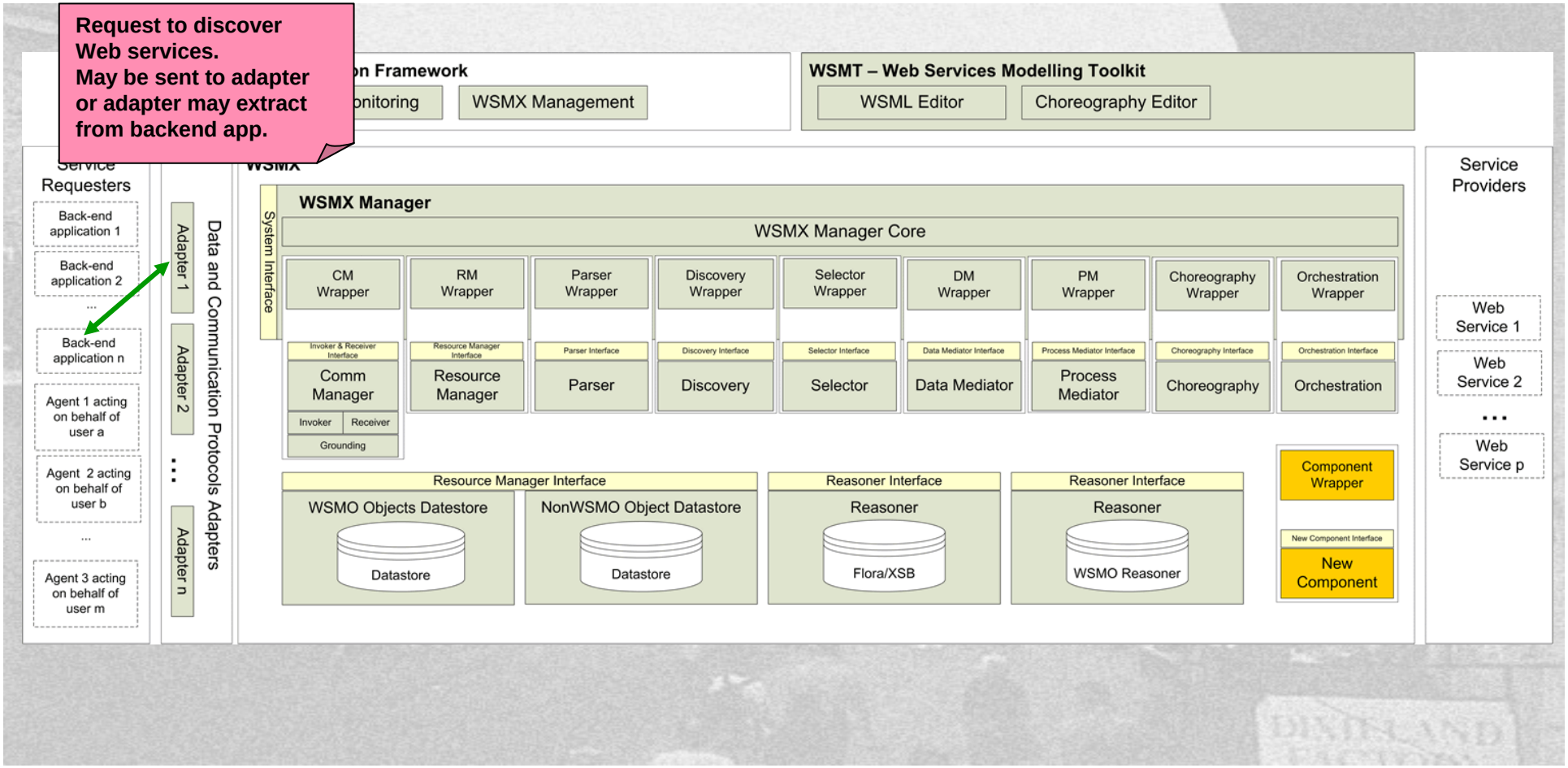

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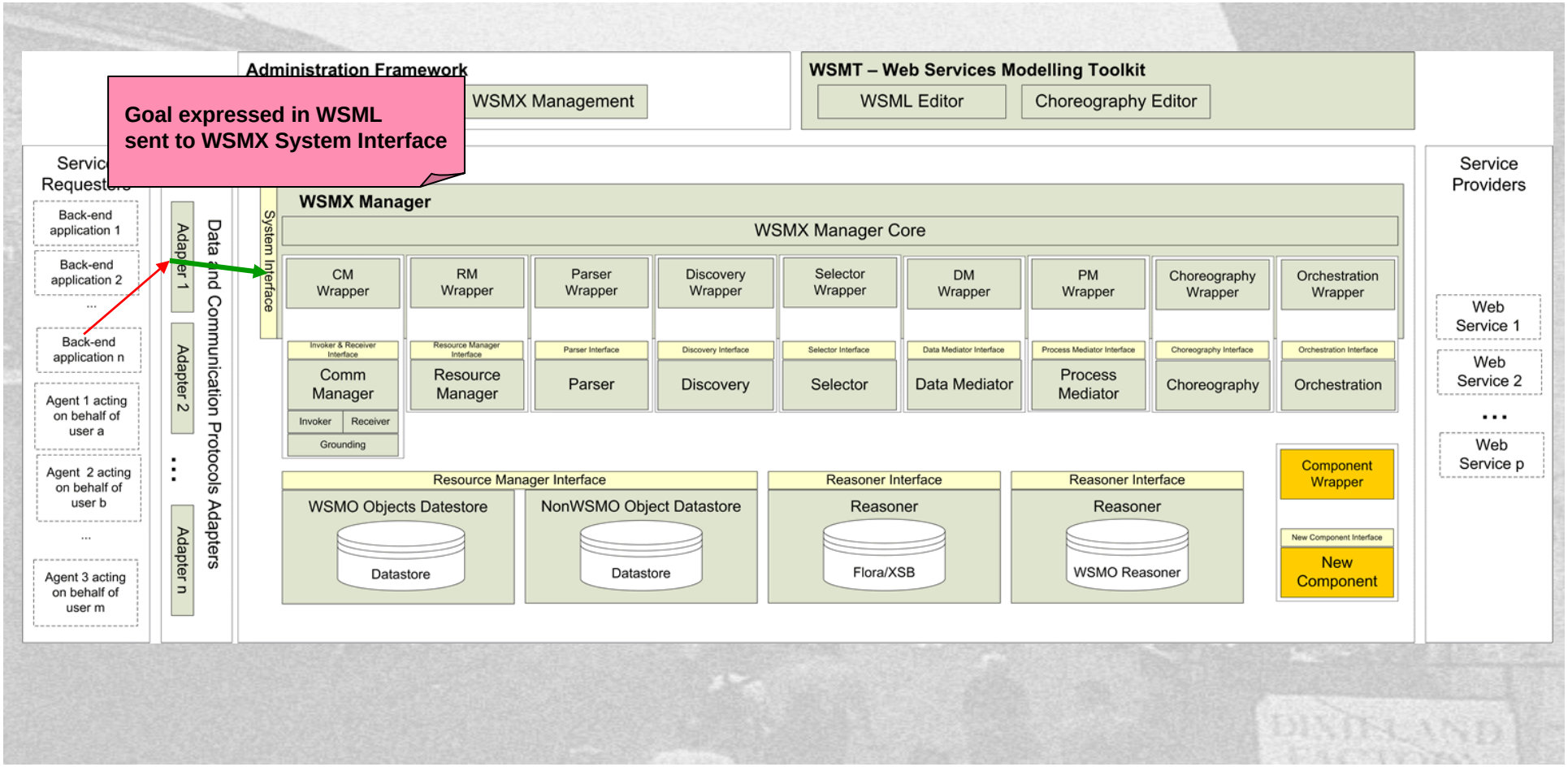

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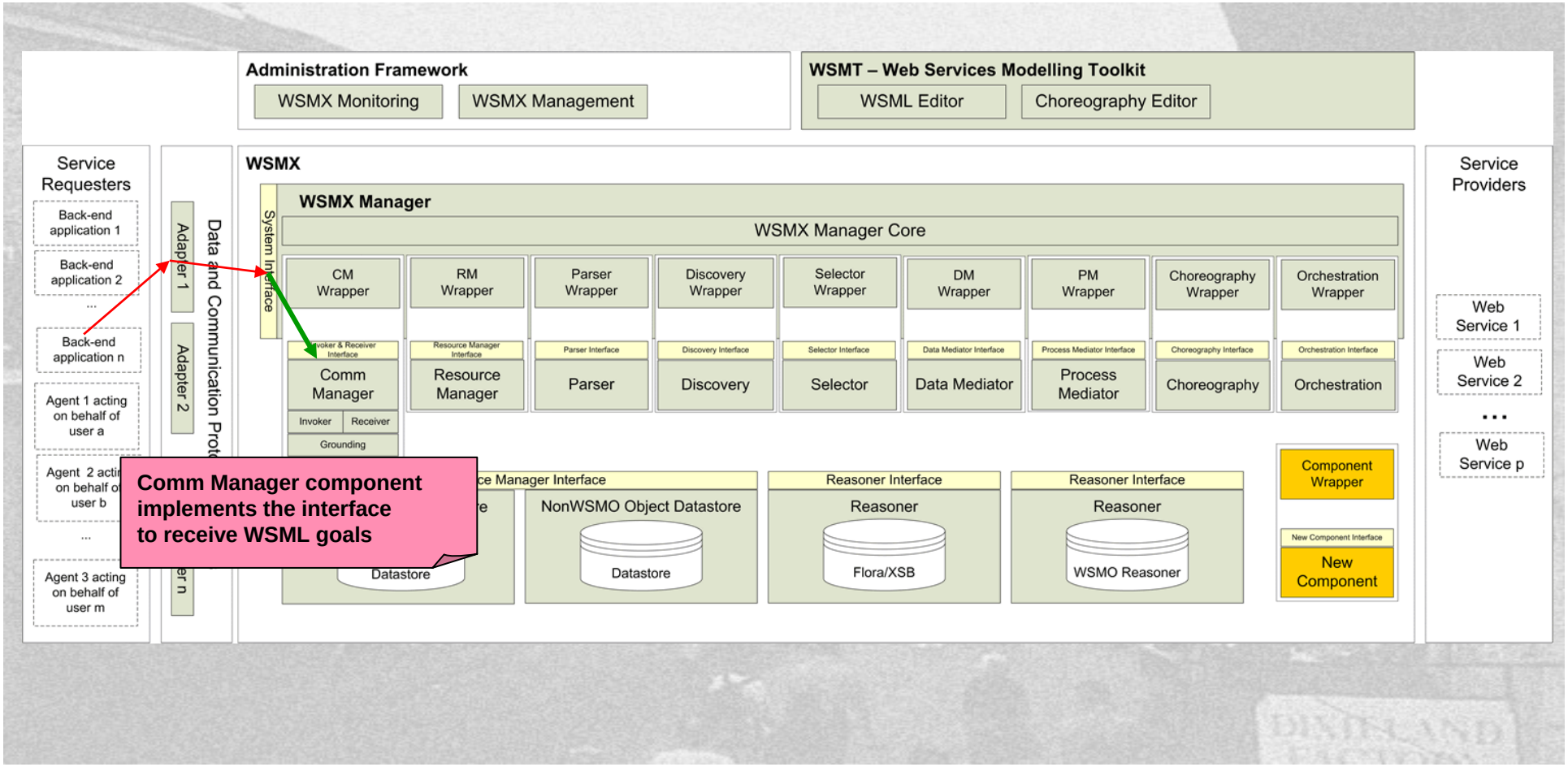

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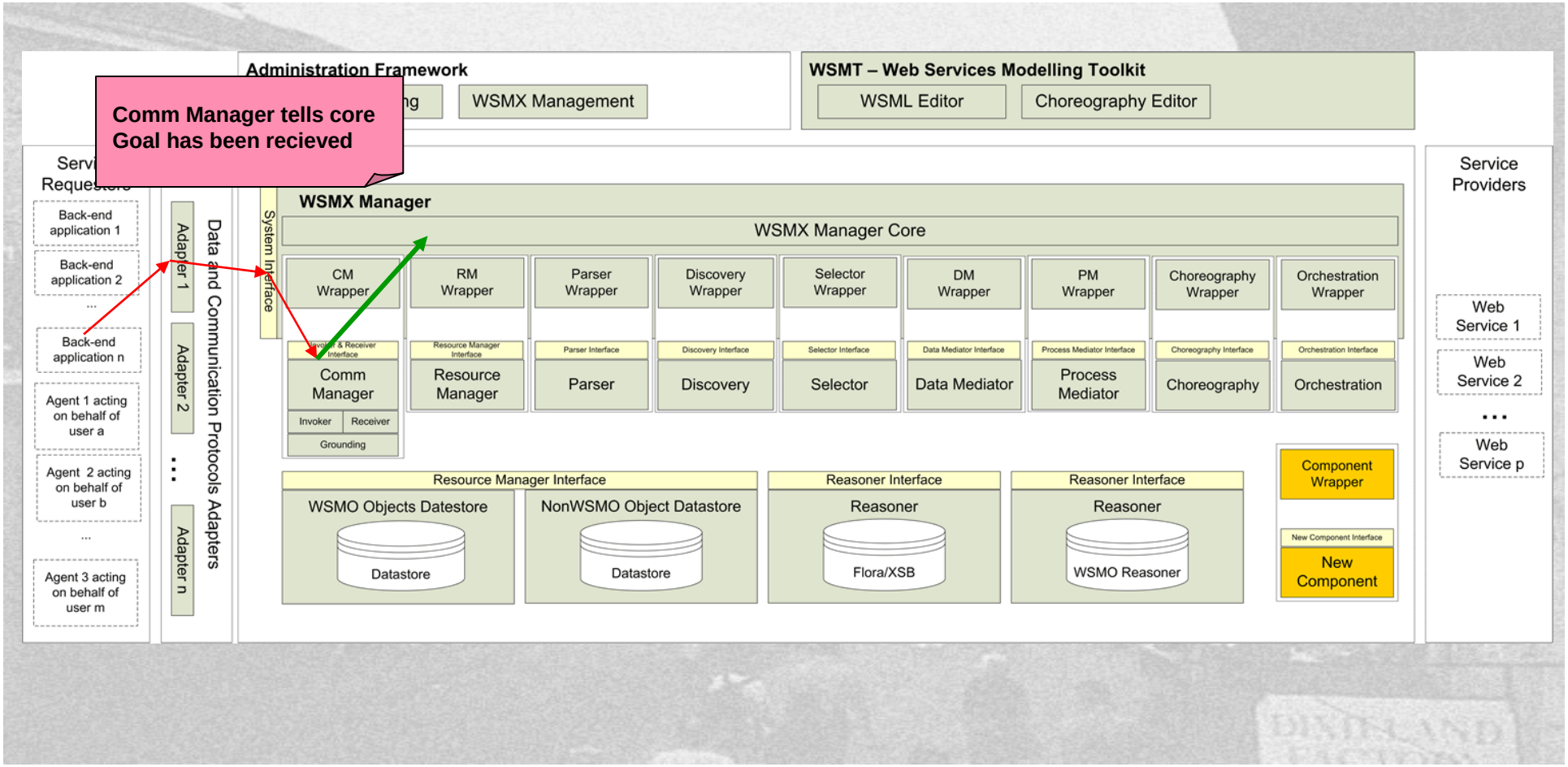

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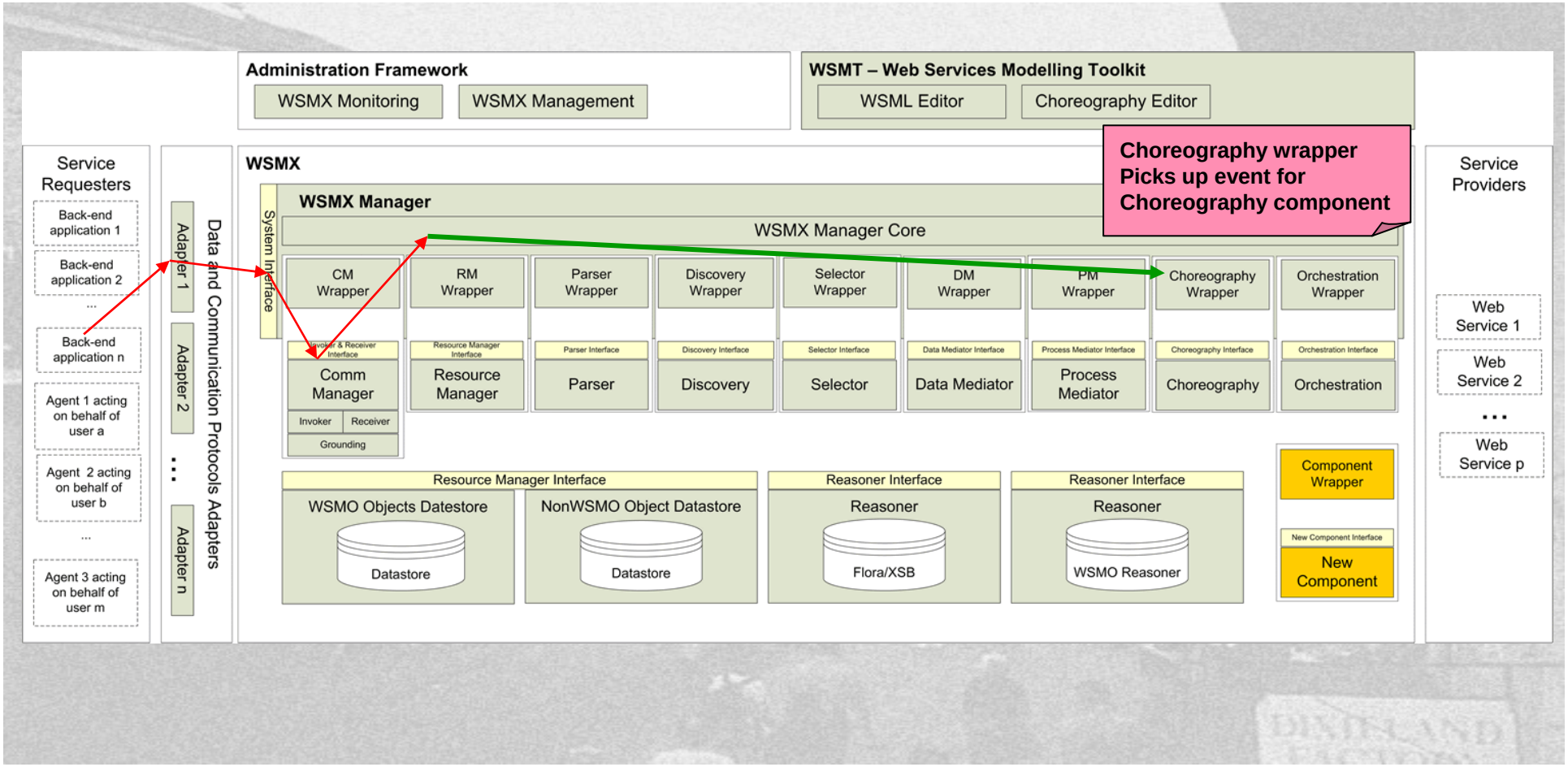

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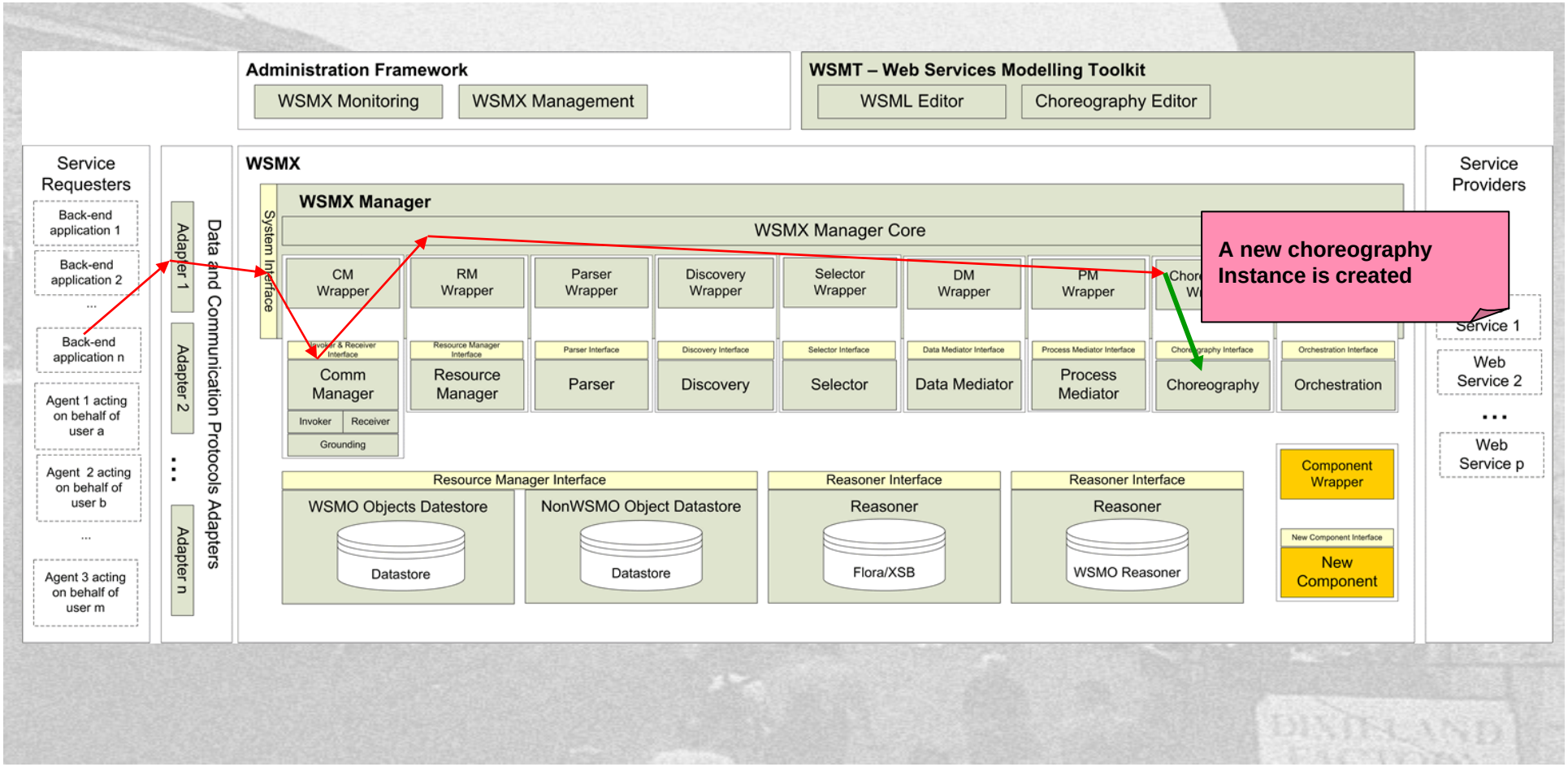

