

# eTourPlan: A Knowledge-Based Tourist Route and Activity Planner

Tshering Dema

Faculty of Computer Science

University of New Brunswick

October 6, 2008

## Acknowledgement

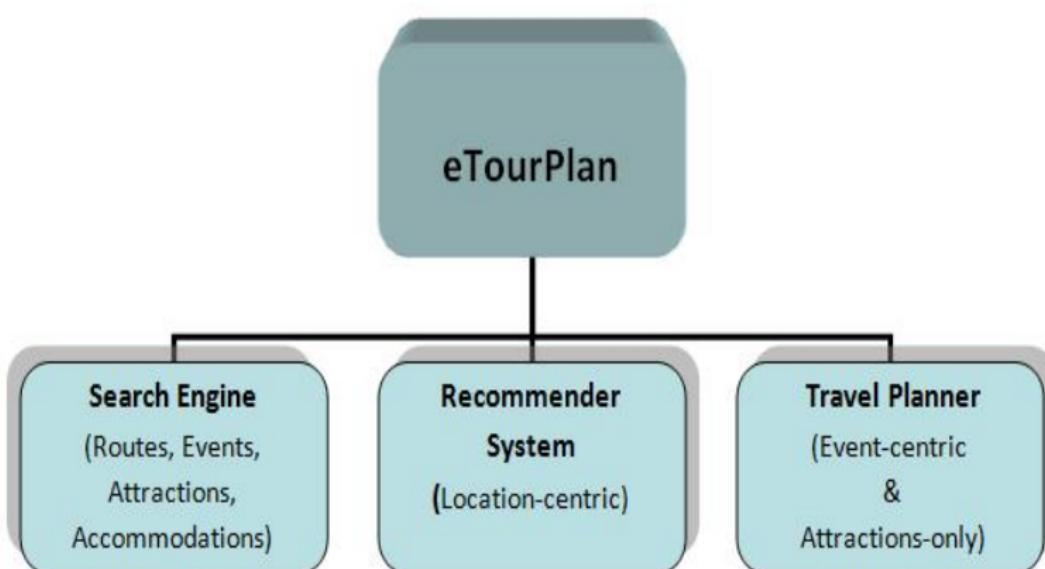
- Supervisors:
    - Dr. Harold Boley
    - Dr. Przemyslaw Rafal Pochech
  - Committee members:
    - Dr. Bruce Spencer
    - Dr. Gerhard Dueck
    - Dr. Yevgen Biletskiy
  - The Bhutan Project funded by Canadian International Development Agency (CIDA)
  - University of New Brunswick (UNB)

## Outline

- ① Introduction
  - ② Background
  - ③ Knowledge Base Design: Ontology and Facts
  - ④ Knowledge Base Design: Rules
  - ⑤ Evaluation of eTourPlan on the Bhutan KB
  - ⑥ Conclusion and Future Work

## 1.1 Introduction

## A knowledge-based eTourism prototype



- Tourism is the world's largest and fastest growing industry
  - The World Tourism Organization predicts that one billion international tourists will travel by the year 2010
  - Most of the prevalent travel recommenders are location-centric
    - **Shortcoming:** Do not function as complete trip planners.  
e.g., time (visit a number of places) > time (available to traveller)
  - Pre-customized travel packages in mass tourism
    - **Shortcoming:** limited flexibility to users' preference specification
  - Independent sources for various tourist facility information (activity and accommodation)
    - **Shortcoming:** Tourist consultants and travellers must visit multiple independent sources to plan a trip tailored to given preferences

## 1.2.1 Motivation

- Tourism is the world's largest and fastest growing industry
  - The World Tourism Organization predicts that one billion international tourists will travel by the year 2010
  - Most of the prevalent travel recommenders are location-centric
    - **Shortcoming:** Do not function as complete trip planners.  
e.g., time (visit a number of places) > time (available to traveller)
  - Pre-customized travel packages in mass tourism
    - **Shortcoming:** limited flexibility to users' preference specification
  - Independent sources for various tourist facility information (activity and accommodation)
    - **Shortcoming:** Tourist consultants and travellers must visit multiple independent sources to plan a trip tailored to given preferences

