Towards Patterns of Web Services Composition

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Based on a paper with the same name authored by
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http://citeseer.ist.psu.edu/472153.html

Introduction

- **The term *(Web) service* denotes an *abstraction* of a set of computational and/or physical activities intended to fulfill a class of *customer needs* or *business requirements***
- **It provide an *interface* to access functionalities offered by *information systems*, *application programs*, and *business process***
- **Enterprises are continuously discovering new opportunities to form *alliances* with other enterprises, in order to *share* their *costs*, *skills* and *resources* by offering integrated services (composite services)**
- **The lack of *high level abstraction* for *Web service integration* has triggered a considerable amount of research and development efforts**
- **The report summarized a number of *design patterns* for the definition and implementation of service integration**

Review of enabling technologies

- **Service composition is an active area of research and development in *different fields*:**
  - **Component-based frameworks**
  - **Cross-enterprise workflows**
  - **Electronic Data Interchange**
  - **XML-based B2B frameworks**

Component-based Frameworks

- **E-commerce applications rely on *distributed object frameworks* such as CORBA, DCOM, EJB and other state-of-the art technologies such as Enterprise Application Integration (EAI) and Enterprise Resource Planning (ERP)**

- **EAI suites provide standard *data and application integration* facilities (e.g. pre-built application adaptors, data transformations, and messaging services among heterogeneous system)**

- **ERP systems provide a single, *homogenous solution* for a number of back-office applications**

Cross-enterprise Workflows

- ***Automate business processes*** **that interconnect and manage communication among disparate systems**

- **New emerging service composition projects consider *loosely coupled services* (CMI, EFlow, CrossFlow, Mentor, CPM, SELF-SERV, ADEPT)**

- **These projects consider critical requirements of B2B e-commerce such as dynamic selection, adaptability, and external manageability of services**

Electronic Data Interchange - EDI

- **EDI is the interorganizational application-to-application transfer of *business documents***
- **EDI documents are structured according to a *standard* and *machine-processable format* (e.g. ANSI X12 and UN/EDIFACT)**
- **Mostly used for the automatic transfer and processing of documents in industries which *trade on high volumes* (e.g. goods transportation, food manufacturing, and automobile production)**

XML-based B2B Frameworks

- **Provide a *common format* to publish and exchange *business information* over the Internet**
- **To support B2B interoperability, describe the *semantics* and *structure* of data and operations of services using XML & domain ontologies**
- ***Ontology* defined terms to describe *entities* (e.g. service properties, operations) of a specific domain (e.g. healthcare, finance, travel) and *relationships* among terms**
- **Some organizations (e.g. RossettaNet) developed common ontologies for different industries**
- **E-commerce platforms that rely on XML-based standards and protocols including IBM WebSphere, WebMethods, Sun ONE, and BEA Collaborate**

Patterns of Service Composition

- **Elementary Service-based *Interactions***
  - **The External Interactions *Gateway* Pattern**
  - **The Contract-Based Outsourcing Pattern**
- **Service *Composition***
  - **Service *Composition* Pattern**
  - **Service *Discovery* Pattern**
- **Composite Service *Execution***
  - ***Central* Authority Pattern**
  - ***Peer-to-Peer* Execution Pattern**