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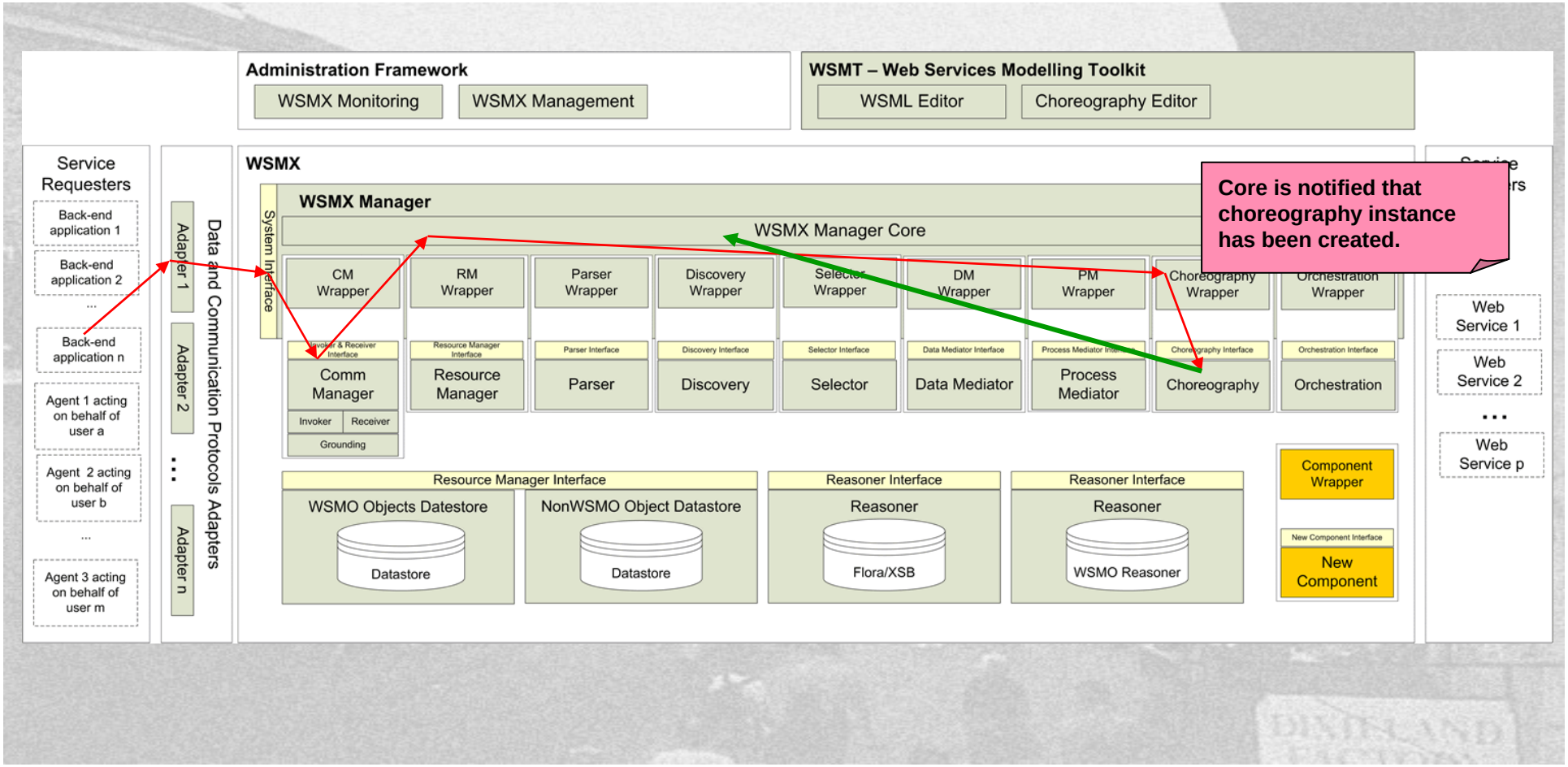

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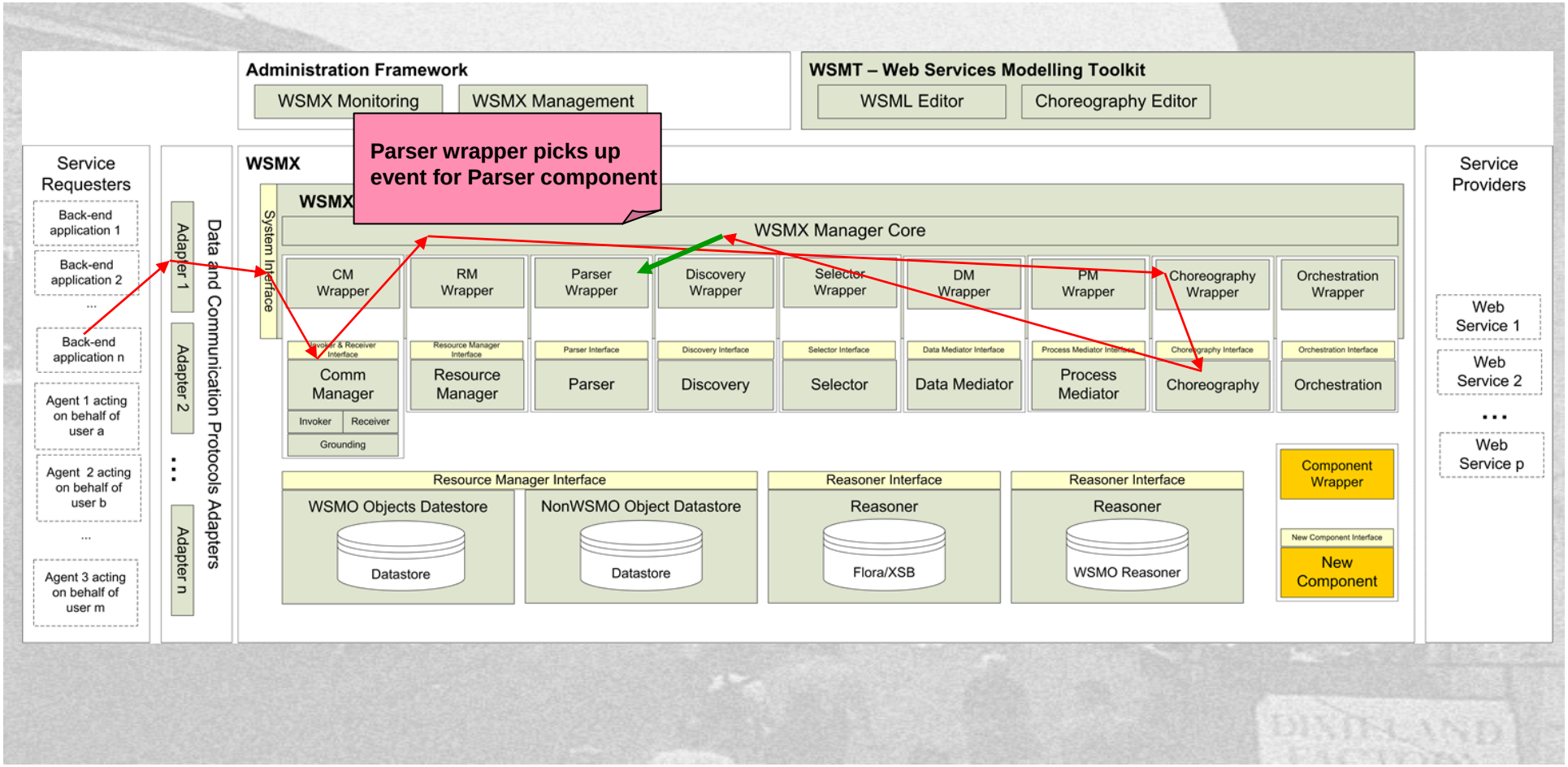

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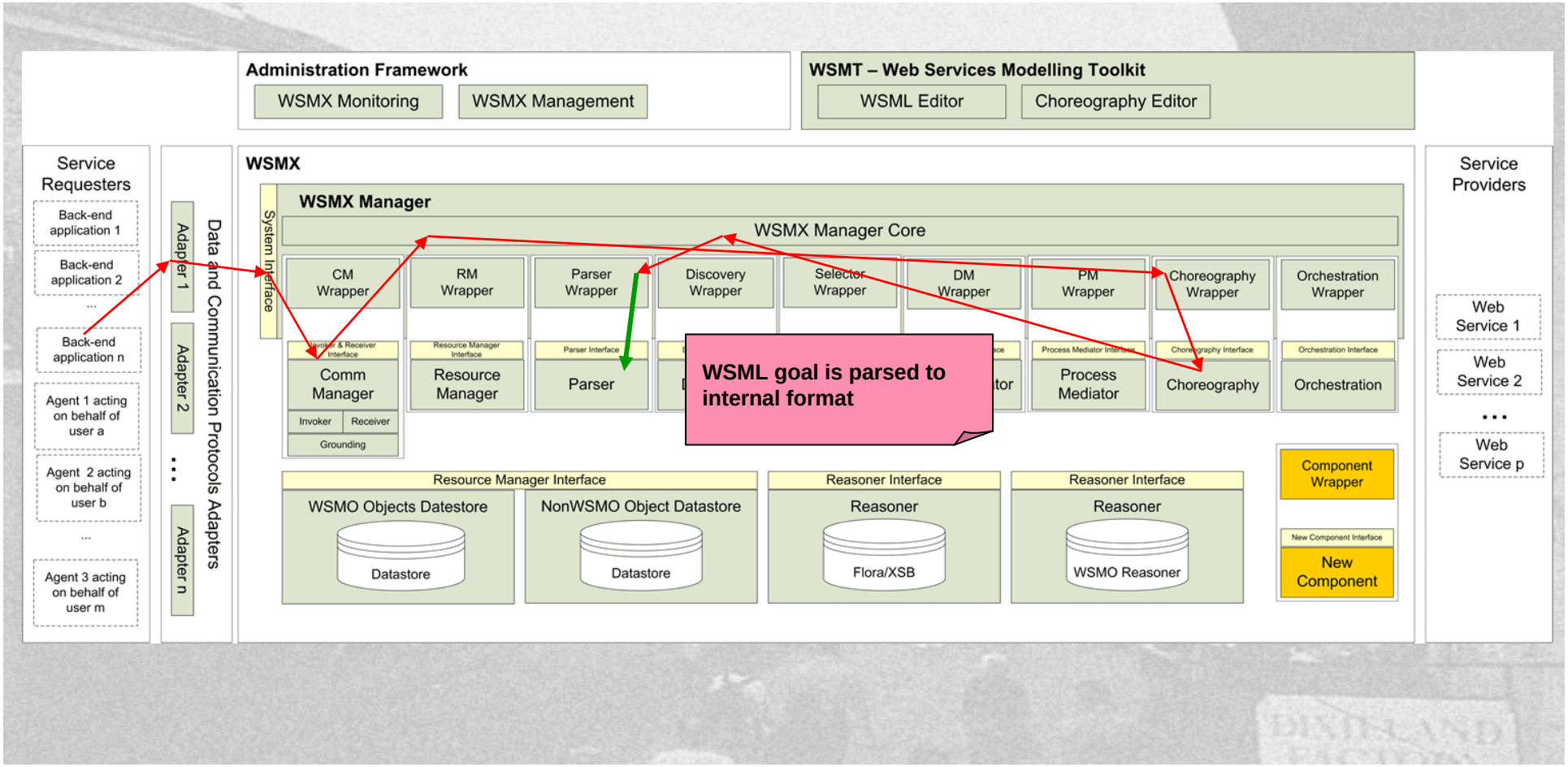

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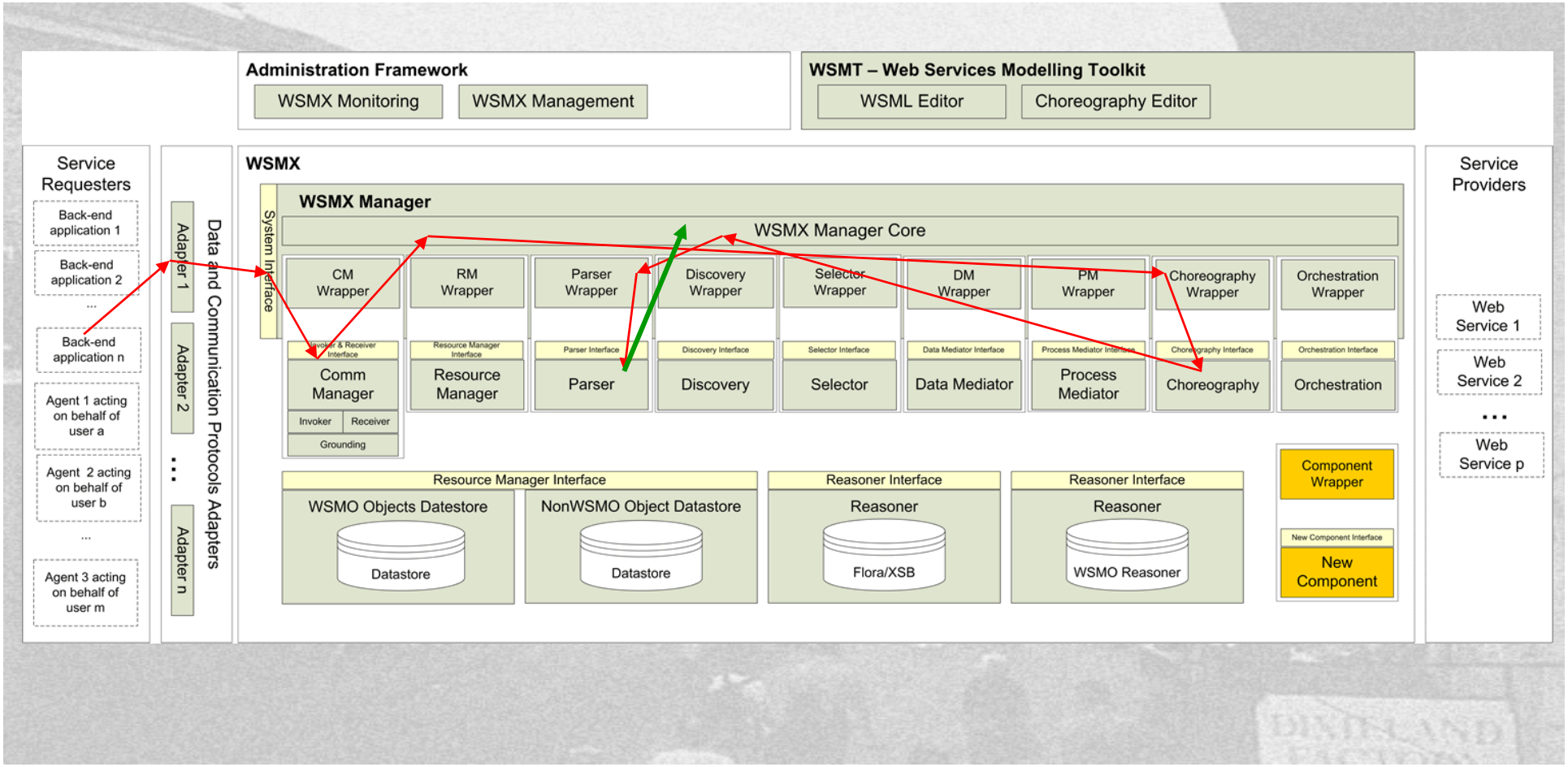

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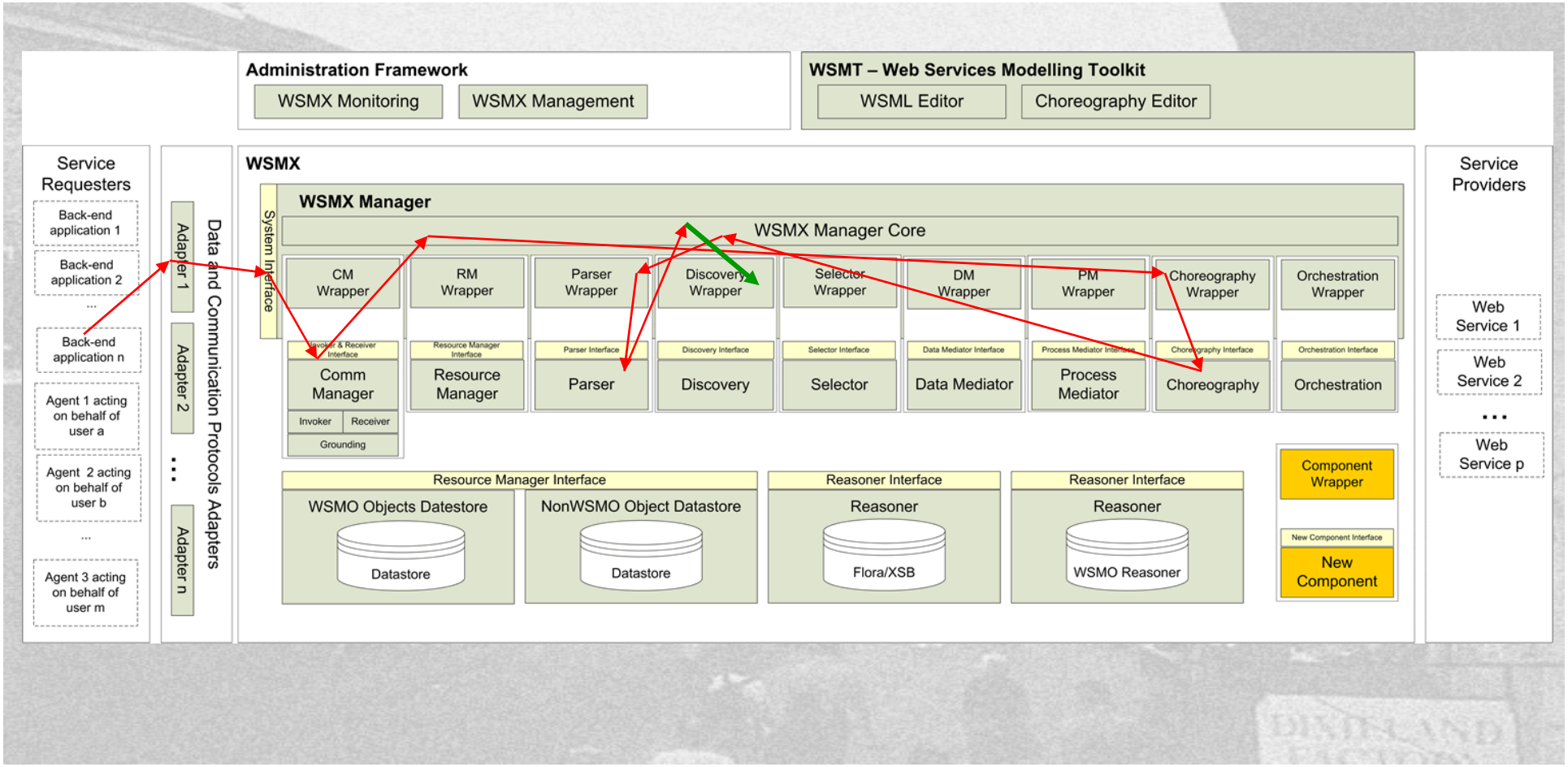

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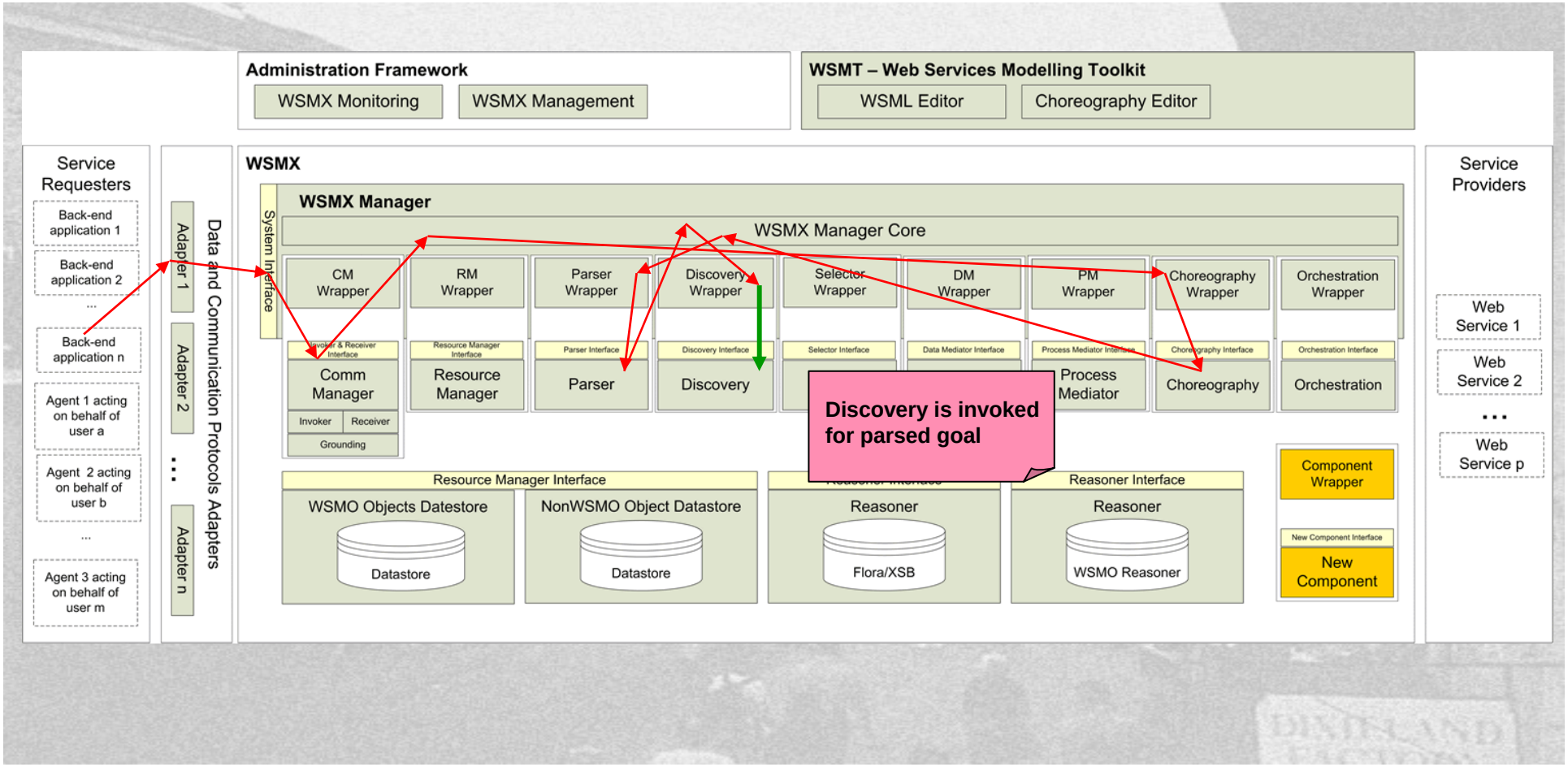
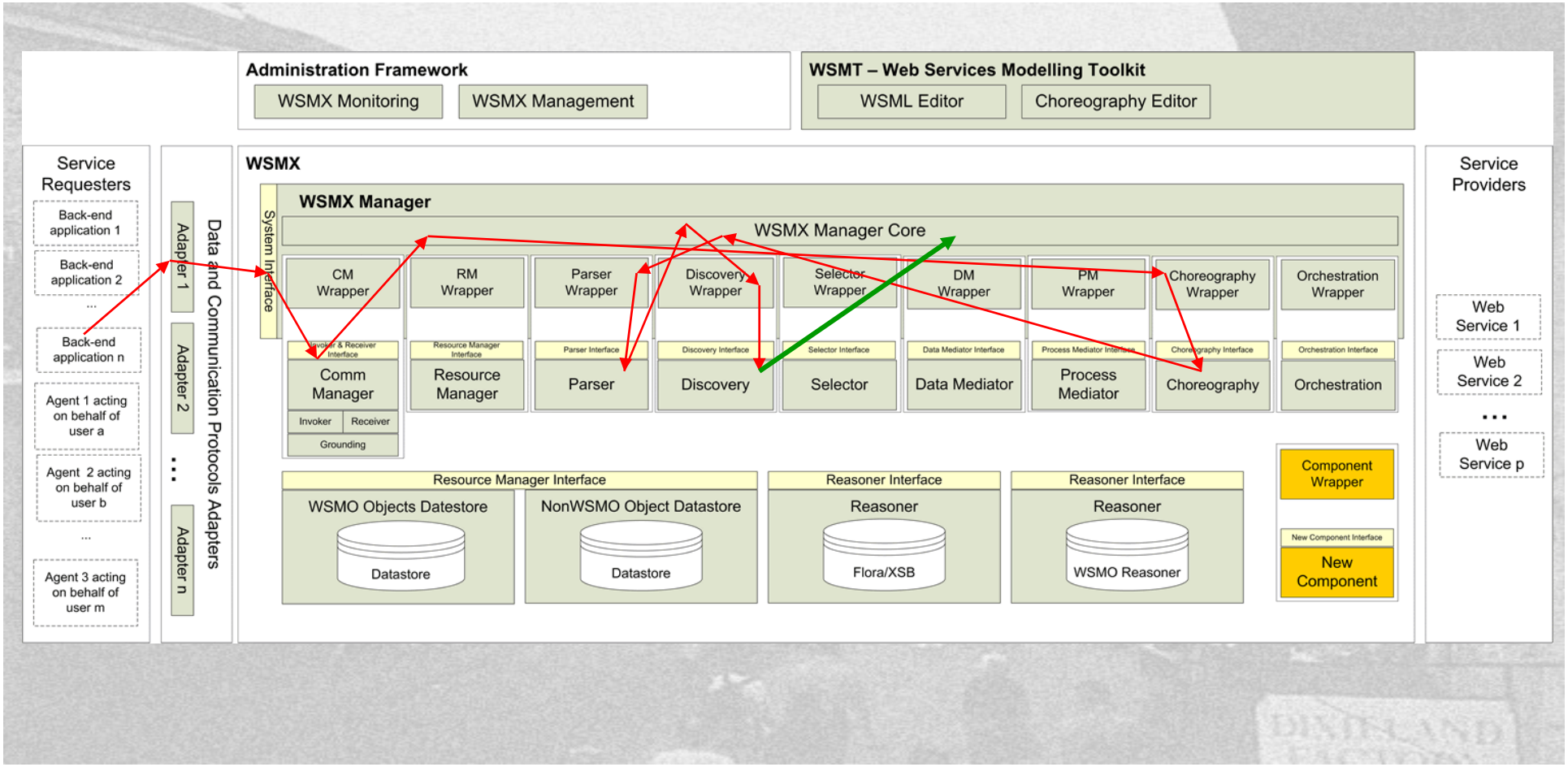