## 1.2.1 Motivation

- Tourism is the world's largest and fastest growing industry
  - The World Tourism Organization predicts that one billion international tourists will travel by the year 2010
  - Most of the prevalent travel recommenders are location-centric
    - **Shortcoming:** Do not function as complete trip planners.  
e.g., time (visit a number of places) > time (available to traveller)
  - Pre-customized travel packages in mass tourism
    - **Shortcoming:** limited flexibility to users' preference specification
  - Independent sources for various tourist facility information (activity and accommodation)
    - **Shortcoming:** Tourist consultants and travellers must visit multiple independent sources to plan a trip tailored to given preferences

## 1.2.1 Motivation

- Tourism is the world's largest and fastest growing industry
  - The World Tourism Organization predicts that one billion international tourists will travel by the year 2010
  - Most of the prevalent travel recommenders are location-centric
    - **Shortcoming:** Do not function as complete trip planners.  
e.g., time (visit a number of places) > time (available to traveller)
  - Pre-customized travel packages in mass tourism
    - **Shortcoming:** limited flexibility to users' preference specification
  - Independent sources for various tourist facility information (activity and accommodation)
    - **Shortcoming:** Tourist consultants and travellers must visit multiple independent sources to plan a trip tailored to given preferences

1.2.2 Motivation

- eTourism is an information-based heterogenous business (distributed nature of its high volume of information)
    - Information gathering, integration, distribution, and exchange are the backbones of the travel industry
  - The Semantic Web is a major endeavour to enhance the Web by enriching its content with semantic (meta)data that can be processed by inference-enabled Web applications
    - Modelling a well-structured and comprehensive Knowledge Base (KB) for consulting will help bolster the eTourism domain

## 1.3 Objectives

To design, implement, and evaluate a knowledge-based eTourism prototype for Bhutan

## 1.3 Objectives

To design, implement, and evaluate a knowledge-based eTourism prototype for Bhutan

- To design a light-weight ontology to capture all the tourism subdomains [aligned with the **Harmonise** eTourism ontology]
  - To build a Bhutan fact base consisting of **FOAF-like** profiles for tourist entities, structured by this ontology
  - To implement rule subsystems needed for generating **travel plans** containing **tour recommendations**:
    - Partonomy rules for the subdivision of regions
    - Derivation rules to deduce transitive closure facts about distances etc.
    - Inference rules for various planning and recommendation modes
    - Query rules to perform semantic searches
  - To evaluate the overall operation of the eTourPlan prototype as run in the **OO jDREW** reasoning engine prototype (giving feedback to the **OO jDREW** open source community)

## 1.3 Objectives

To design, implement, and evaluate a knowledge-based eTourism prototype for Bhutan

- To design a light-weight ontology to capture all the tourism subdomains [aligned with the **Harmonise** eTourism ontology]
  - To build a Bhutan fact base consisting of **FOAF-like** profiles for tourist entities, structured by this ontology
  - To implement rule subsystems needed for generating **travel plans** containing **tour recommendations**:
    - Partonomy rules for the subdivision of regions
    - Derivation rules to deduce transitive closure facts about distances etc.
    - Inference rules for various planning and recommendation modes
    - Query rules to perform semantic searches
  - To evaluate the overall operation of the eTourPlan prototype as run in the **OO jDREW** reasoning engine prototype (giving feedback to the **OO jDREW** open source community)

## 1.3 Objectives

To design, implement, and evaluate a knowledge-based eTourism prototype for Bhutan