Elementary Service-based Interactions

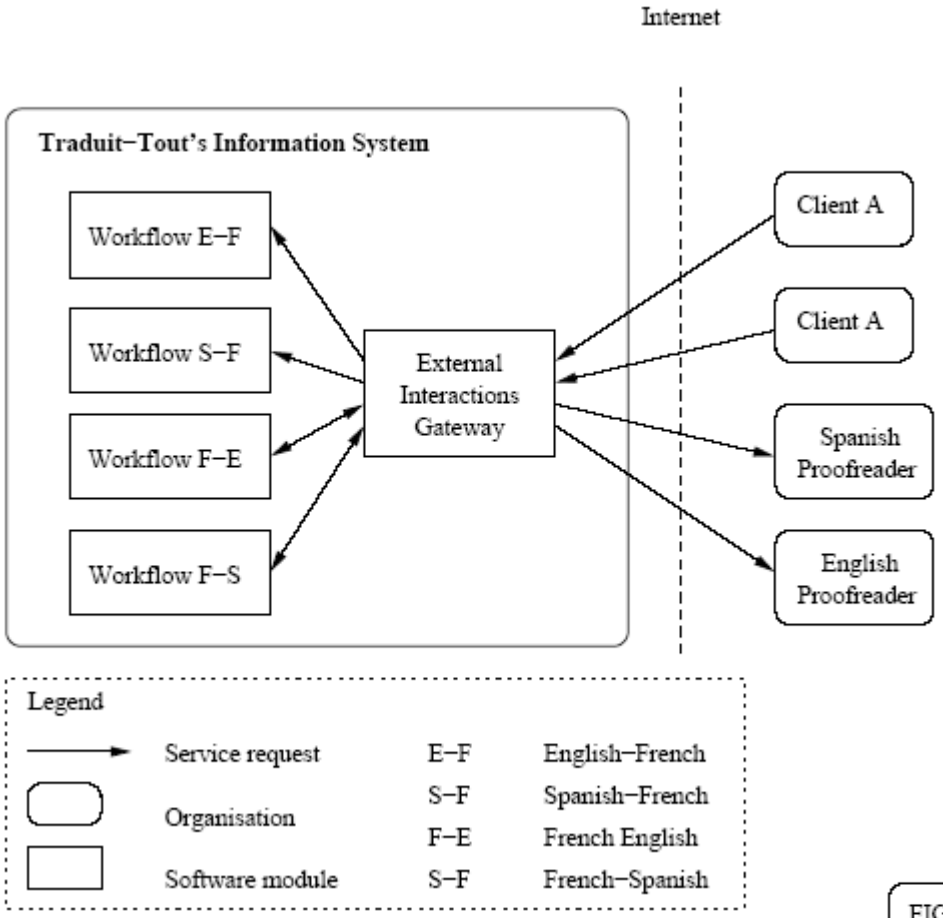
- **In the setting of B2B e-Service, it is the *interaction of Information System (IS)* between service provider and service consumer**
- **Their IS are *heterogeneous* in both the managerial and technological viewpoints**
- **Service provider needs to make sure their IS has a *clearly defined interface* to their e-service**
- **Service consumer needs to make sure their IS *interact properly* with the e-service interface**

The External Interaction Gateway Patterns

- **Each of the services provided by the organization has it own *interaction requirements* (e.g. document formats, data model, domain ontologies, message sequencing)**

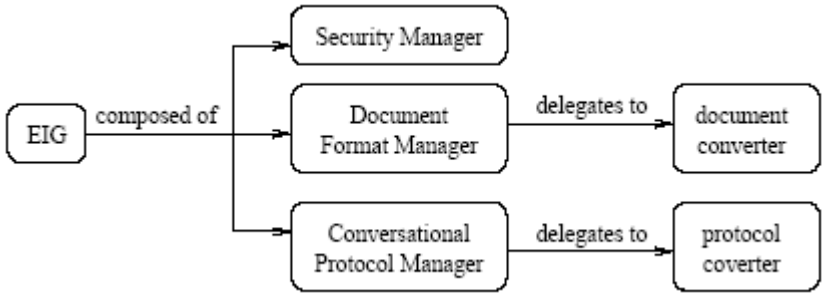
- **Issue arise in this situation:**
  - **For different data model and format of business document, how the *conversion between formats* operated?**
  - **For different interaction protocols, how to *ensure proper interaction* between applications?**
  - **For the exchange of critical business information, how to *ensure* the *confidentiality*, *integrity* and *non-repudiation?***

The External Interaction Gateway Patterns



- **Solution: using a software entities called as *External Interaction Gateway* (EIG)**

- **Internal architecture of EIG:**



The External Interaction Gateway Patterns

- **Handling *document format heterogeneity* based on separation between syntax and data model of a standard**
- **The *syntax* of a document standard is specified as an XML DTD or an XML Schema**
- **The *data model* is specified in the RDF Schema Language**
- **Transformation of document XD (with XML standard S) into document XD' (with XML standard S')**
  - **Abstraction: XD → RD (data model of S)**
  - **Conversion: RD → RD' (data model of S')**
  - **Refinement: RD' → XD' (syntax of S')**

XD – XML Document
RD – RDF Document

The Contract-Based Outsourcing Pattern

- **Contract is a *planned set of actions and interactions* that need to undertaken during the delivery of a service**
- **Contracts for a given service are abstracted into *contract templates* with a set of parameters**
- **Contract templates are included in the *advertisement* of a service offer**
- **Typical steps:**
  - **Queries *service catalog*(s)**
  - **Retrieves *service offers* with their *contract templates***
  - **Instantiates the contract by providing a set of *parameter values***
  - **For special requirement, *negotiation* for contracts with providers may be needed**
  - **Execute the contract through *contract enactment module***