System Architecture



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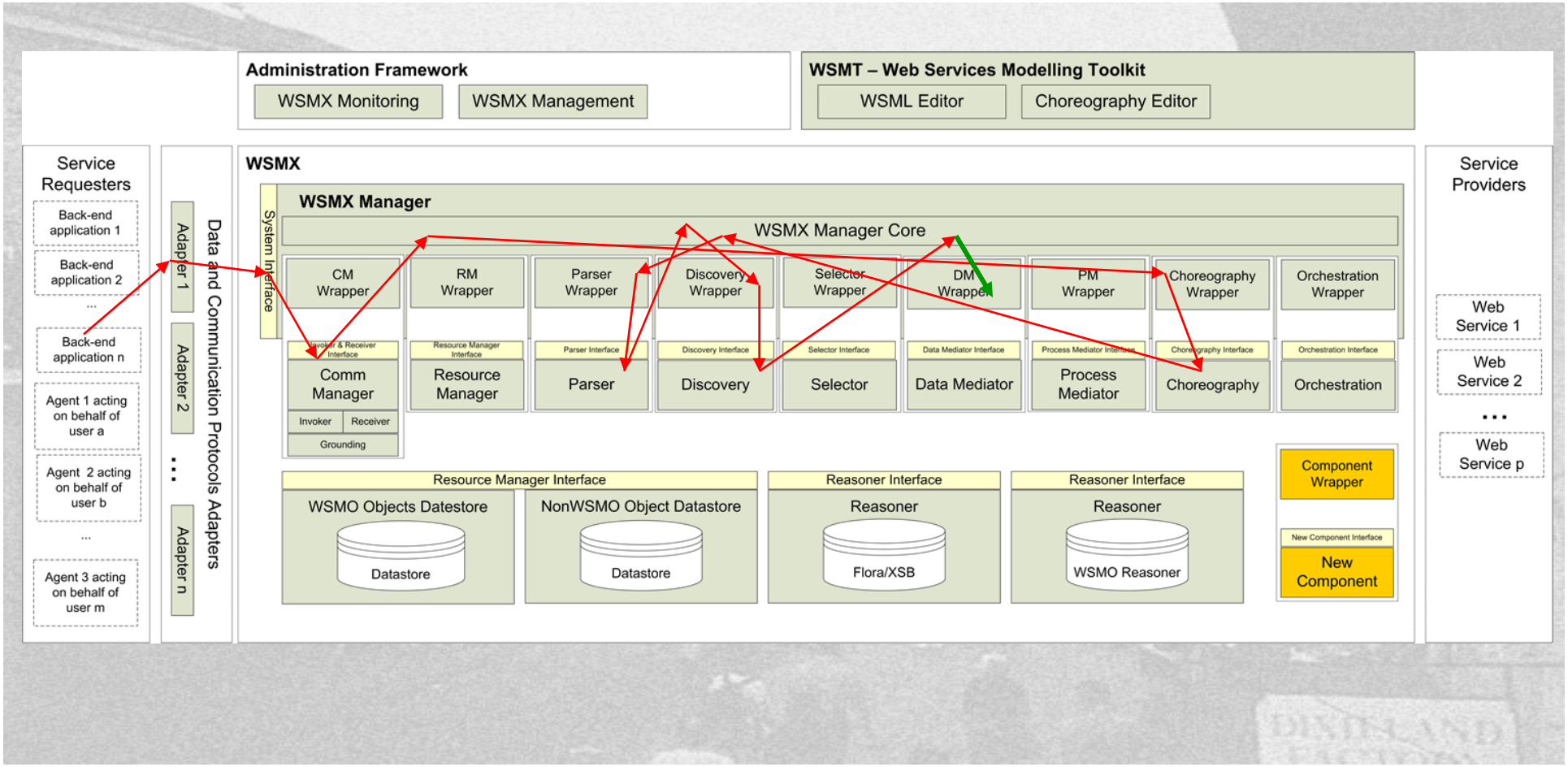

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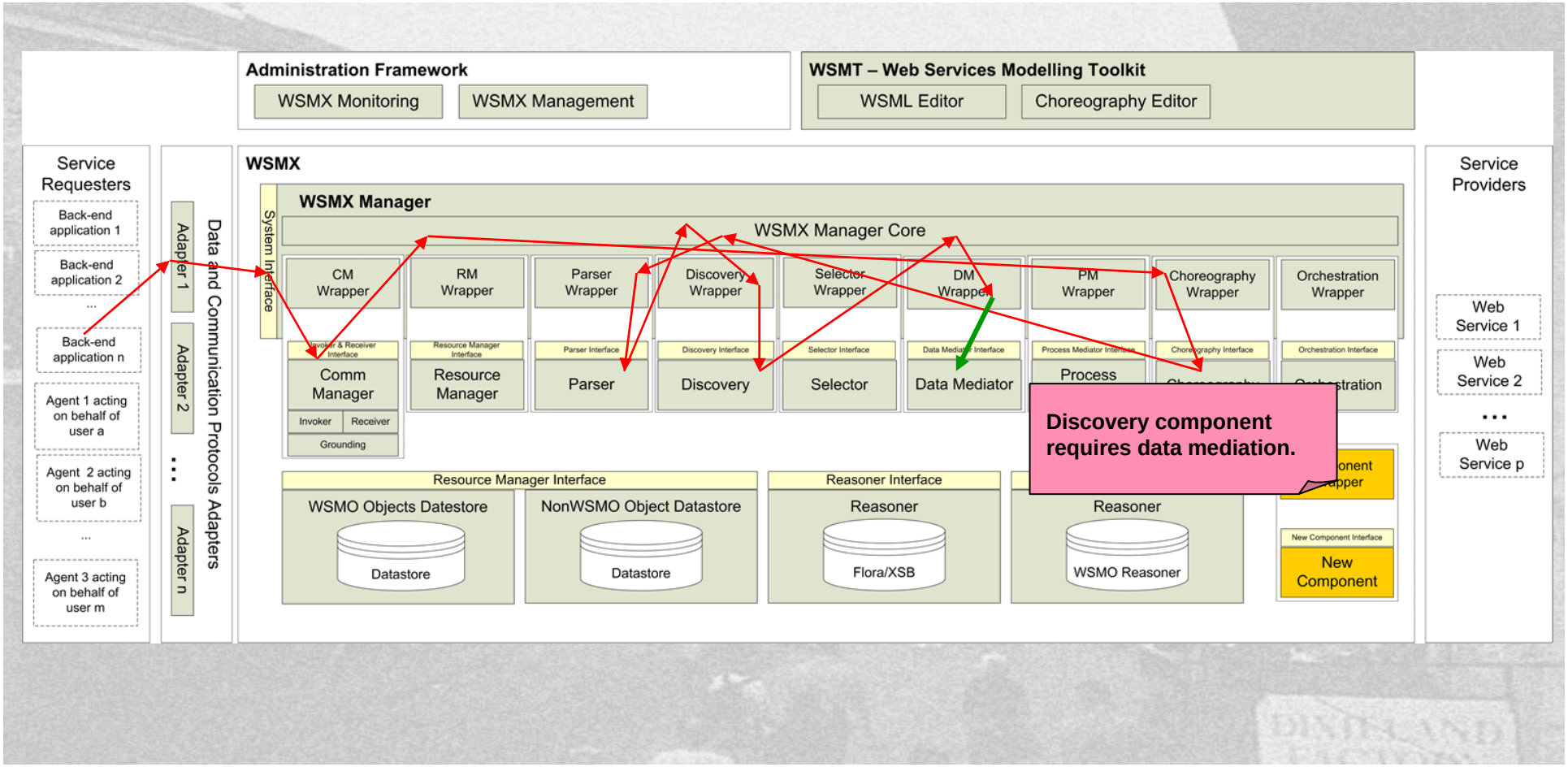

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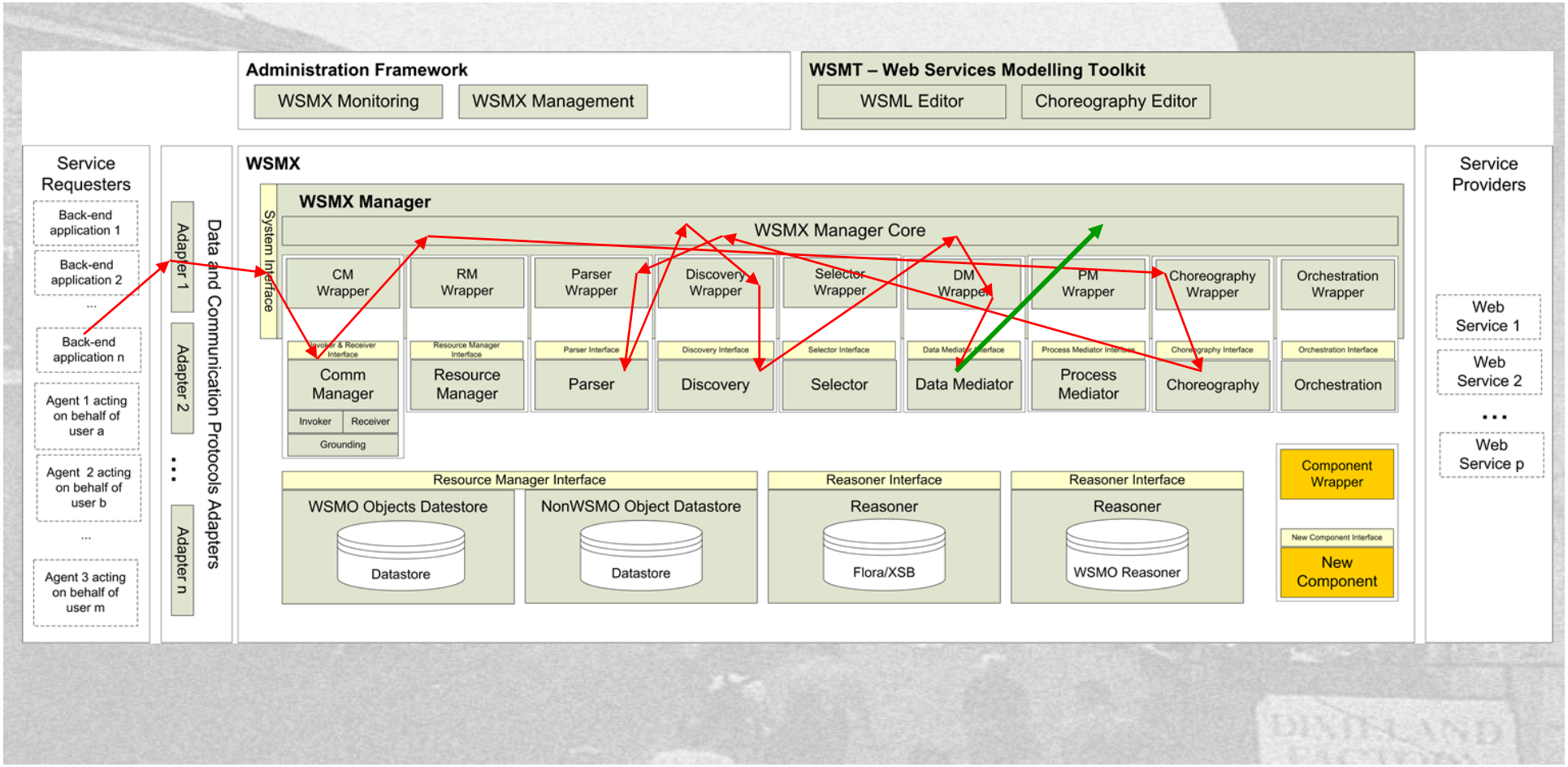

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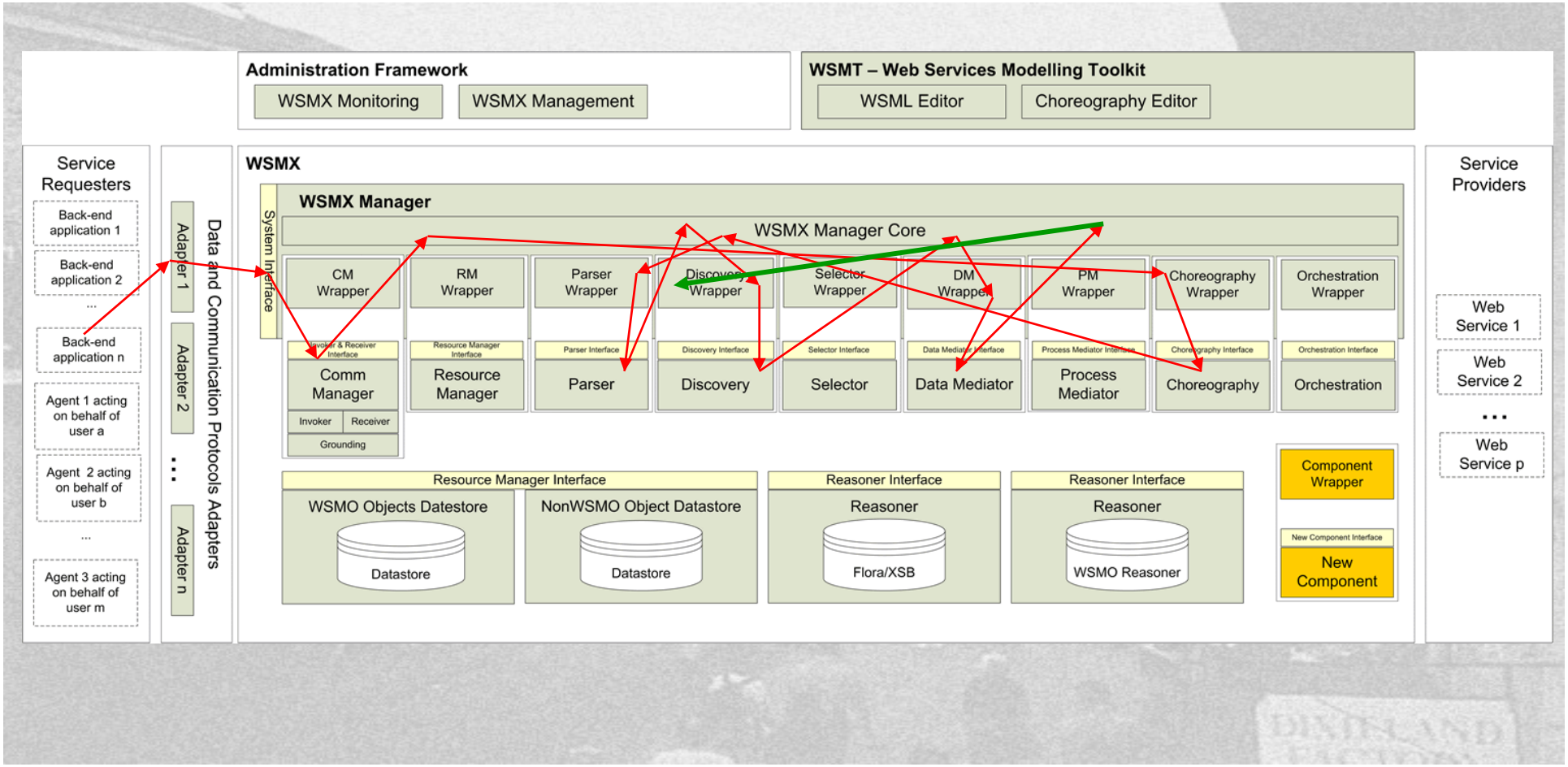

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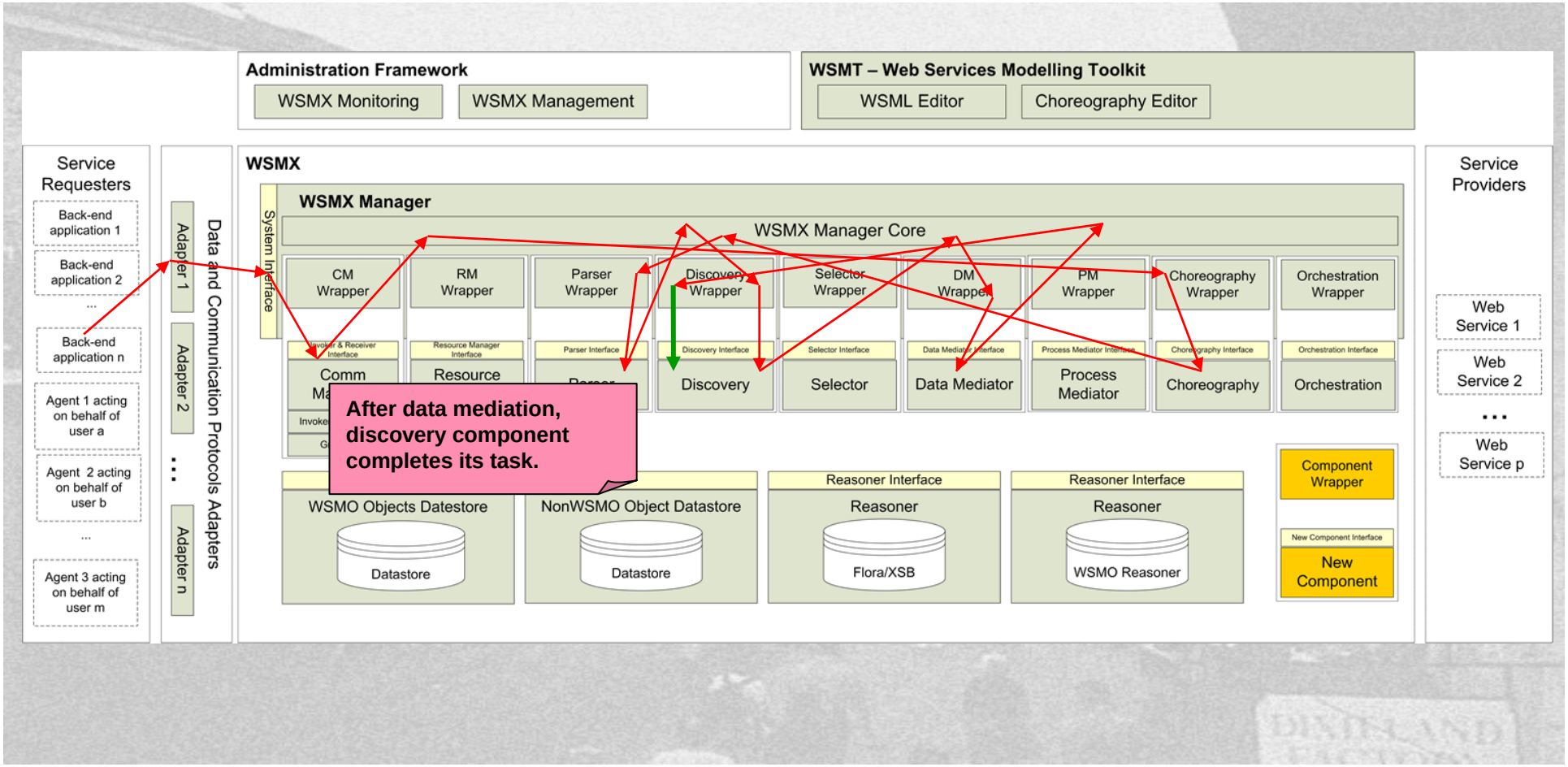

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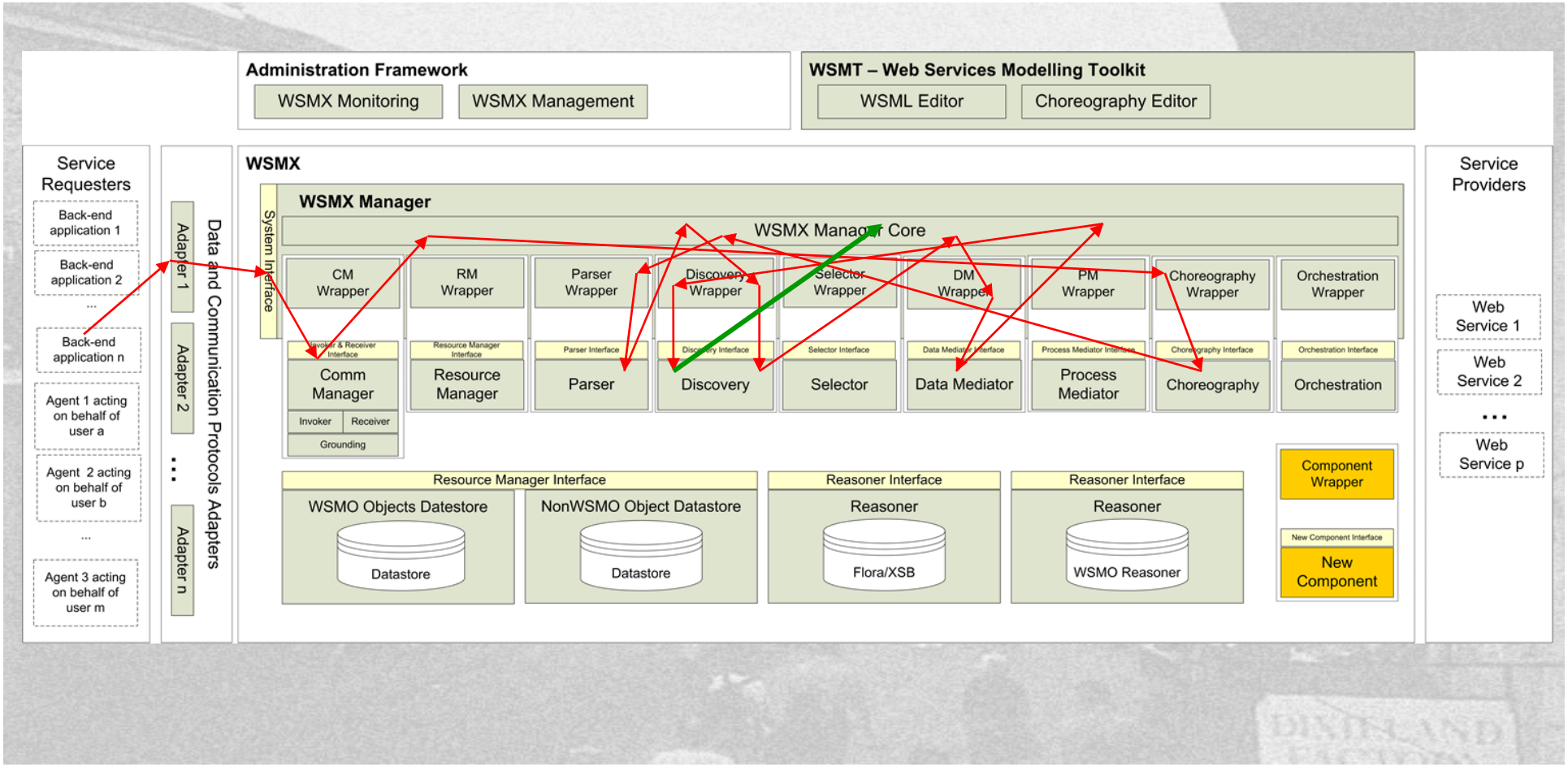

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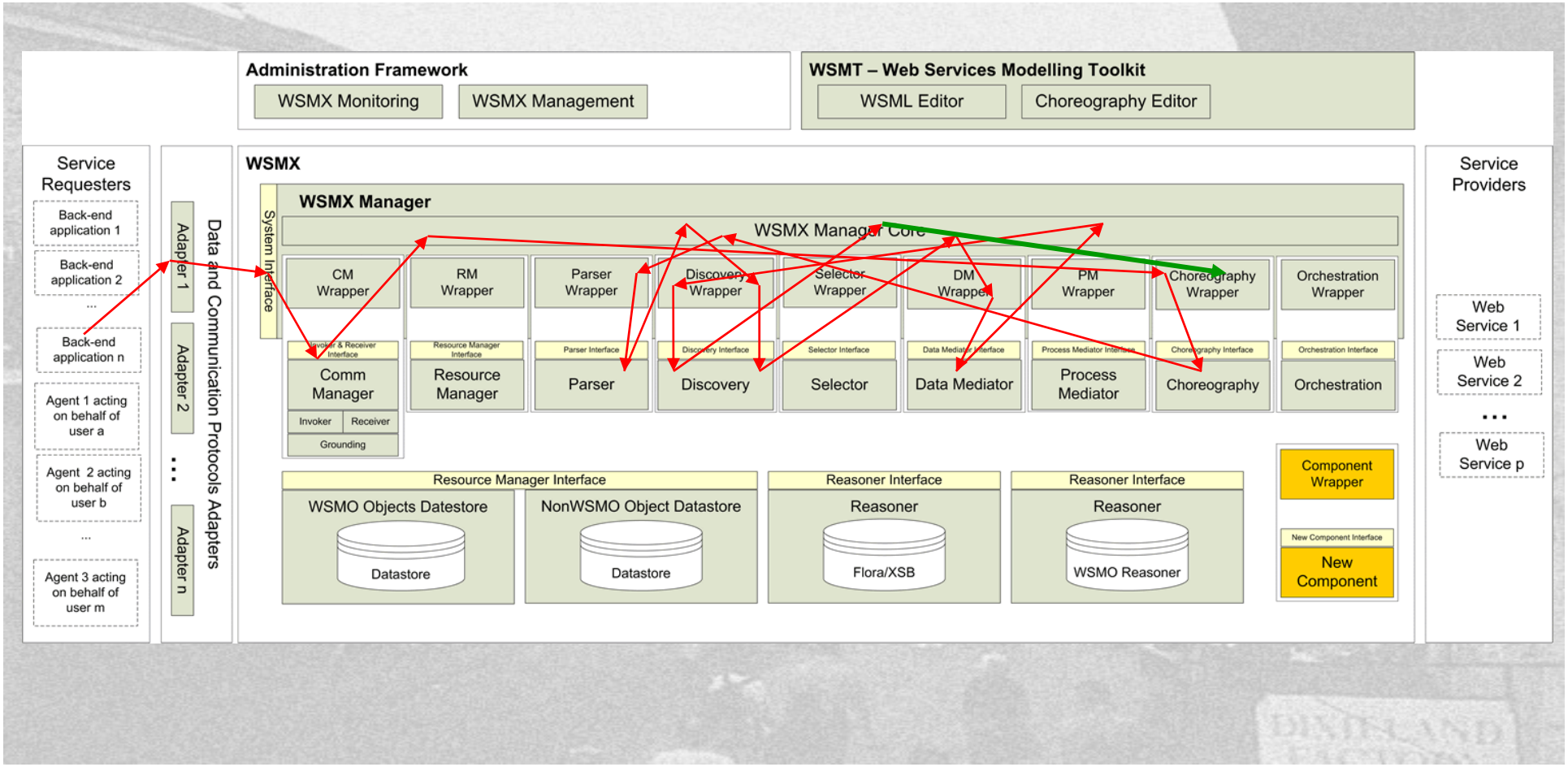

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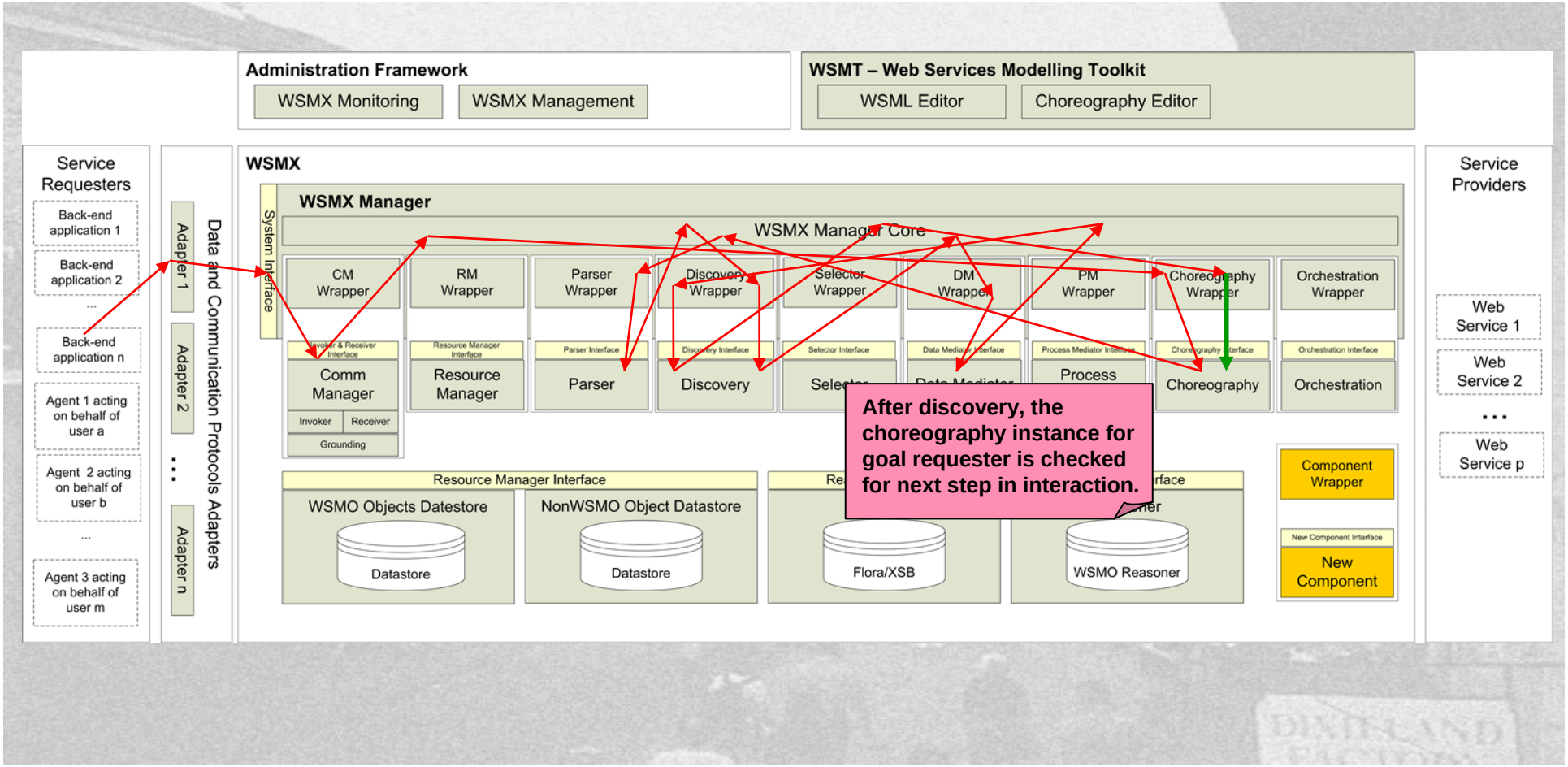

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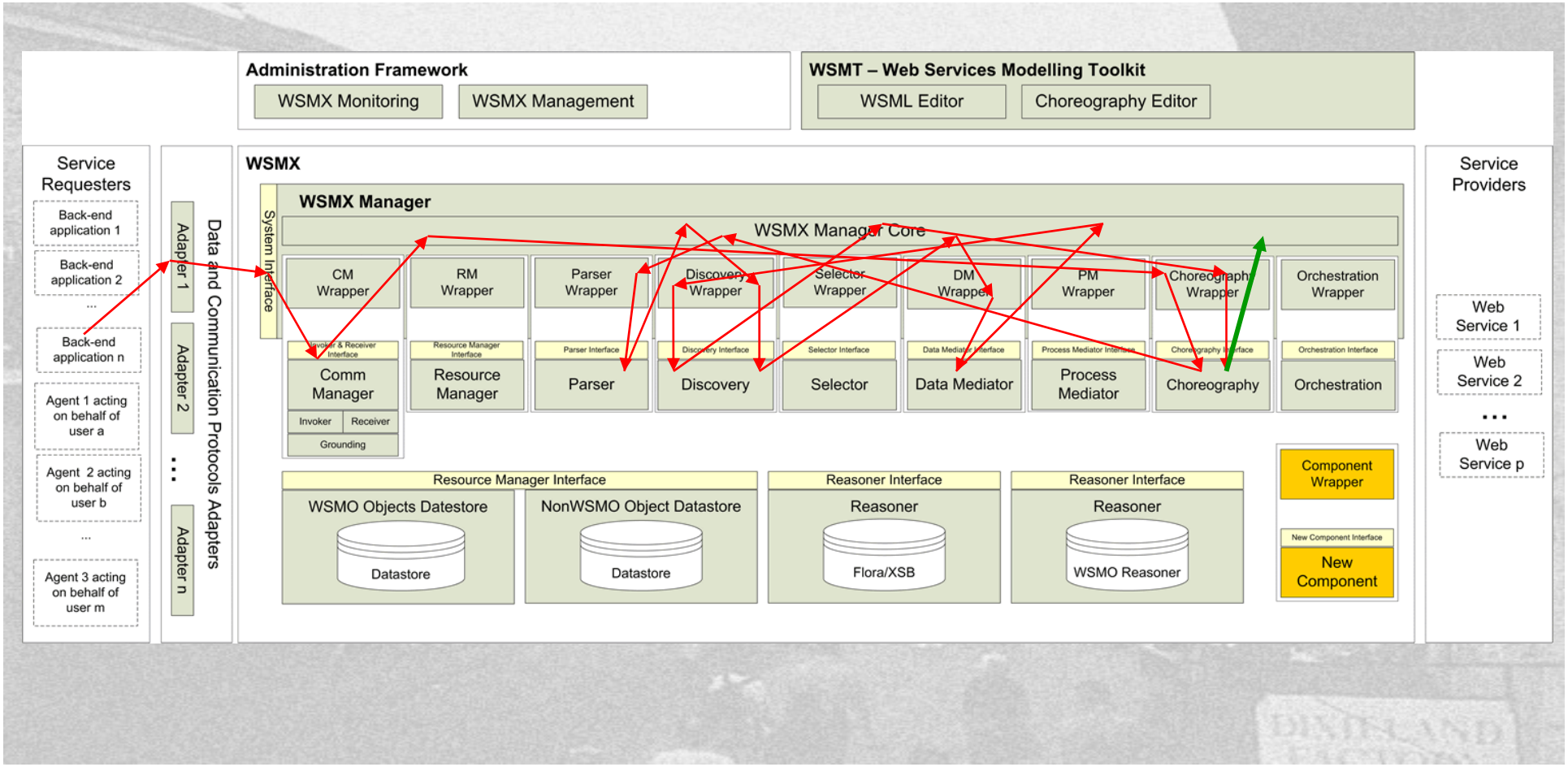

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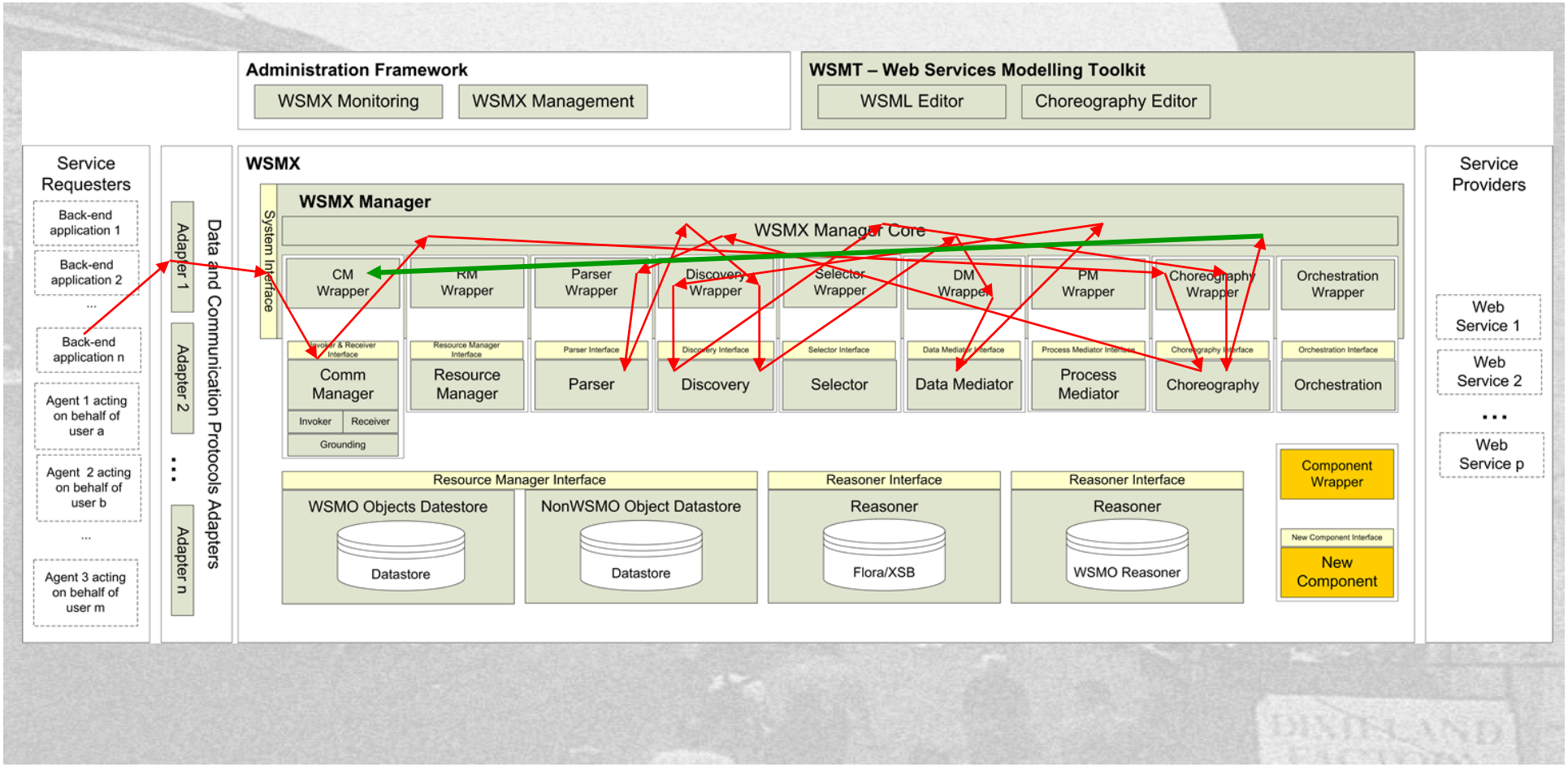

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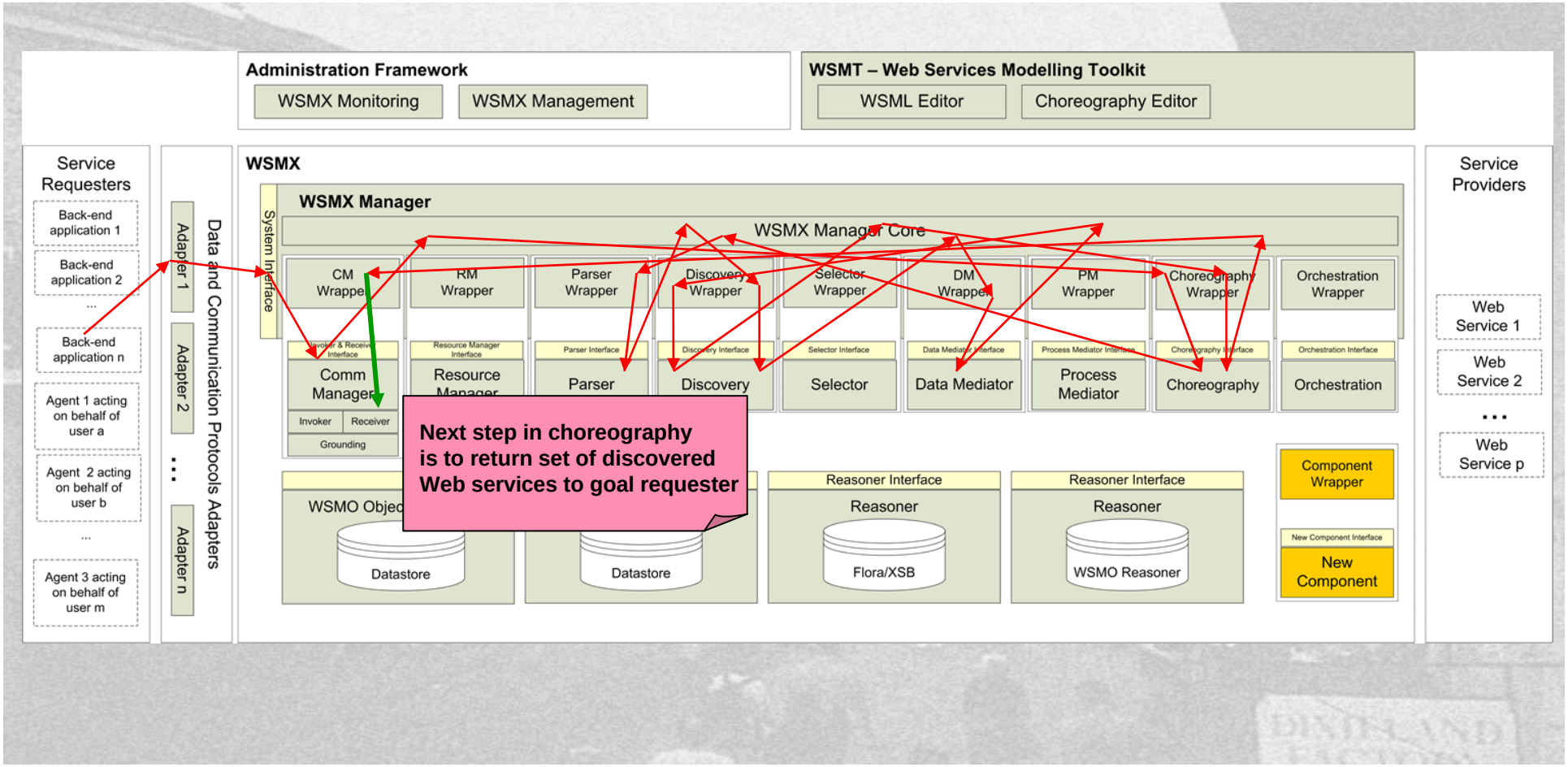

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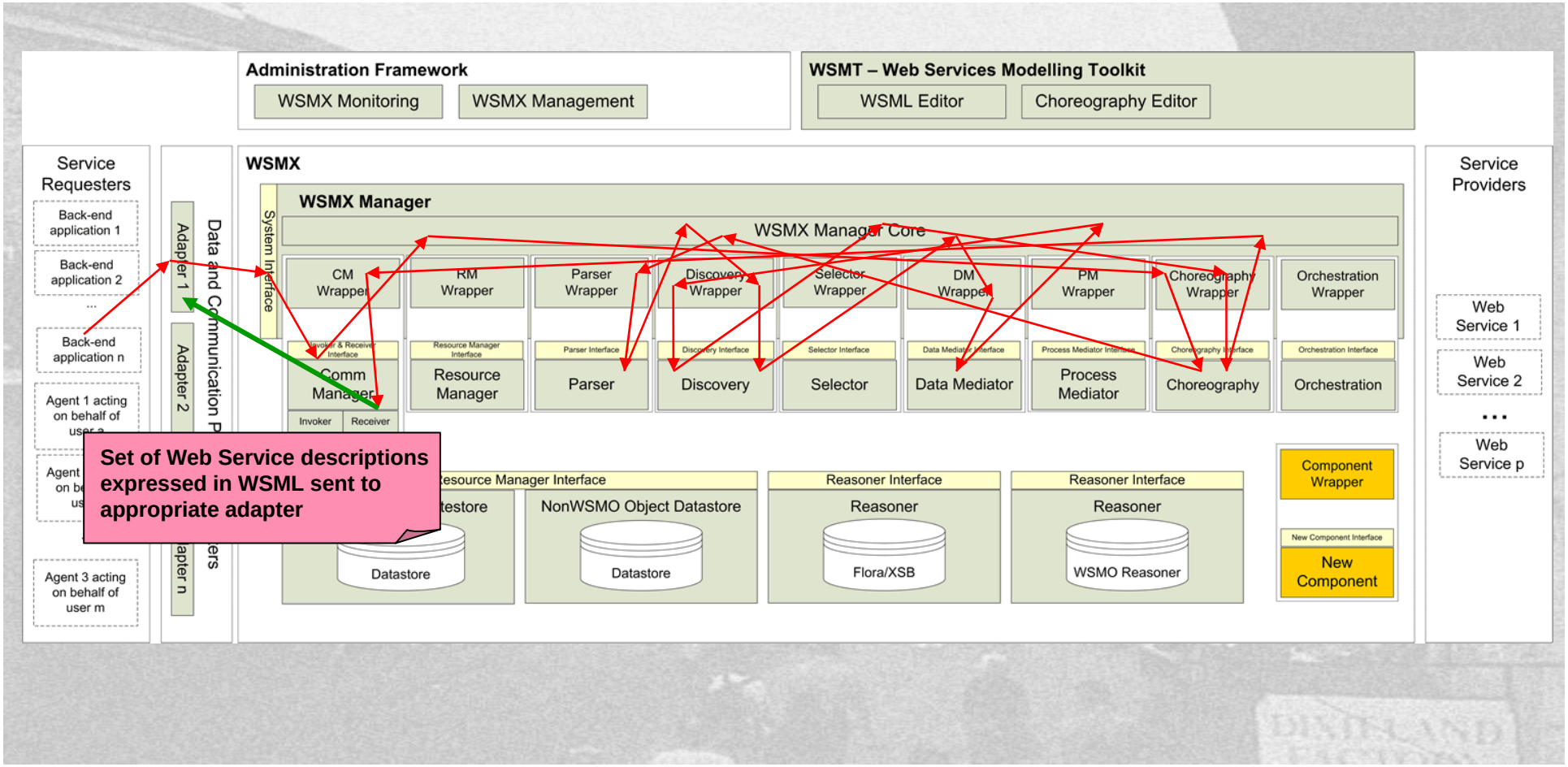