The Contract-Based Outsourcing Pattern

- **Known Implementations**
  - **CrossFlow – *contracts* are *statically specified* (no dynamic negotiation) by service providers and advertised in a service marketplace**
  - **MEMO – exchange standardized messages based on *speech-act theory*, structure, sequencing and semantics of the message exchanged during the negotiation is fixed**
  - **ADEPT – using one-to-many negotiation framework based on *multi-attribute utility theory*, each agent try to *maximizes* its *own utility function* which encodes the preferences and business constraints of the organization**

Service Composition

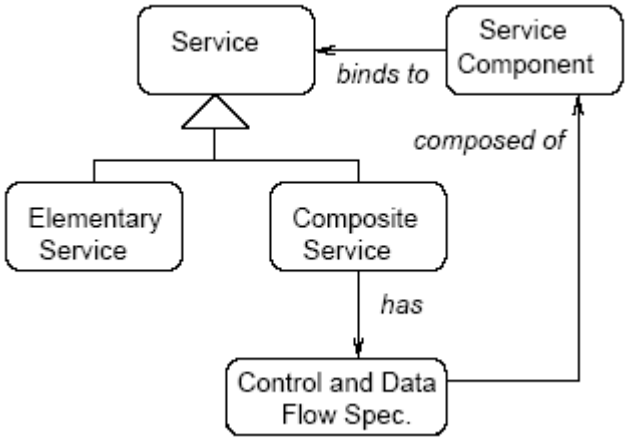
- **Fast and dynamic integration of business process is an essential requirement for organization**

- **Business partners with *permanent* (long term) relationships**
  - **Components are known in advance and alliances are statically defined**
  - **Static composition of service is sufficient**
- **Business partners with *temporary* (short term) relationships**
  - **Not assume an a priori trading relationship among partners**
  - **Dynamic composition of service is needed**

Service Composition Pattern

- **Important characteristics for *static composition*:**
  - **Describe interaction of services without referring to any implementation or execution model**
  - **Support nesting of composite services**
  - **Maintain a high level specification of a composite service while ensuring its executability**

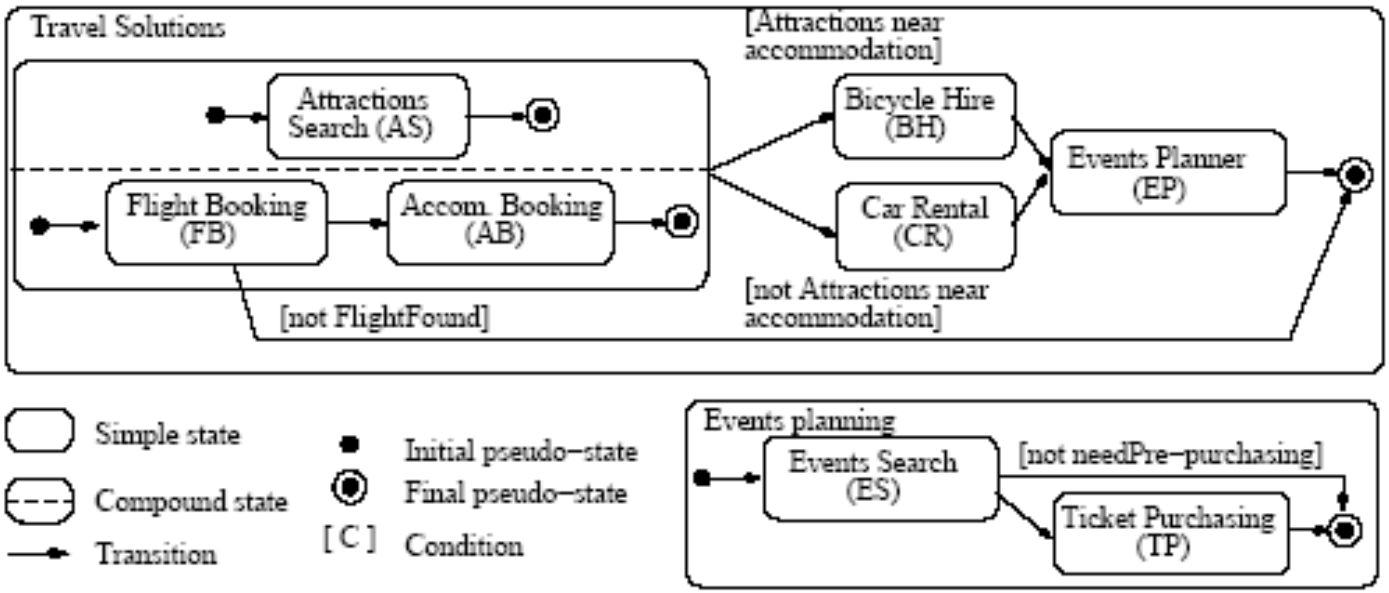
- **Solution: aggregation specification with *control flow* and *data flow* specification**