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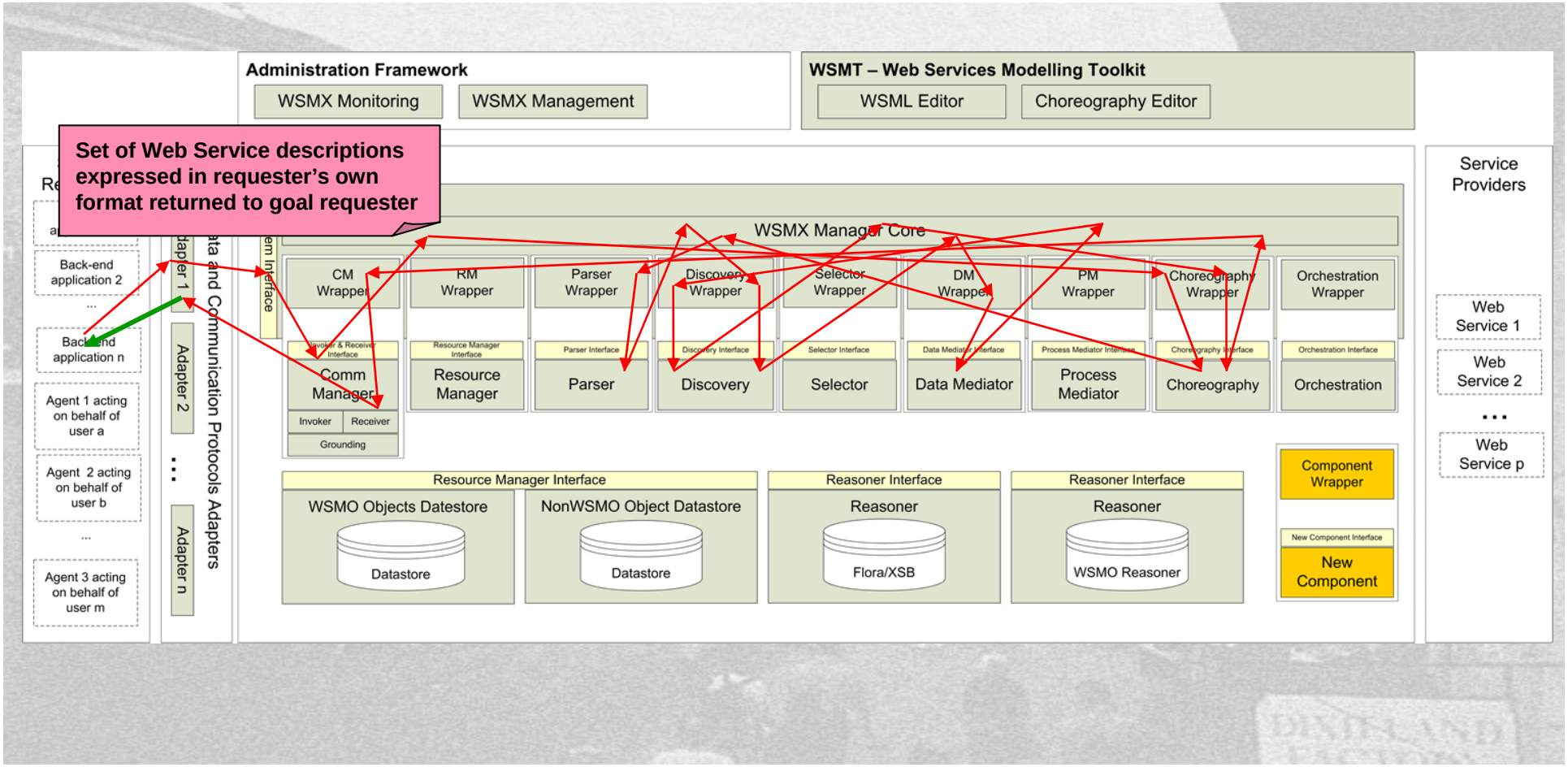


WSMX Summary

- Event based component architecture
- Conceptual model is WSMO
- End to end functionality for executing SWS
- Has a formal execution semantics
- Open source code base at sourceforge
- Developers welcome

WSMX Useful Links

- Home
  - http://www.wsmx.org/
- Overview
  - http://www.wsmo.org/2004/d13/d13.0/v0.1/
- Architecture
  - http://www.wsmo.org/2004/d13/d13.4/v0.2/
- Mediation
  - http://www.wsmo.org/2004/d13/d13.3/v0.2/
- Execution Semantics
  - http://www.wsmo.org/2004/d13/d13.2/v0.1/
- Open source code base at SourceForge
  - https://sourceforge.net/projects/wsmx

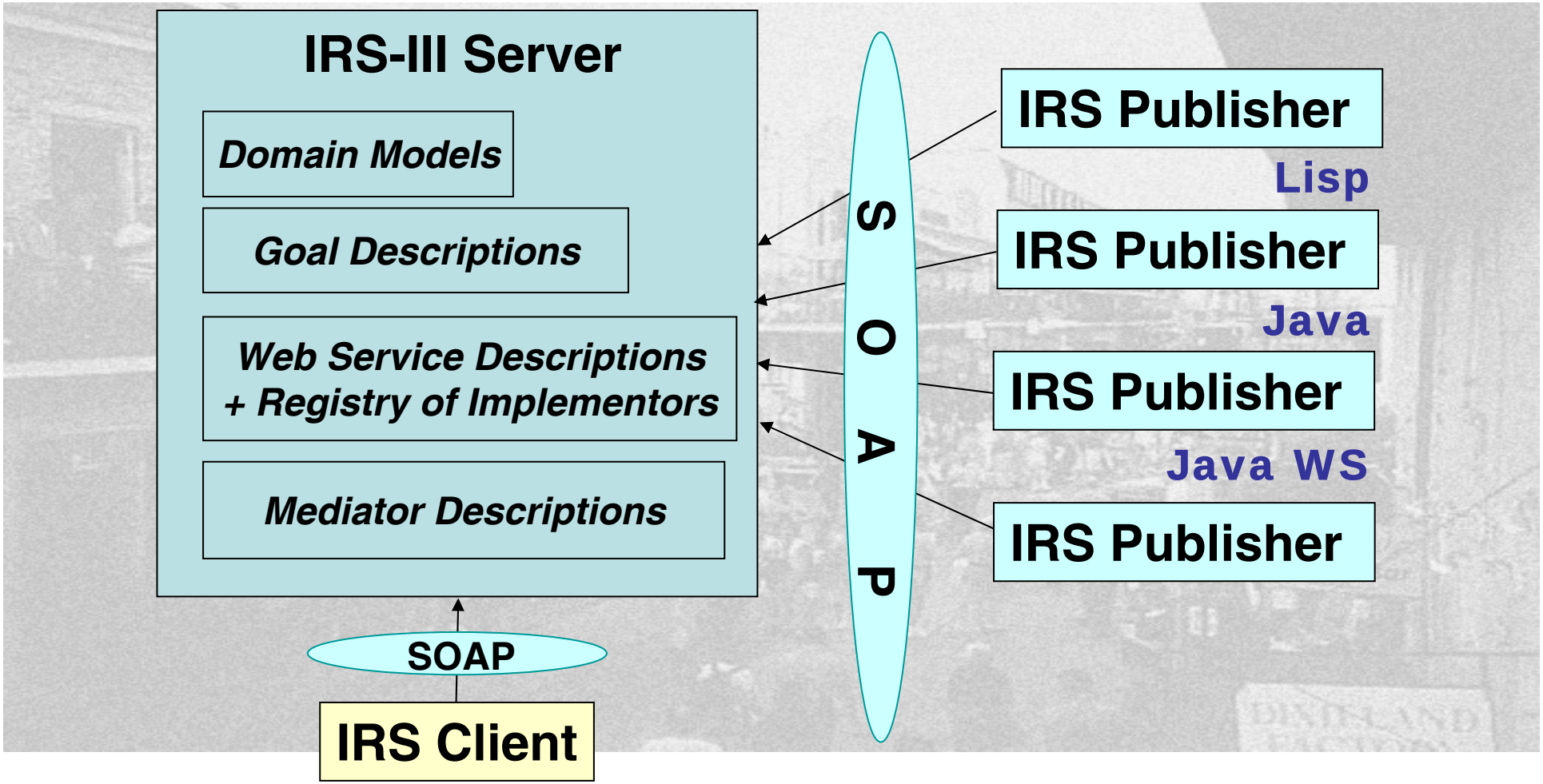
IRS-III: A framework and platform for Semantic Web Services

Liliana Cabral

IRS-III

The Internet Reasoning Service is an infrastructure for publishing, locating, executing and composing *Semantic Web Services*, organized according to the *WSMO* conceptual model

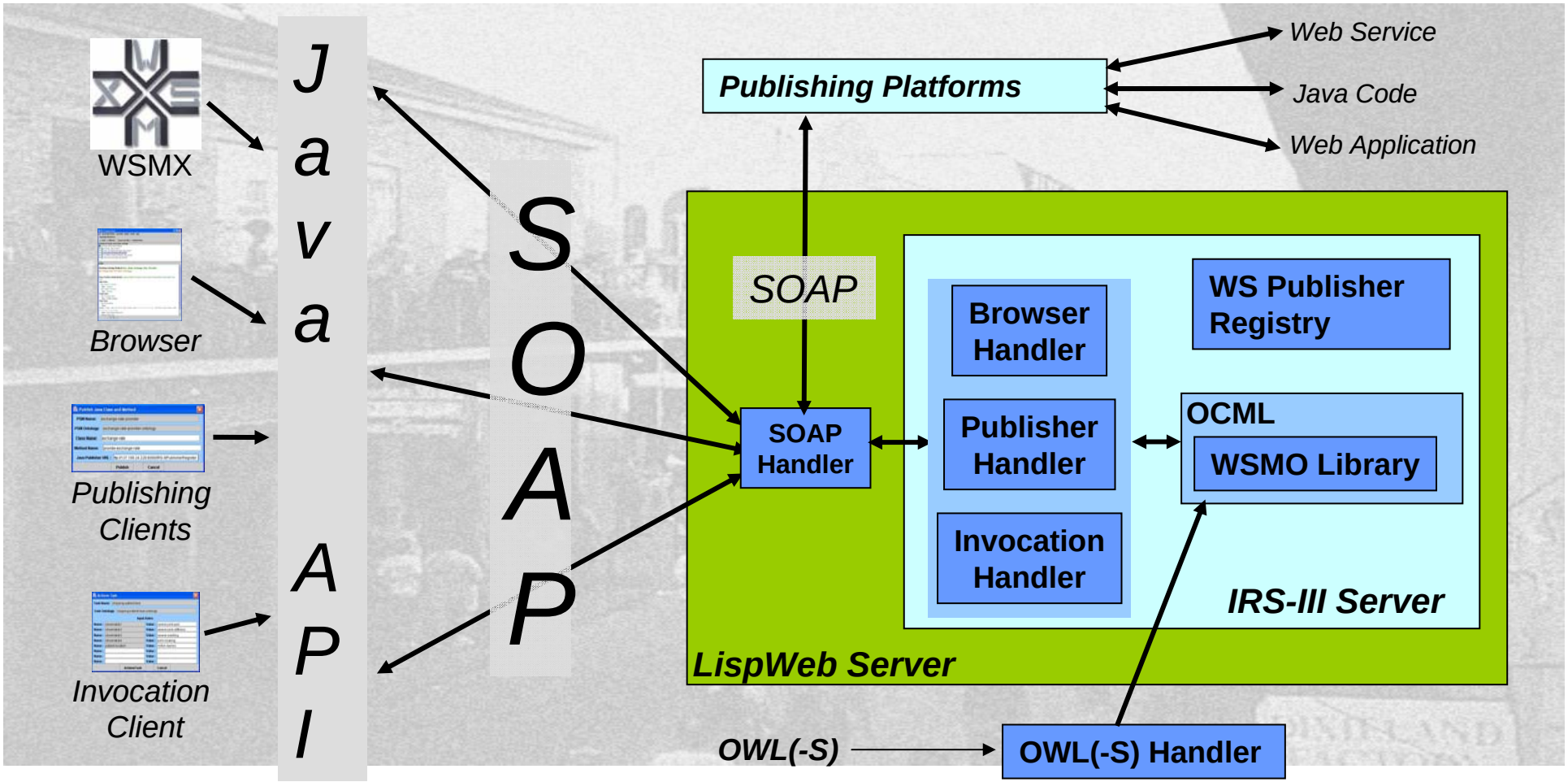
IRS-III Framework



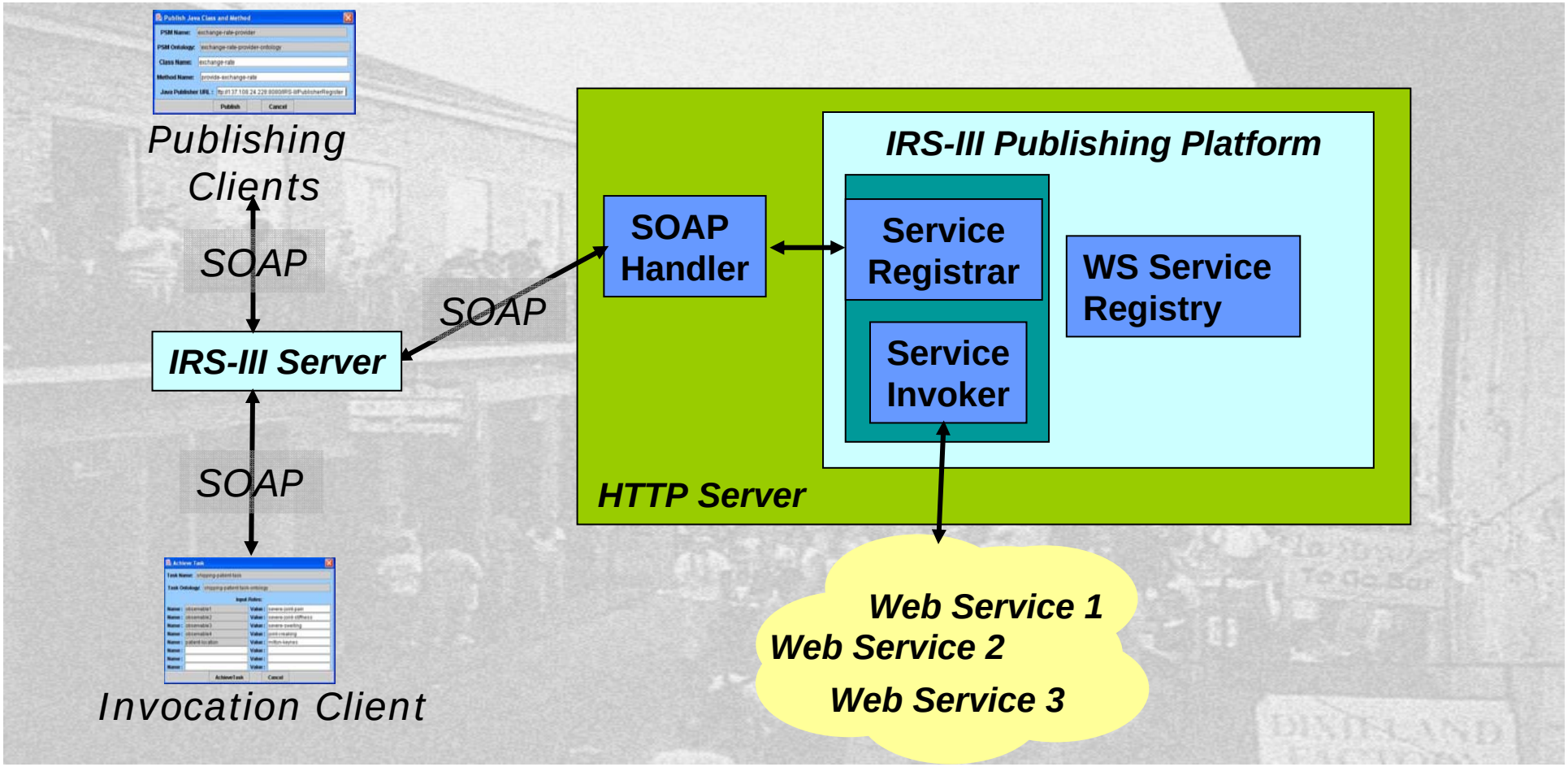
IRS-III Features

- Provides *capability-centred* service invocation
- Provides built-in brokering and service discovery support
- Publishing support for variety of platforms
  - Java Web Services, Java, Lisp, Web Applications
- Enables publication of ‘standard code’
  - Provides clever wrappers automatically, which turn code into web services
  - One-click publishing of web services
- Provides Java API for client applications
- Based on Soap messaging standard

IRS-III Architecture



Publishing Platform Architecture

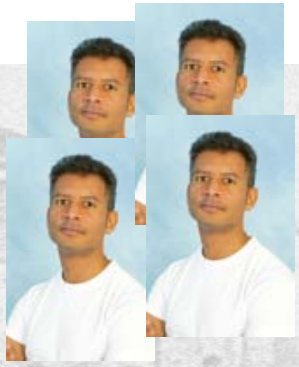


IRS-III/WSMO differences

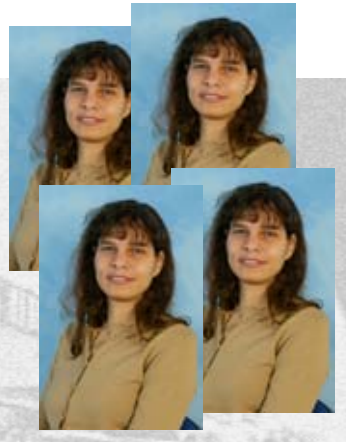
- Underlying language OCML
- Goals have inputs and outputs
- IRS-III broker finds applicable web services via mediators
  - Used mediator within WS capability
  - Mediator source = goal
- Web services have inputs and outputs ‘inherited’ from goal descriptions
- Web service selected via assumption (in capability)

SWS in IRS III

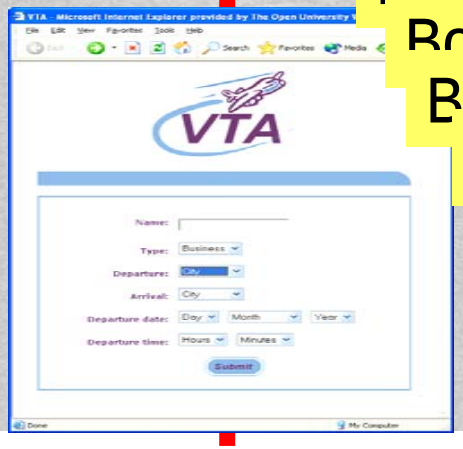
Customer



Customer Team



Development Team



Buy book goal

Book Flight goal

Buy cinema tickets goal

Buy train ticket goal

English Train Ticket

B Austrian Train Ticket

B German Train Ticket

B French Train Ticket

Booking Web Service

SWS Creation & Usage Steps

- Create a goal description
  - (e.g. book-train-goal)
  - Add input and output roles
  - Include role type and soap binding
- Create a wg-mediator description
  - Link a goal to a Web Service
  - Source component = goal
  - Possibly add a mediation service
- Create a web service description
  - Used-mediator of WS capability = wg-mediator above
- Publish Lisp function against web service description
- Invoke web service by ‘achieve goal’

Multiple Web Services for a Goal

- Each WS links to a Goal through the mediator in the used-mediator slot of capability
  - Some WS may share a mediator
- Define a constraint for solving the Goal - a logical expression for assumption slot of WS capability
  - logical expression format
    - (kappa (?goal) <ocml relations>)
  - Getting the value of an input role
    - (wsmo-role-value ?goal <role-name>)

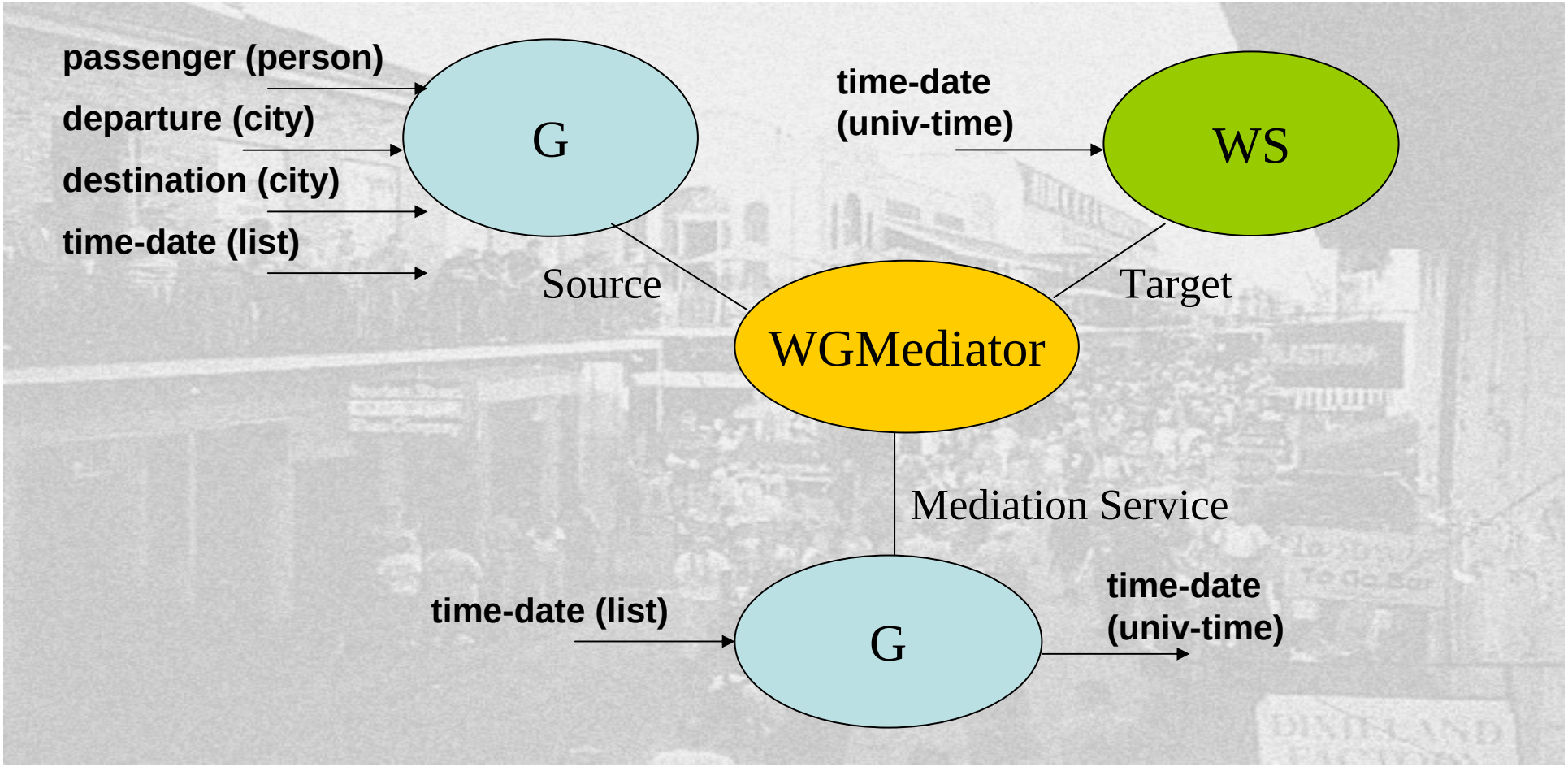
Valid Logical Expressions (relations)

- Classes are unary relations
  - e.g. (country ?x)
- Slots are binary relations
  - e.g. (is-capital-of ?x ?y)
- Standard relations in base (OCML toplevel) ontology:

  =, ==, <, >, member
- Example:

```
(kappa (?goal)
        (member (wsmo-role-value ?goal 'has_source_currency) '(euro pound)))
```

Defining a WG-Mediator



Defining a Mediation Service

- Defined in the Mediator
- Mediation-service = Goal
- Web Service implements the mediation (mappings)
- Mediation Goal input roles are a subset of source Goal input roles
- Mediation Goal output is a subset of target Web Service input roles.

Goal Based Invocation

Invocation

Goal -> WG Mediator -> WS/Capability/Used-mediator

Instantiate Goal Description

Exchange-rate-goal
Has-source-currency: us-dollars
Has-target-currency: pound

Web Service Discovery

European-exchange-rate-ws
Non-european-exchange-rate-ws
European-bank-exchange-rate-ws

WS -> Capability -> Assumption expression

Web service selection

European-exchange-rate

Mediation

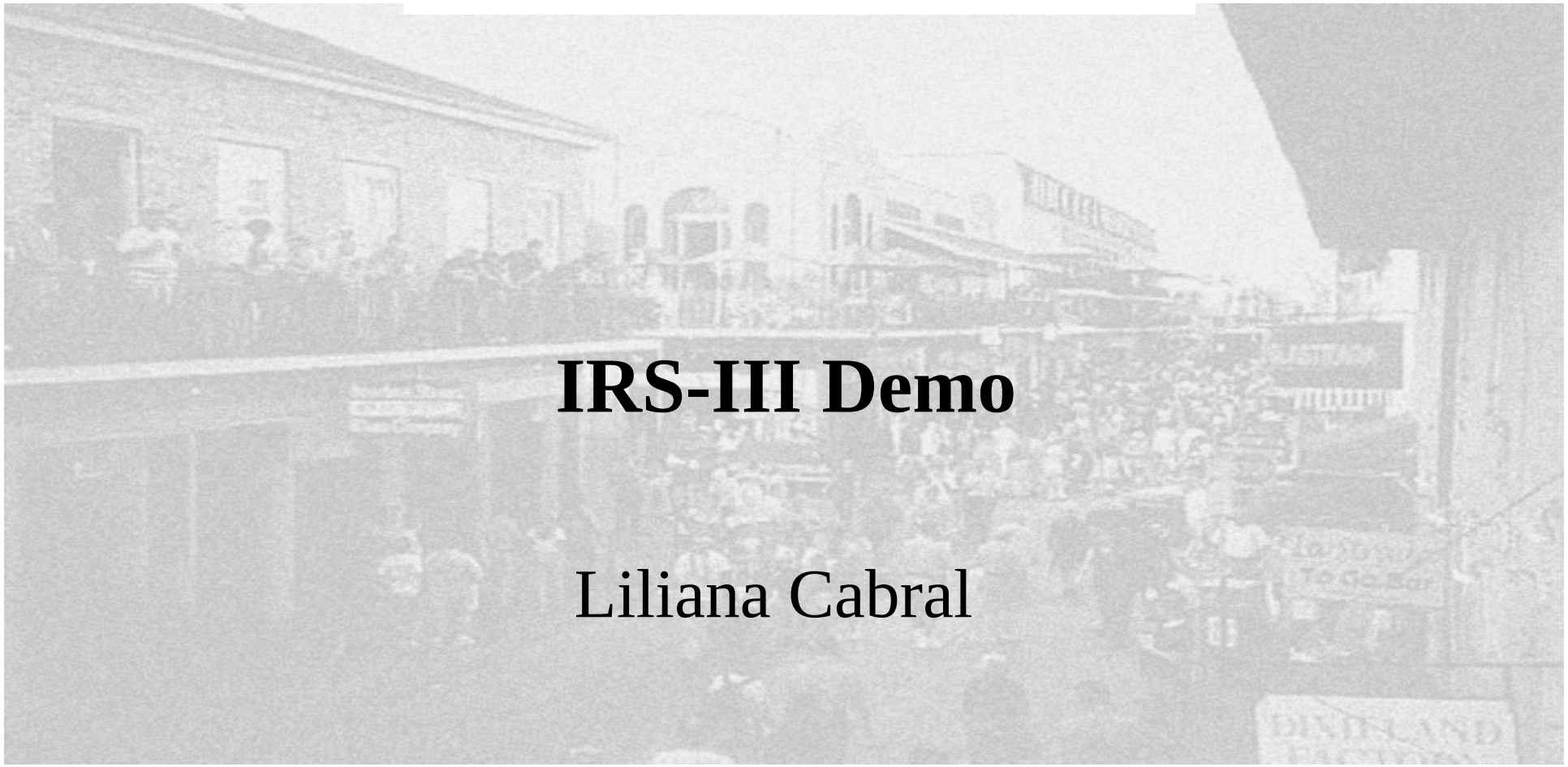
Mediate input values

‘$’ -> us-dollar

Invocation

Invoke selected web service

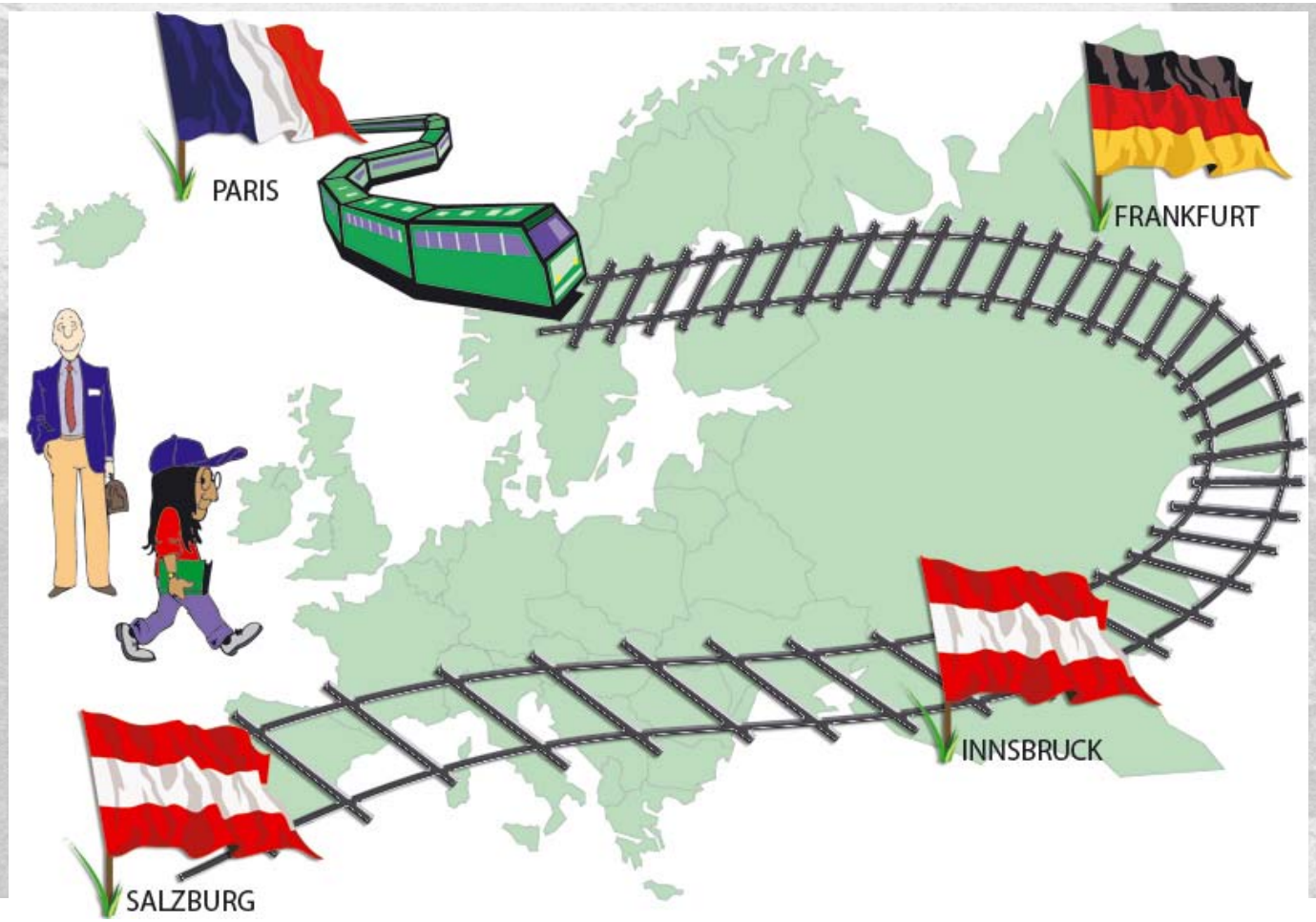
European-exchange-rate



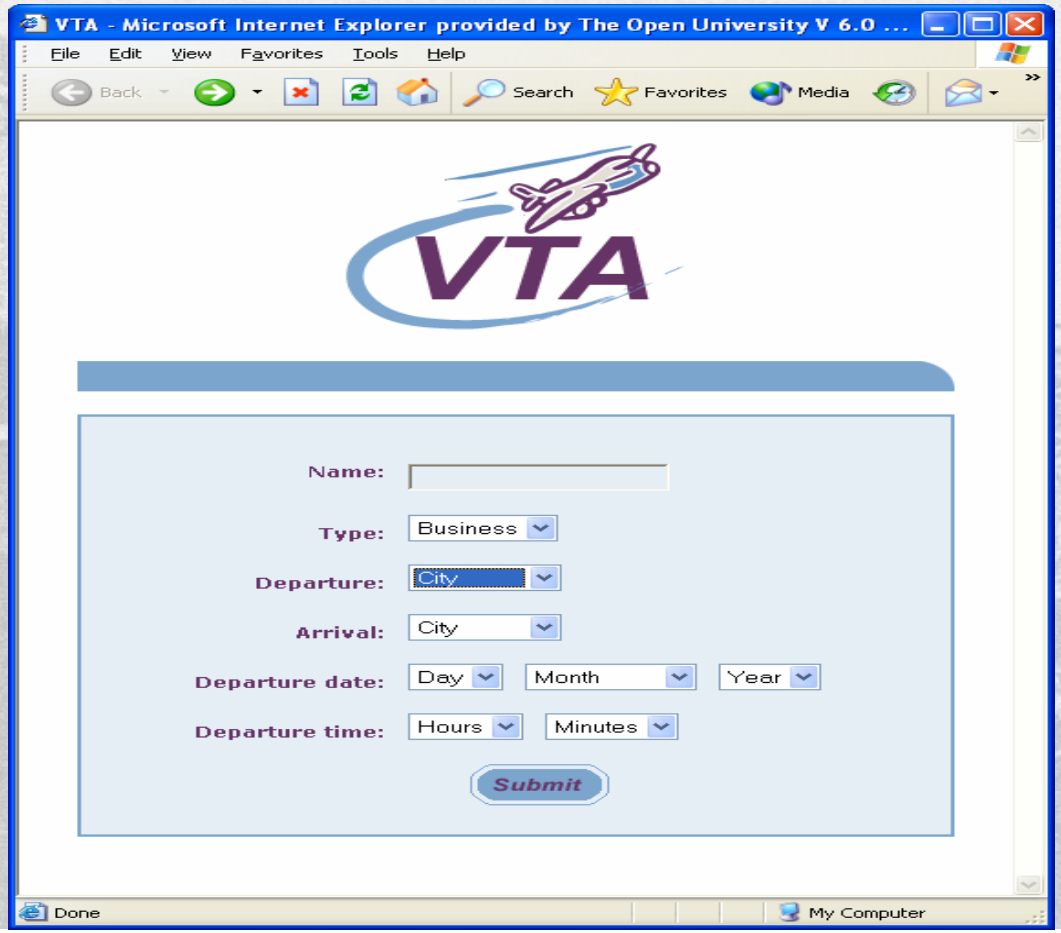
IRS-III Demo

Liliana Cabral

European Travel Scenario



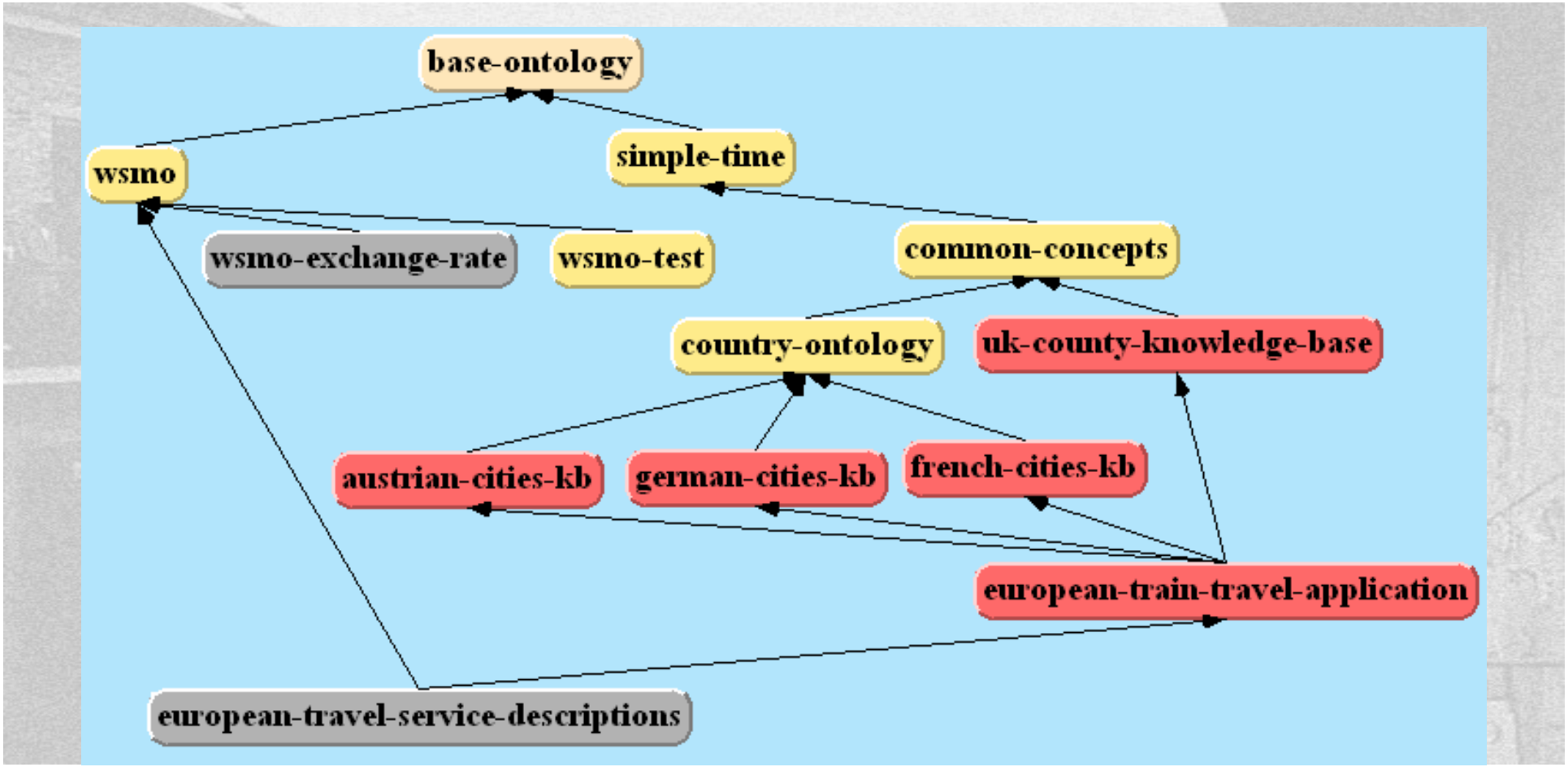
European Travel Demo



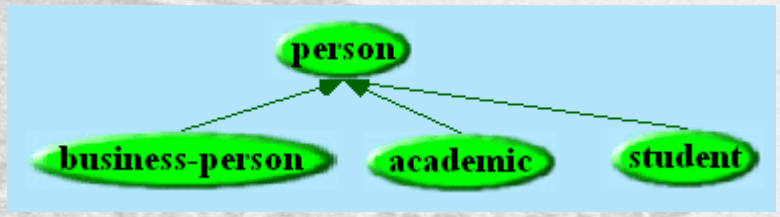
Demo - Objective

- Develop an application for the European Travel scenario based on SWS. The application should support a person booking a train ticket between 2 European cities at a specific time and date
- Create Goal, Web service and Mediator WSMO descriptions in IRS-III (european-travel-service-descriptions) for available services. Service constraints involves start and end locations and the type of traveller. Use the assumption slot to express this.
- Publish available lisp functions against Web Service descriptions
- Invoke the web services through ‘Achieve Goal’
- Solution using IRS-III browser will be provided

Travel Related Knowledge Models



Key Classes, Relations, Instances (European-Train-Travel-Application)



Is-in-country <city> <country> e.g.

(is-in-country berlin germany) -> true

student instances: john matt michal

business-person instances: liliana michael

Goals

- 1- Get train timetable
  - Inputs: origin and destination cities, date
  - Output: timetable (list)
- 2- Book train
  - Inputs: passenger name, origin and destination cities, departure time-date
  - Output: booking information (string)

Services

- 1 service available for goal 1
  - No constraints
- 6 services available for goal 2
  - As a provider write the constraints applicable to the services to satisfy the goal (assumption logical expressions)
- 1 wg-mediator mediation-service
  - Used to convert time in list format to time in universal format

Service constraints

- Services 2-5
  - Services for (origin and destination) cities in determined countries
- Service 4-5
  - Need a mediation service to map goal time-date to service time-date
- Services 6-7
  - Services for students or business people in Europe

Available Functions (1/3)

1- get-train-times

paris london (18 4 2004)

"Timetable of trains from PARIS to LONDON on 18, 4, 2004
5:18
…23:36"

2- book-english-train-journey

christoph milton-keynes london (20 33 16 15 9 2004)

"British Rail: CHRISTOPH is booked on the 476 going from MILTON-KEYNES to LONDON at 16:34, 15, SEPTEMBER 2004.

The price is 179 Euros.“

3- book-french-train-journey

sinuhe paris lyon (3 4 6 18 8 2004)

"SNCF: SINUHE is booked on the 593 going from PARIS to LYON at 6:12, 18, AUGUST 2004.

The price is 25 Euros."

Available Functions (2/3)

4- book-german-train-journey

christoph berlin frankfurt 3305020023

"German Rail (Die Bahn): CHRISTOPH is booked on the 362 going from BERLIN to FRANKFURT at 14:47, 24, SEPTEMBER 2004.

The price is 35 Euros."

5- book-austrian-train-journey

sinuhe vienna innsbruck 3304686609

"Austrian Rail (OBB): SINUHE is booked on the 681 going from VIENNA to INNSBRUCK at 17:43, 20, SEPTEMBER 2004.

The price is 36 Euros."

Available Functions (3/3)

6- book-student-european-train-journey

john london nice (3 4 6 18 8 2004)

"European Student Rail Travel: JOHN is booked on the 408 going from LONDON to NICE at 6:44, 18, AUGUST 2004.

The price is 86 Euros."

7- book-business-european-train-journey

liliana paris innsbruck (3 4 6 18 8 2004)

"Business Europe: LILIANA is booked on the 461 going from PARIS to INNSBRUCK at 6:12, 18, AUGUST 2004.

The price is 325 Euros."

8- mediate-time (lisp function) or JavaMediateTime/mediate (java)

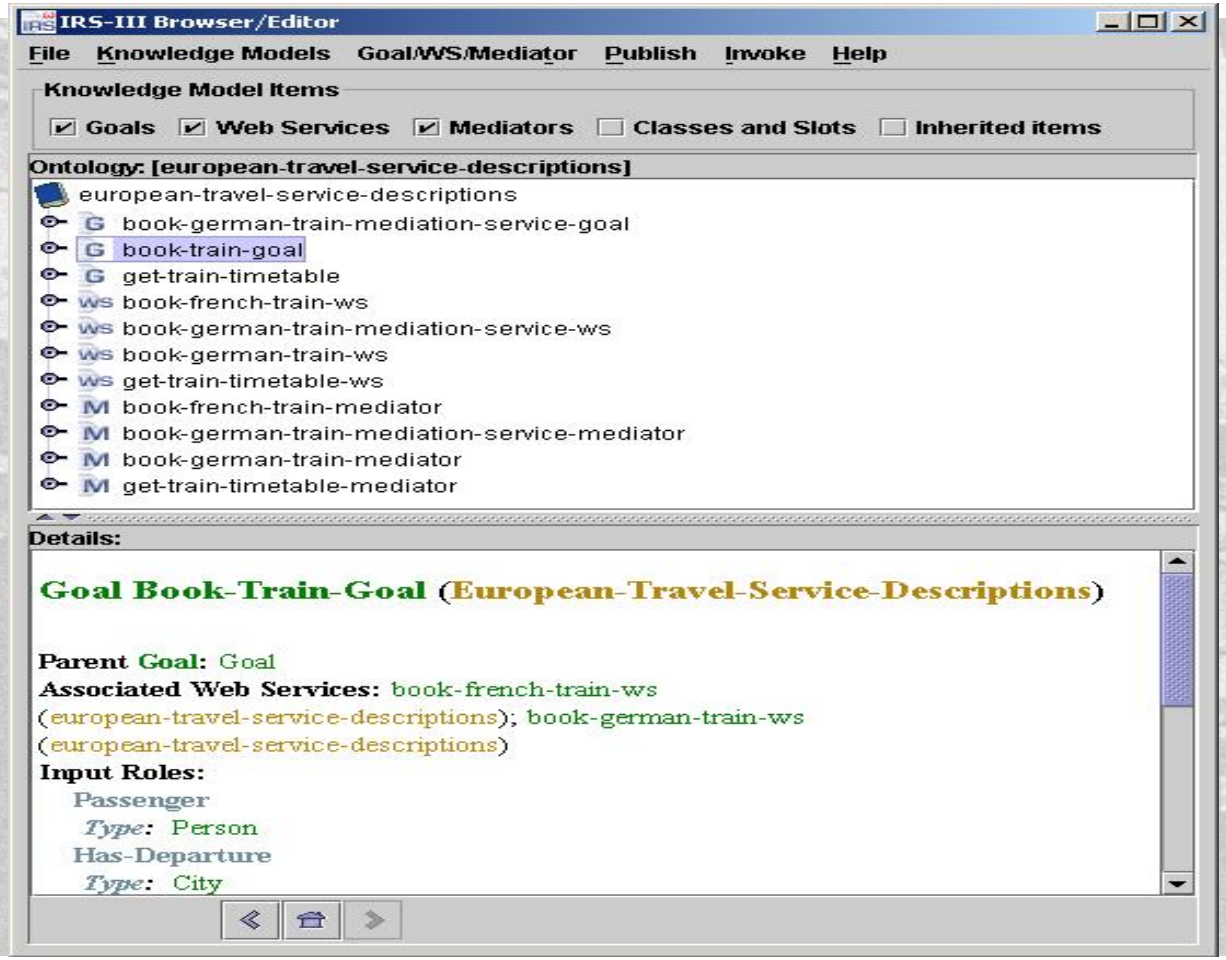
(9 30 17 20 9 2004)

3304686609

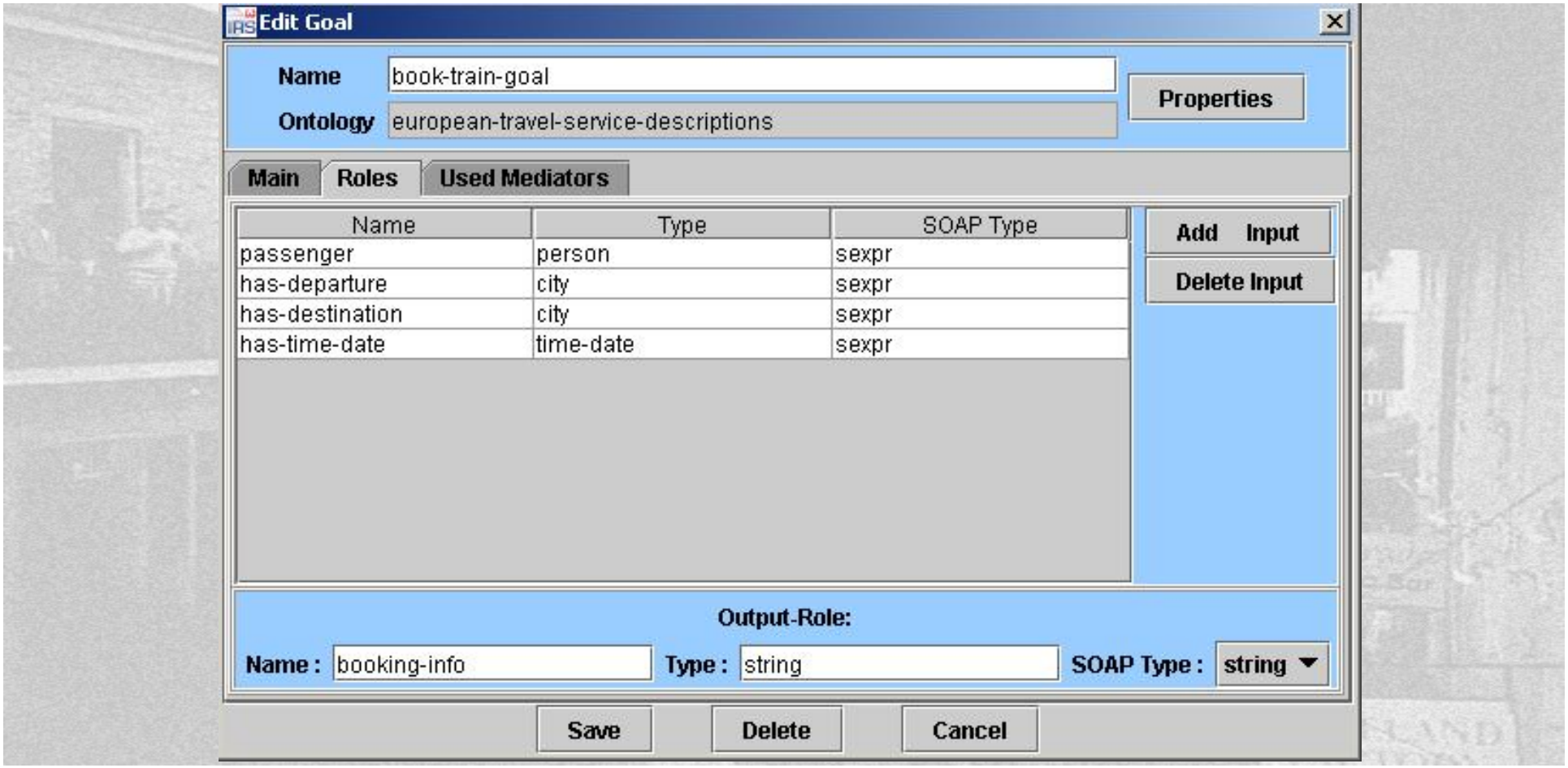
Using IRS-III Browser for the VTA Demo application