Service Composition Pattern

- **Use of statechart as a *formal notations* for *workflow specification***
- **Statechart made up of *states* and *transitions* with *Event-Condition-Action (ECA) rules***

- **Example of control flow specification of “Travel Solutions” using statechart:**



Service Composition Pattern

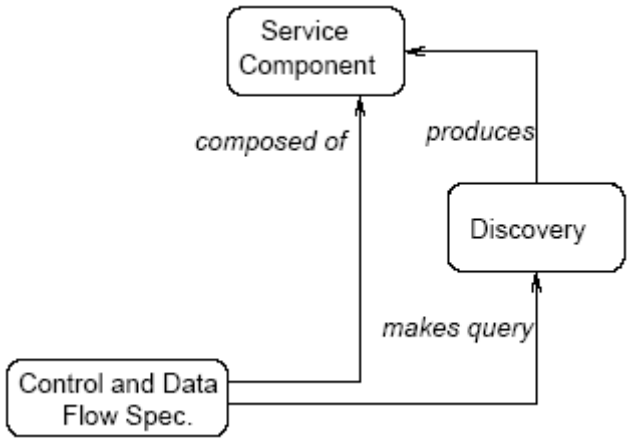
- **Known Implementations**
  - **CMI – service is modeled by *state machine* that specifies the possible states of a service and their transitions**
  - **EFlow – composite service is modeled as a *graph*, it defines the order of execution of service component among the nodes (service, decision, event)**
  - **WebBIS – adopts an *ECA-rule* approach for defining composite service**
  - **SELF-SERV – use a subset of *statecharts* to express the control-flow of composite services**

Service Discovery Pattern

- **Problem relates to Web-based service integration in *large*, *autonomous*, *heterogeneous,* and *dynamic* environments**

- **Important characteristics for *dynamic composition*:**
  - **Information to identify service components at run-time**
  - **Integrate component services with a high level specification of composite service**

- **Solution:**
  - **automated *service discovery* facility**
  - **composite *service specification* allows automatically discover of service components**



Service Discovery Pattern

- **Known Implementations**
  - **CMI – use *placeholder activity* as an abstract activity that will be *replaced* at runtime with a concrete activity, *selection policy* is specified to choose the best implementation**
  - **EFlow – service node contains a search recipe, it is a query represented in a query language**
  - **WebBIS – use a concept of *push-community* which describes the capabilities of a desired service, actual service can *register* with one or several push-communities, need a *mapping* of the operations in the community and the actual services**

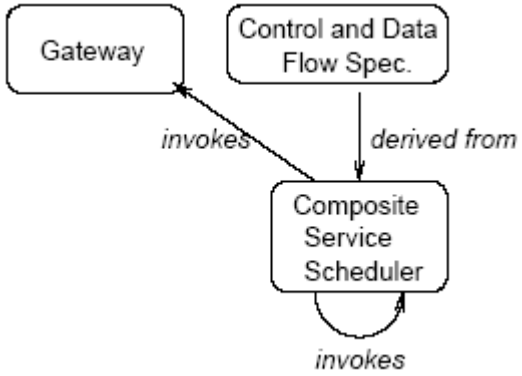
Composition Service Execution

- **Execution of a composite service assuming that its *control* and *data semantics* are *already defined***
- **Execution involve the *activation* of all its *component* services hosted on a number of remote providers**
- **Two possible execution patterns**
  - **Components are coordinated by a *central* scheduler**
  - **Coordinate the execution through *peer-to-peer* communication**