- Semantic Descriptions of:
  - Goals
  - Web Services
  - Mediators
- Publishing
- Invocation

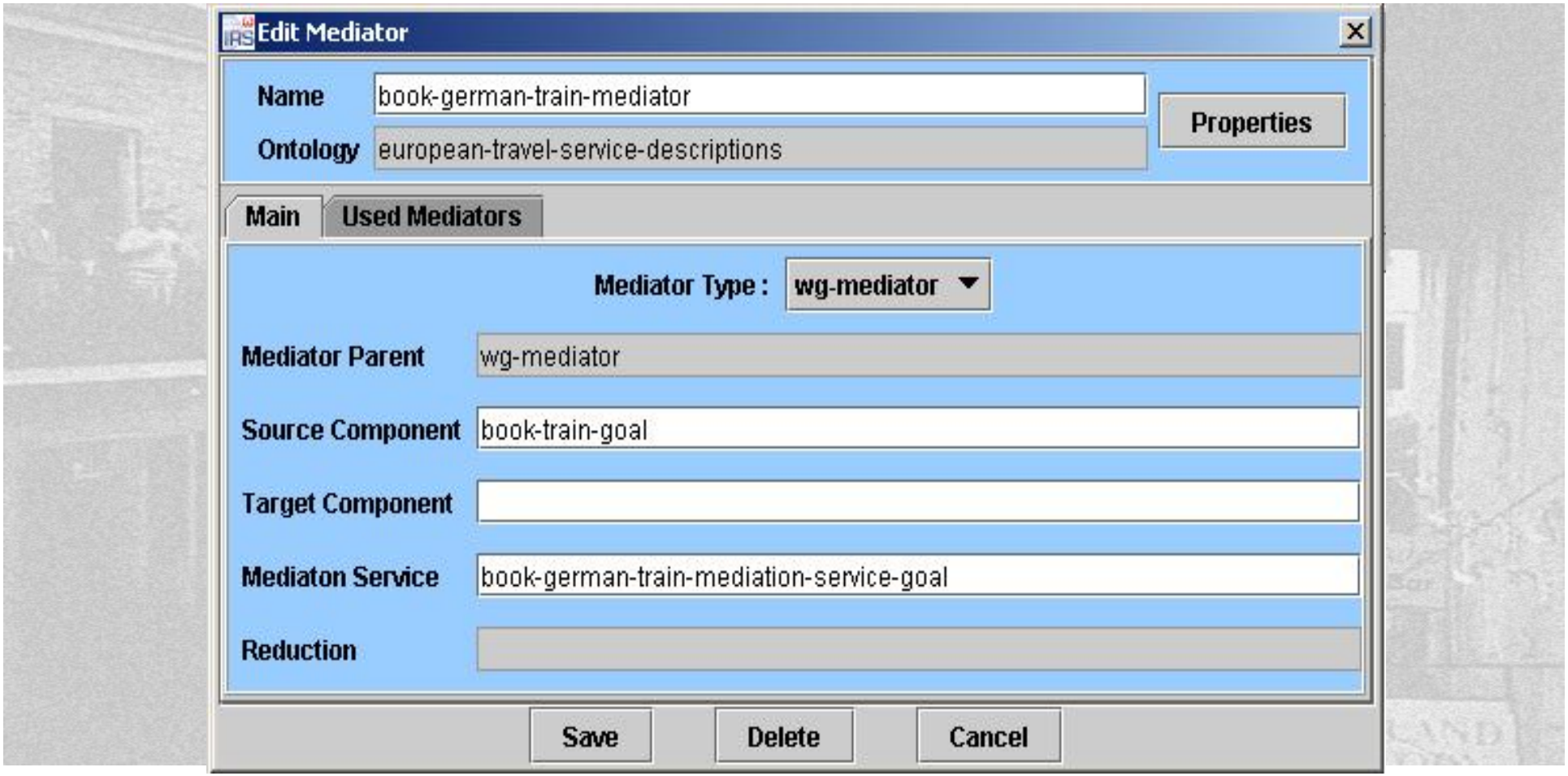
IRS-III Browser



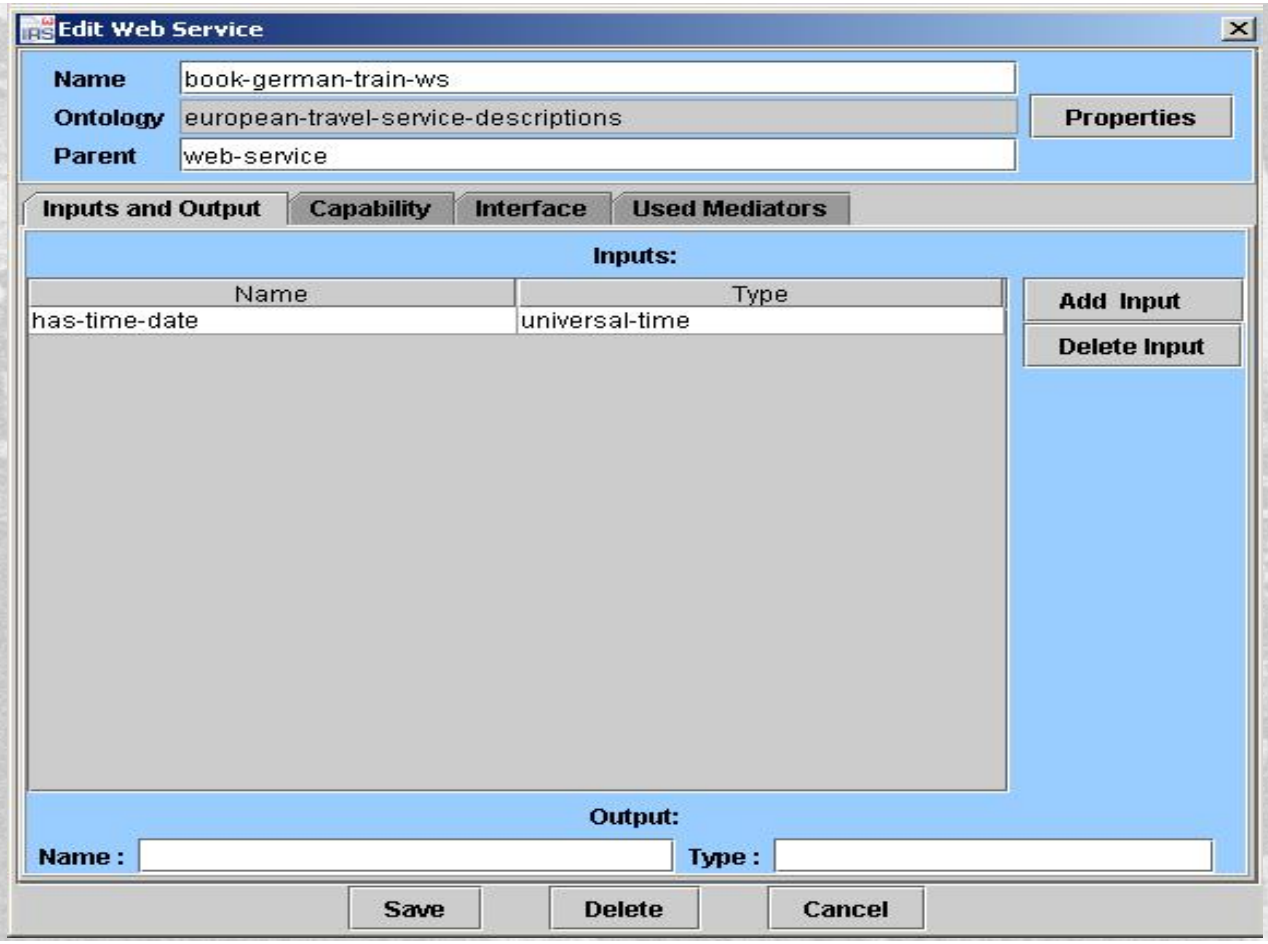
Creating a Goal description



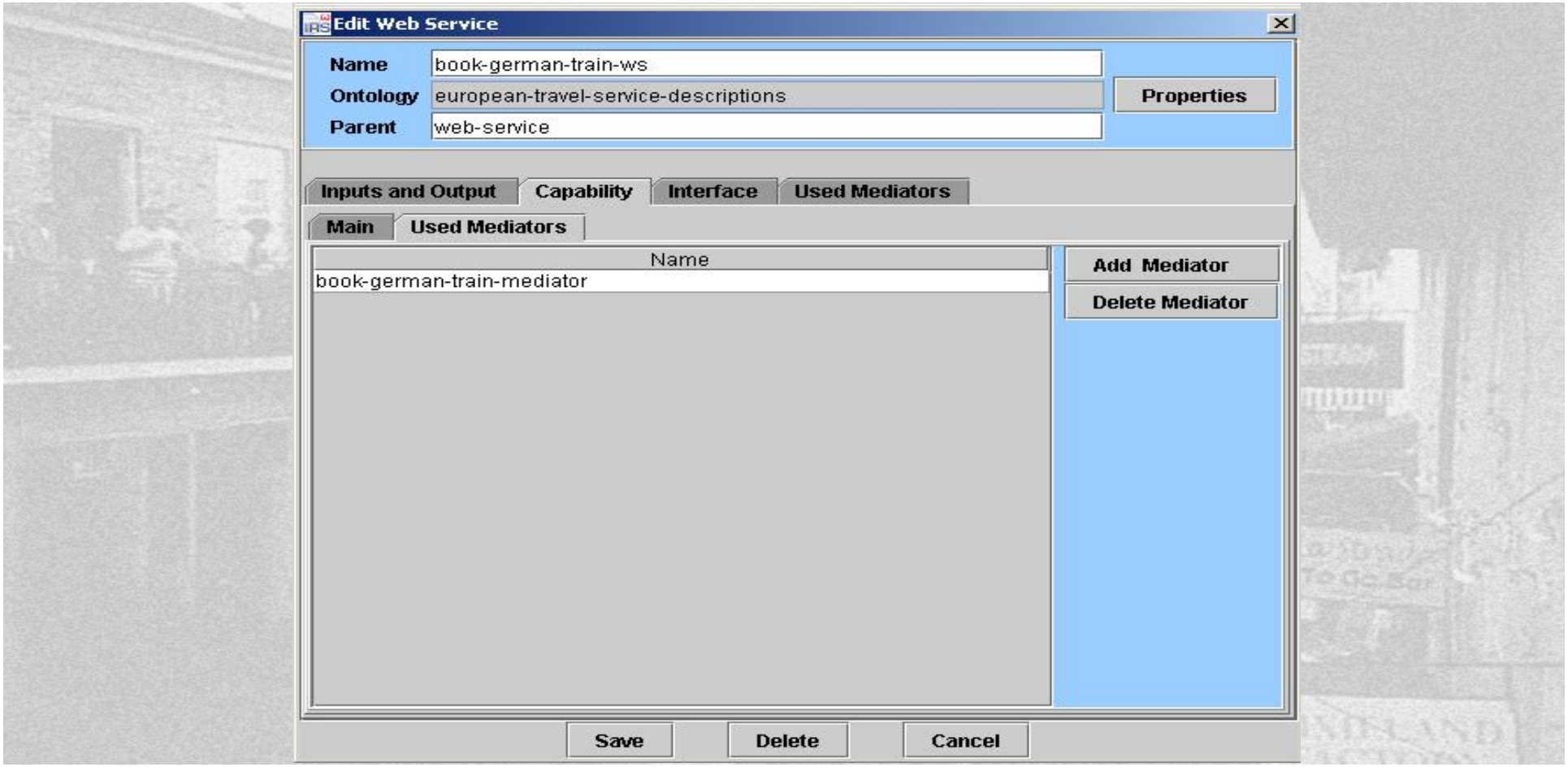
Creating a Mediator description



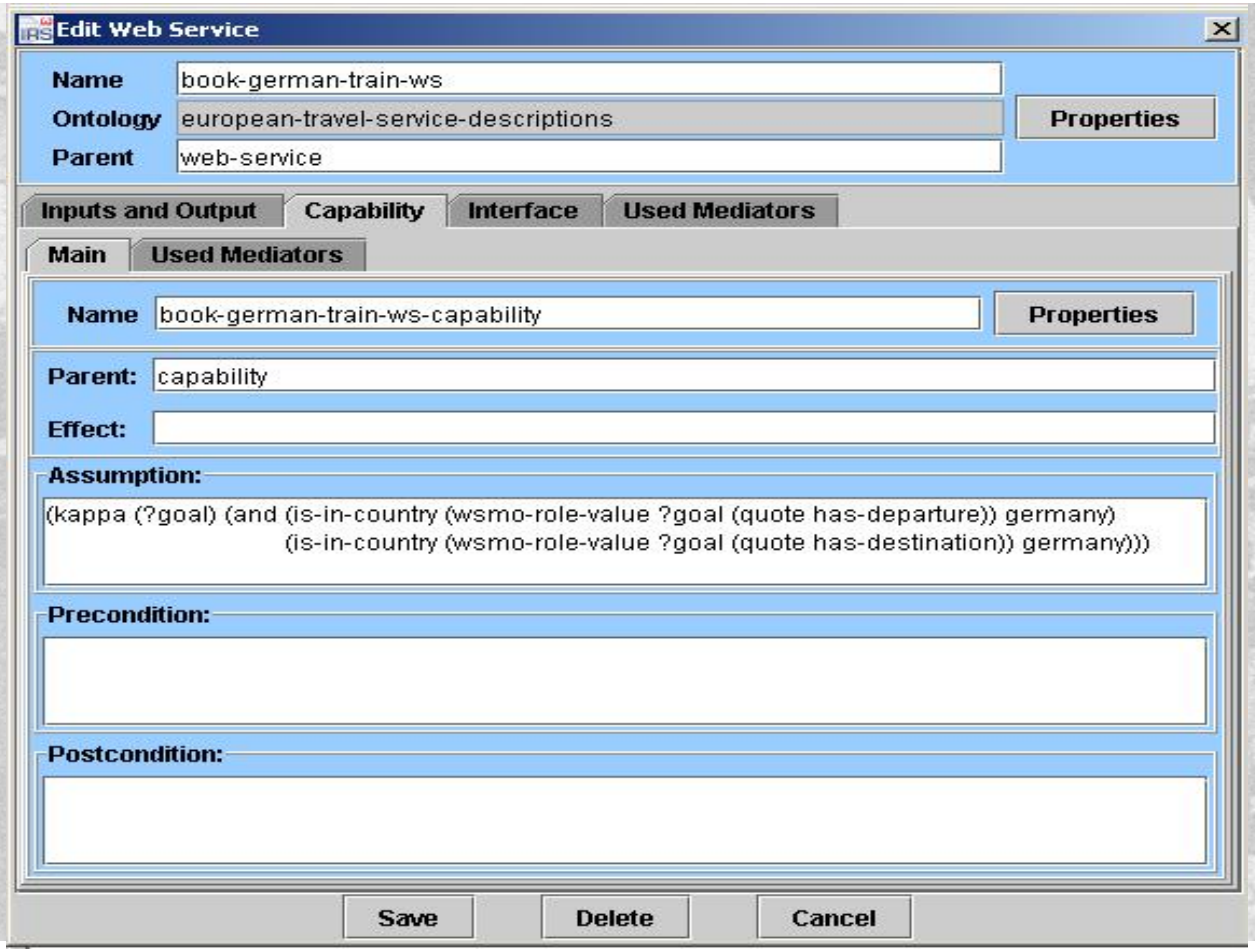
Creating a Web Service description



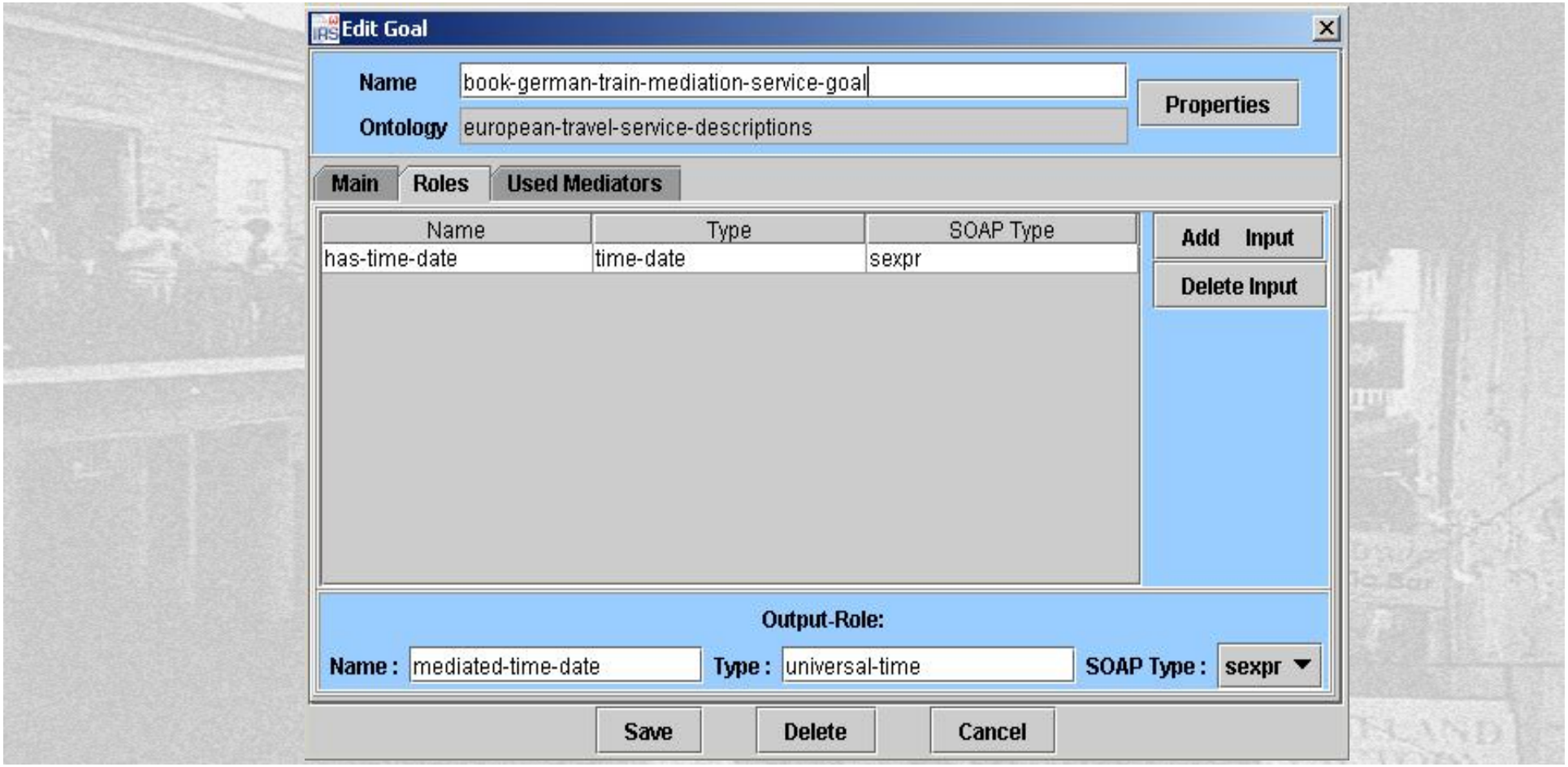
Adding a Mediator to the Web Service Capability



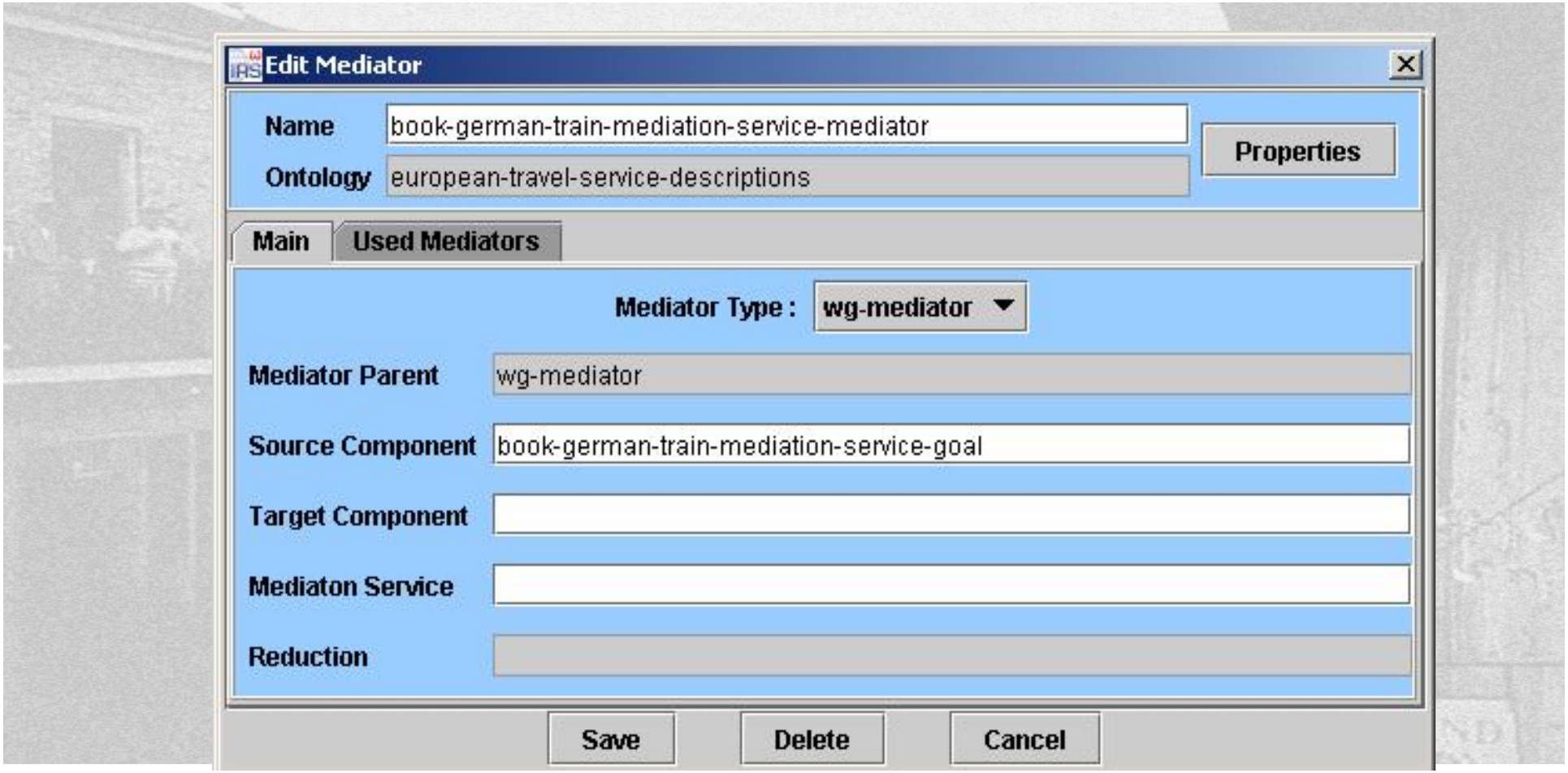
Adding a constraint to the Web Service Capability