Central Authority Execution Pattern

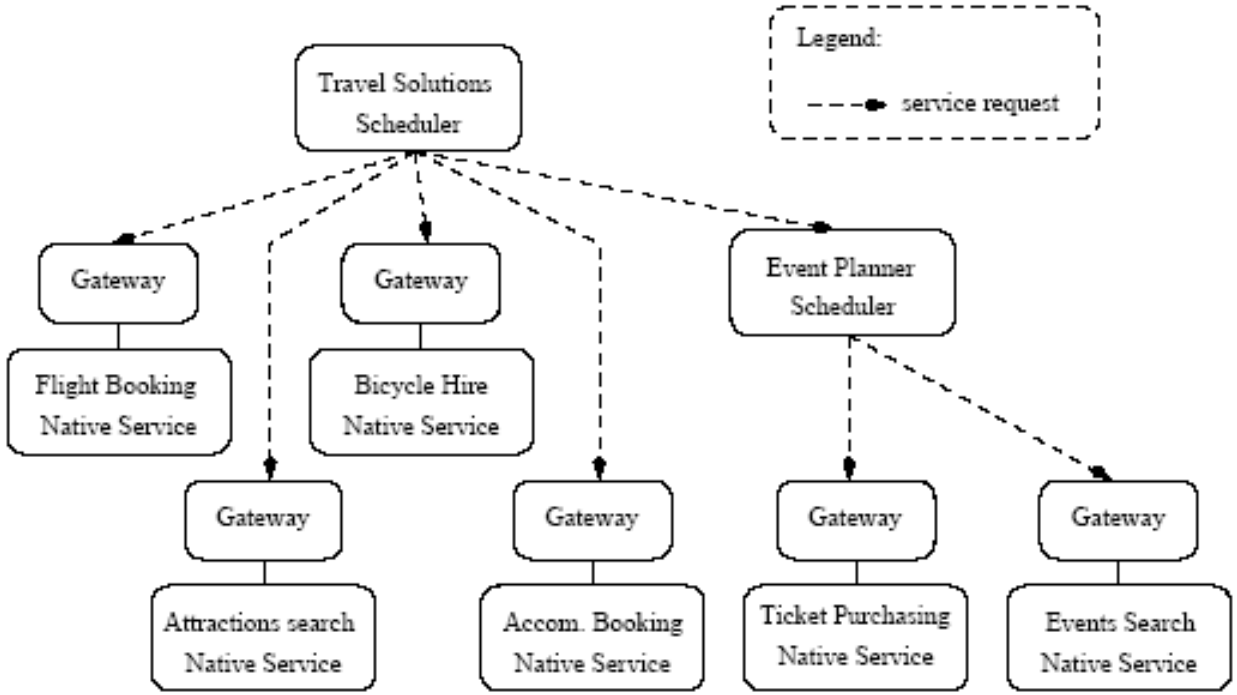
- **Provider of composite service S should hold a *Composite Service Scheduler***

- **The scheduler responsible for:**
  - ***Invoke* each of S's *components* according to the order and conditions in control flow specification**
  - **Receive and processes *service requests***
  - **Handling and *processing data* according to the data semantics of composite service**



Central Authority Execution Pattern

- **Example of centralized execution of “Travel Solutions” service**

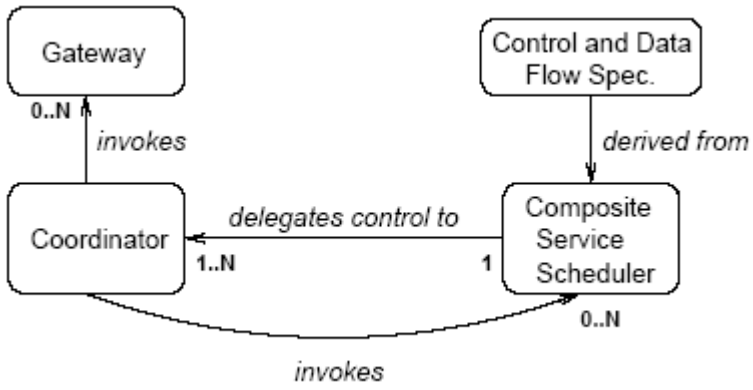


Central Authority Execution Pattern

- **Known Implementations**
  - **ADEPT – a workflow can be recursively decomposed into *sub-workflows*, leading to a *tree structure***
  - **EFlow – execution model is based on *centralized process engine*, not support recursive definition of composite services**