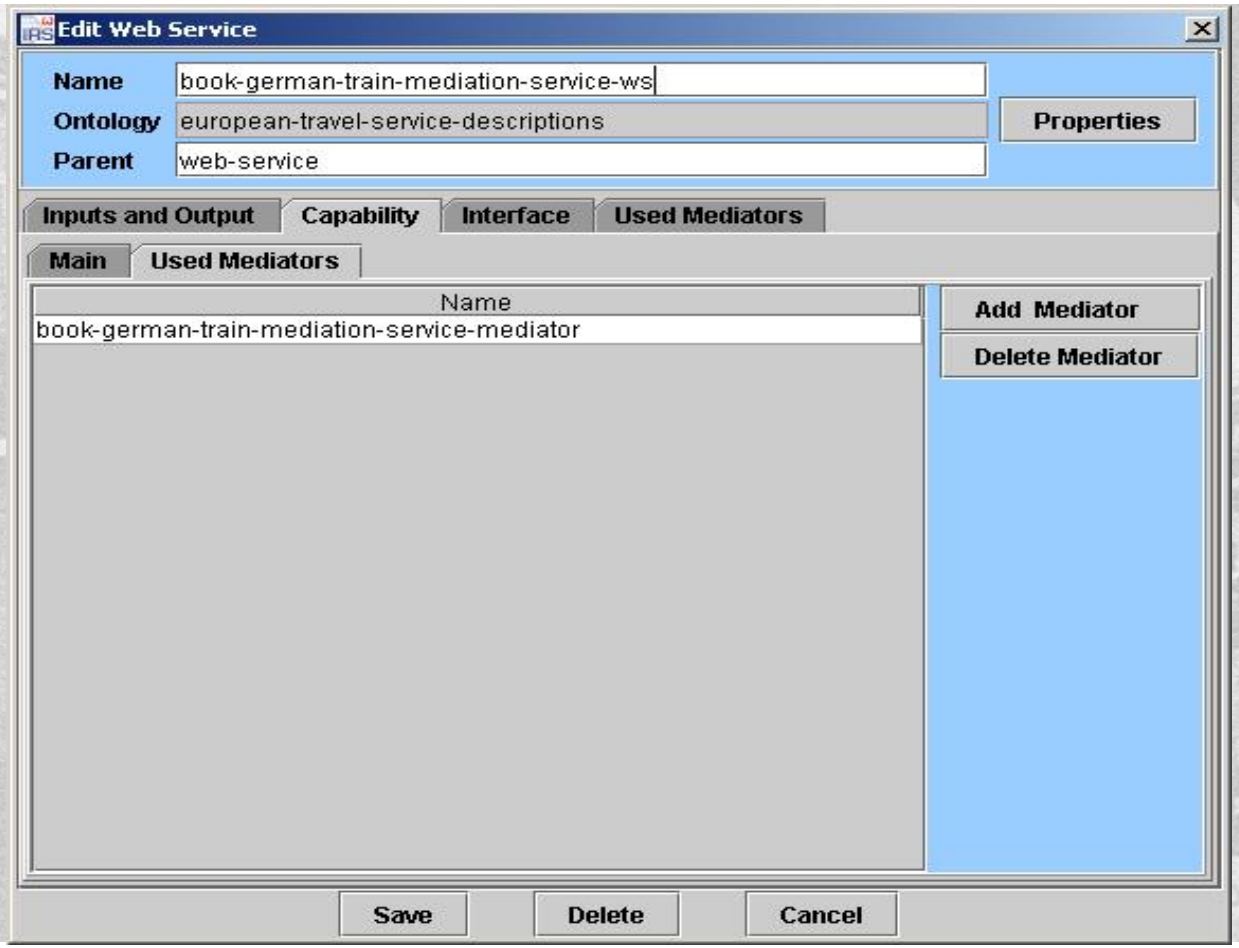
Creating a Goal (Mediation Service)



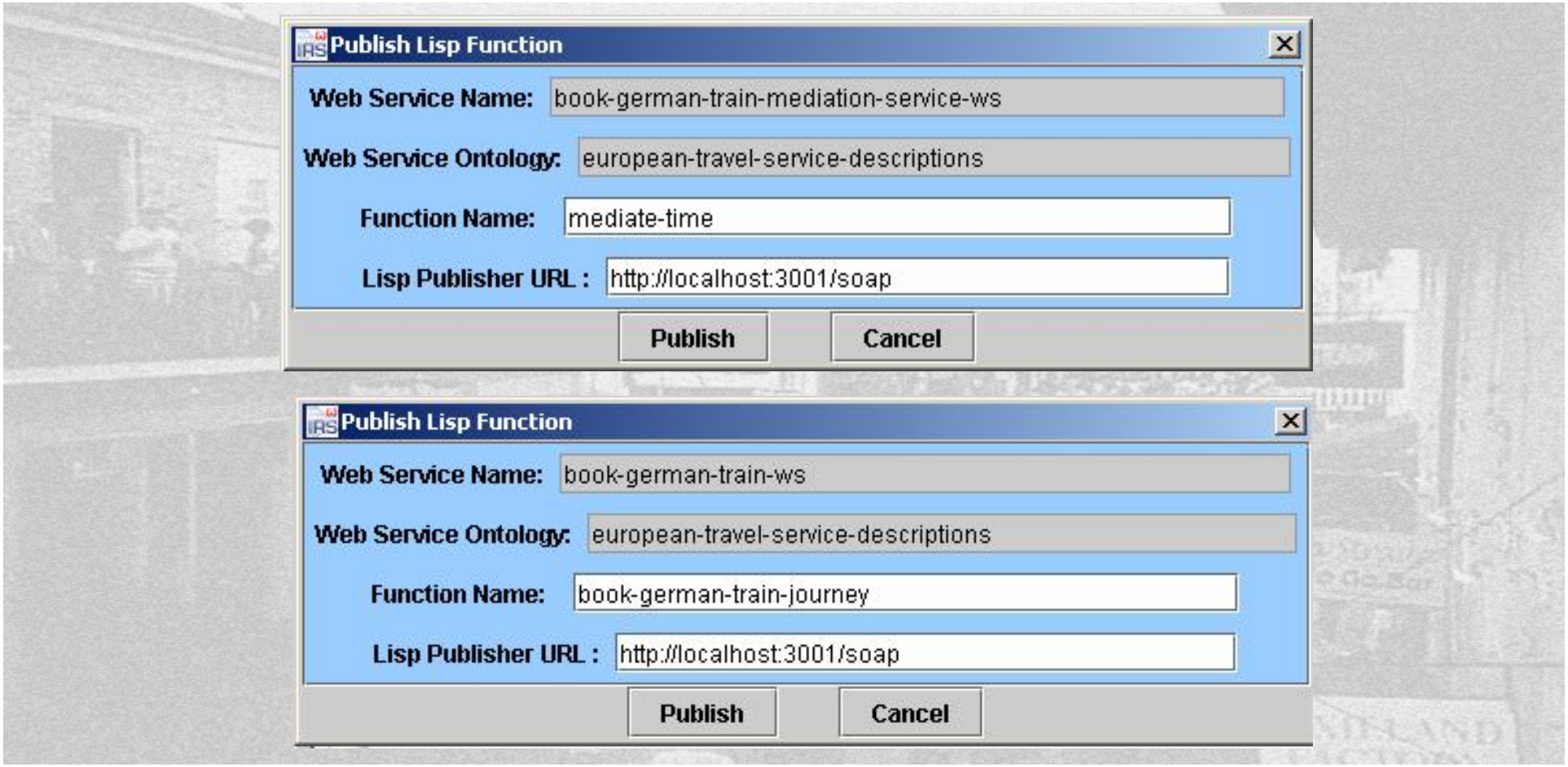
Creating a Mediator description (Mediation Service)



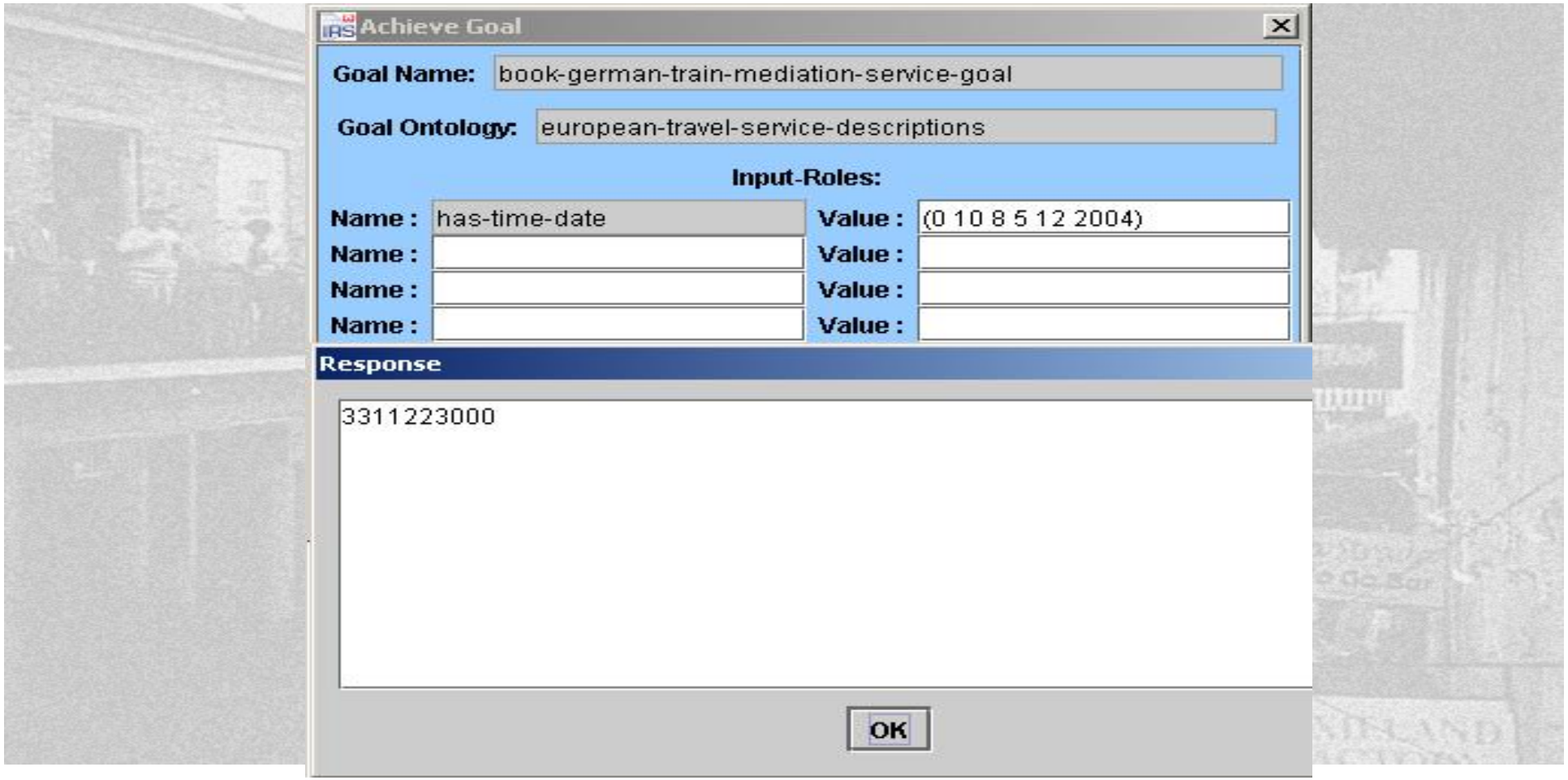
Adding a Mediator to the Web Service (Mediation Service)



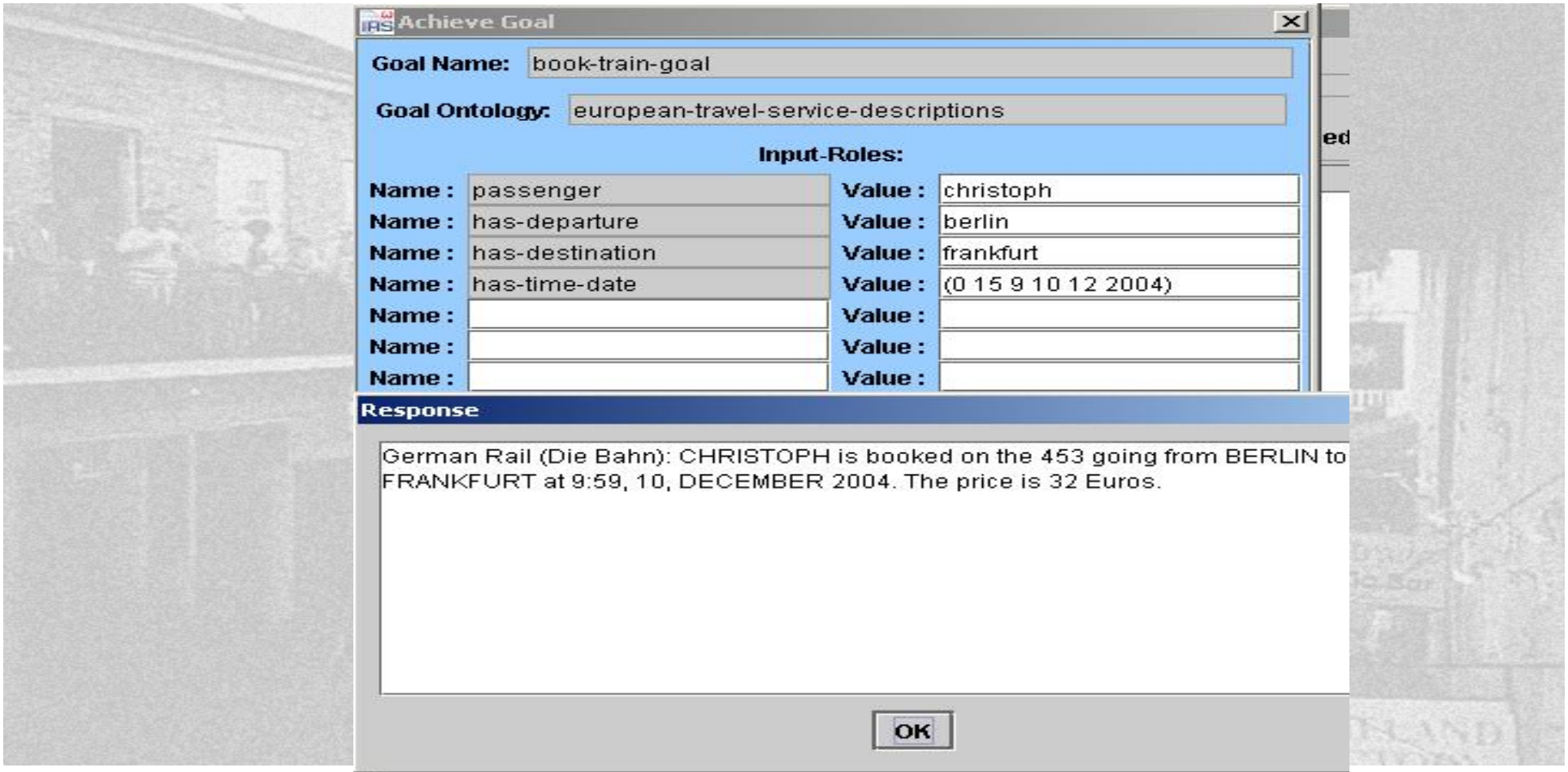
Publishing Web Services (lisp functions)



Achieving a Goal (Mediation Service)



Achieving a Goal

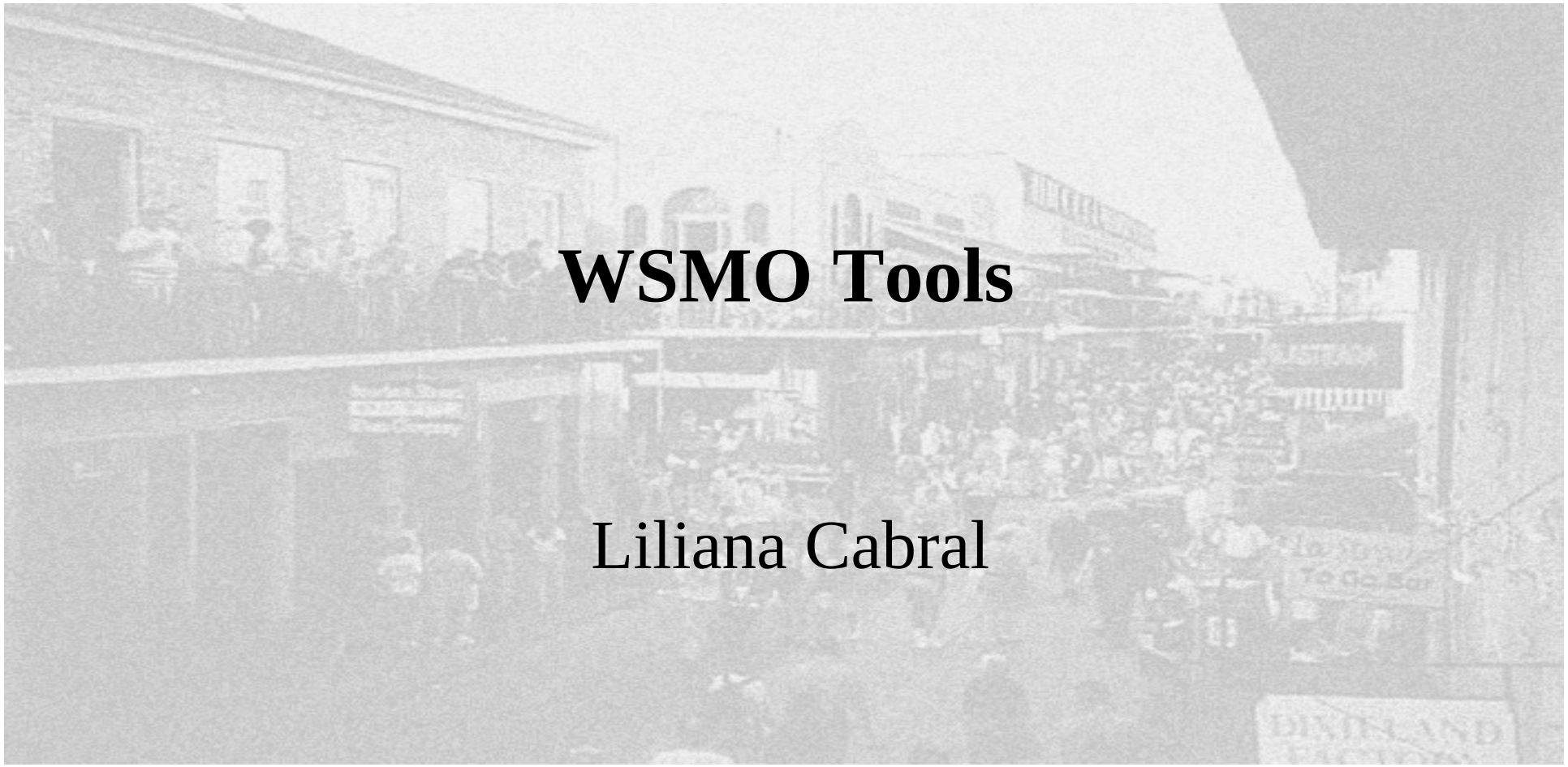


IRS-III Future Work

- IRS-III Choreography definition language is being specified.
  - Based on guarded state transitions as forward chaining rules
- IRS-III Orchestration is being defined.
- OO-mediators will have mapping rules.

IRS-III Link

- Webpage: http://kmi.open.ac.uk/projects/irs/
- Download available:
  - Java API
  - Browser/Editor

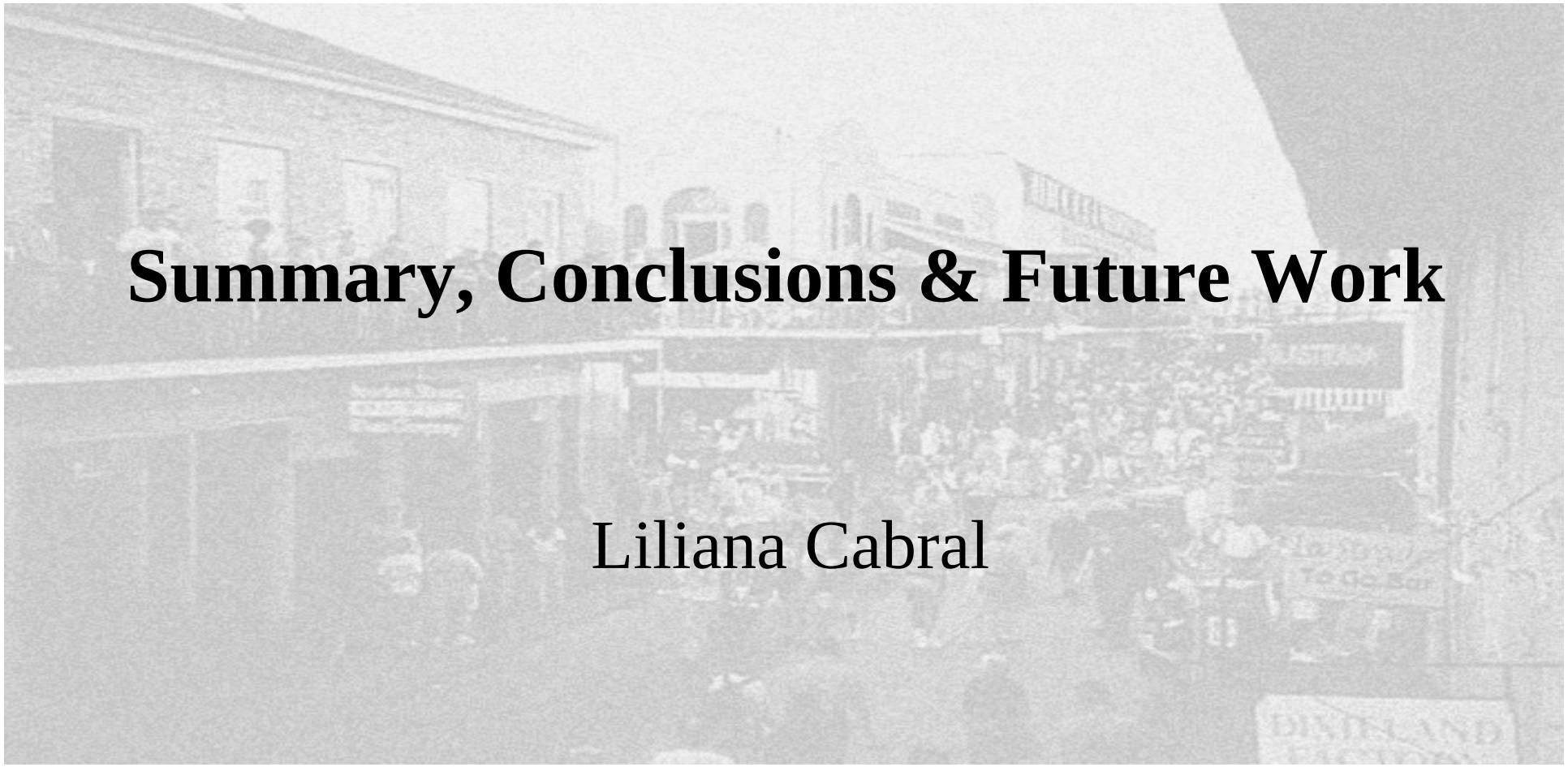


WSMO Tools

Liliana Cabral

WSMO Tools (in development)

1. **WSMX Server -** http://sourceforge.net/projects/wsmx
2. **IRS-III API -** http://kmi.open.ac.uk/projects/irs/
3. **WSMO API/WSMO4J -** http://wsmo4j.sourceforge.net/
   Java API for WSMO / WSML
4. **WSMT – Web Services Modelling Toolkit**
5. **WSMO Studio -** http://www.wsmostudio.org/
   (currently: SWWS Studio)
   Creation and editing of WSMO specifications
   WSML Editor
   Ontology Management System OMS
   Open for Plug-Ins for SWS tools (discovery, composer, …)
6. **WSML Validator and Parser**
   validates WSMO specifications in WSML
   parsing into intermediary FOL format (every FOL compliant syntax can be derived from this)
7. **OWL Lite Reasoner for WSML-OWL variant**
   OWL Lite Reasoner based on TRIPLE



Summary, Conclusions & Future Work

Liliana Cabral

Conclusions

- This tutorial should enable you to:
  - understand aims & challenges within Semantic Web Services
  - understand the objectives and features of WSMO
  - model Semantic Web Services with WSMO
  - correctly assess emerging technologies & products for Semantic Web Services
  - use implemented tools to create SWS

References WSMO

- The central location where WSMO work and papers can be found is WSMO Working Group: http://www.wsmo.org
- In regard of WSMO languages: WSML Working Group: http://www.wsml.org
- WSMO implementation: WSMX working group can be found at: http://www.wsmx.org
- WSMX open source can be found at: https://sourceforge.net/projects/wsmx/

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- Michal Zaremba, Armin Haller, Maciej Zaremba, and Matthew Moran : *WSMX-Infrastructure for Execution of Semantic Web Services*, ISWC 2004: Demo Papers, Nov, 2004, Hiroshima, Japan.

References IRS-III

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