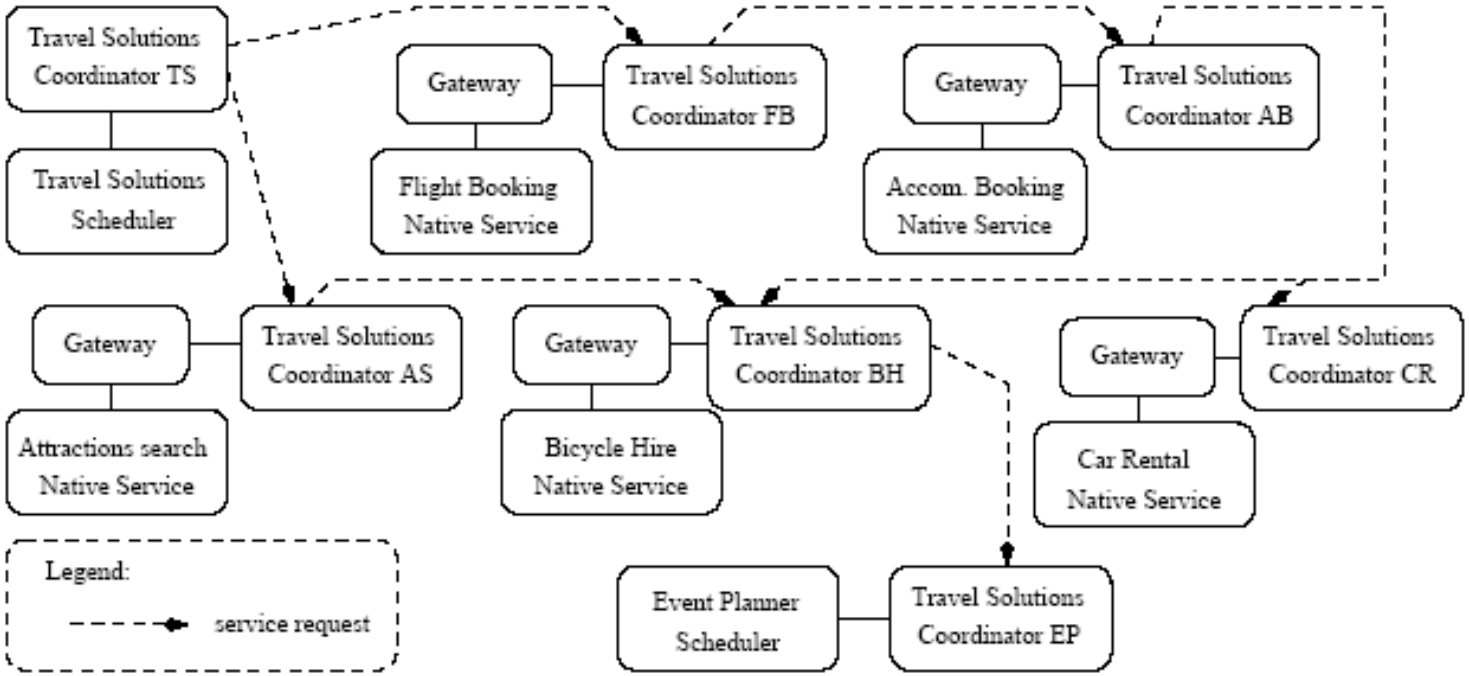
Peer-to-Peer Execution Pattern

- **Responsibility of coordinating the execution of a composite service is *distributed* across the providers**
- **A software components called *coordinators* are hosted by each of the providers**
- **Coordinator responsible for:**
  - ***Initiate* the *execution* of service components**
  - ***Notify* the *completion* of this execution to the next coordinators**
  - ***Interrupt* the service *execution* during the occurrence of a certain external events**



Peer-to-Peer Execution Pattern

- **Example of distributed execution of “Travel Solutions” service**



Peer-to-Peer Execution Pattern

- **Known Implementations**
  - **SELF-SERV – responsibility of coordinating the composite service execution is distributed across several *lightweight software components* hosted by the service providers**
  - **CPM – support the execution of inter-organizational business processes through *peer-to-peer collaboration***
  - **Mentor – *partition* the overall workflow specification *into several sub-workflows* and distributing the execution of the sub-workflows**

Conclusion

- **Discussed a number of *patterns* for the definition and implementation of service integration**
- **These patterns suggest a methodology for building a new composite service**
  - **Identify elementary services and expose them through a *gateway interface* (External Interactions Gateway Pattern)**
  - **Specify *control and data flow semantics* of the new service based on these elementary services or other composite services (Service Composition Pattern)**
  - ***Component* services can be *identified at run-time* (Service Discovery Pattern)**
  - ***Coordination* for the execution of composite service can be *centralized* or *distributed* across the service providers (Service Execution Patterns)**