- To design a light-weight ontology to capture all the tourism subdomains [aligned with the **Harmonise** eTourism ontology]
  - To build a Bhutan fact base consisting of **FOAF-like** profiles for tourist entities, structured by this ontology
  - To implement rule subsystems needed for generating **travel plans** containing **tour recommendations**:
    - Partonomy rules for the subdivision of regions
    - Derivation rules to deduce transitive closure facts about distances etc.
    - Inference rules for various planning and recommendation modes
    - Query rules to perform semantic searches
  - To evaluate the overall operation of the eTourPlan prototype as run in the **OO jDREW** reasoning engine prototype (giving feedback to the OO jDREW open source community)

## 1.3 Objectives

To design, implement, and evaluate a knowledge-based eTourism prototype for Bhutan

- To design a light-weight ontology to capture all the tourism subdomains [aligned with the **Harmonise** eTourism ontology]
  - To build a Bhutan fact base consisting of **FOAF-like** profiles for tourist entities, structured by this ontology
  - To implement rule subsystems needed for generating **travel plans** containing **tour recommendations**:
    - Partonomy rules for the subdivision of regions
    - Derivation rules to deduce transitive closure facts about distances etc.
    - Inference rules for various planning and recommendation modes
    - Query rules to perform semantic searches
  - To evaluate the overall operation of the eTourPlan prototype as run in the **OO jDREW** reasoning engine prototype (giving feedback to the **OO jDREW** open source community)

1.4 Travel Planner

eTourPlan

- A knowledge-based eTourism prototype using Semantic Web techniques:
    - A well-structured and comprehensive KB for tourism subdomains
    - Rule subsystems for search, recommendation and travel planning
    - Utilizing Bhutan tourist information as a use case
    - Results of running eTourPlan in the prototype RuleML engine OO jDREW are reported



### 2.1.1 Travel Planning Strategies

	Attraction-Only Planning	Event-Only Planning	Event-Centric Planning
Complete Planning	Planning attractions based on related locations	Planning events based on their dates and locations	Planning events with additional attraction recommendation
Sequence Planning	System orders the user-specified attractions	System orders the user-specified events	System orders both events and attractions
Partial Planning	System orders and adds to user-specified attractions	System orders and adds to user's specified events	System orders and adds to user's specified events and attractions



## 2.1.2 Recommender System

## Knowledge-based Recommenders

- Use ontologies and rules for knowledge representation
  - Derive implicit facts from ontology-structured facts using rules
  - Provide recommendations as wide-ranging as its KB
  - Respond to user's stated requirements

## A “NEED” for providing trip planning options

## 2.2 The Semantic Web

### Concept

- Machine-understandable metadata
- Knowledge representation and automatic data integration
- Desirable for structuring vast information-based business (e.g. Tourism)

### Semantic Web techniques

- Knowledge representation by using XML, RDF and ontologies
- To perform inferences and automated reasoning using Description-Logic and/or Rule Engines

## 2.3 FOAF: Friend Of A Friend

### Friend Of A Friend: Semantic Social Networking

- Provides extended RDF Schema (RDFS) vocabulary
- Person-centric RDF knowledge representation
- Enables Semantic Web methods for formalised personal homepages

An approach similar to FOAF is transferred to semantically describe and link profiles for tourist entities

## 2.4 The Harmonise ontology

**Ontology:** Shared understanding of the relevant concepts and relationships of a domain

#### **Harmonise ontology:**

- eTourism ontology for information exchange in travel and tourism
  - Classifications of data items for events, attractions, accommodations, and restaurants
  - A market validation by 12 pilot organizations (based across Europe) through the Harmo-TEN project
  - Some key players in the Tourism Harmonization Network are:
    - the Open Travel Alliance (OTA)
    - the World Tourism Organization (WTO)
    - the Travel Technology Initiative (TTI)
    - the International Federation for IT, Travel and Tourism (IFITT)



## 2.5 Semantic eTourism Prototype

**Machine-readable representation of information in the form of:**

## Ontologies:

- Good basis for reasoning and classification
  - Uniform definitions of tourism subdomains
  - Remove semantic ambiguity

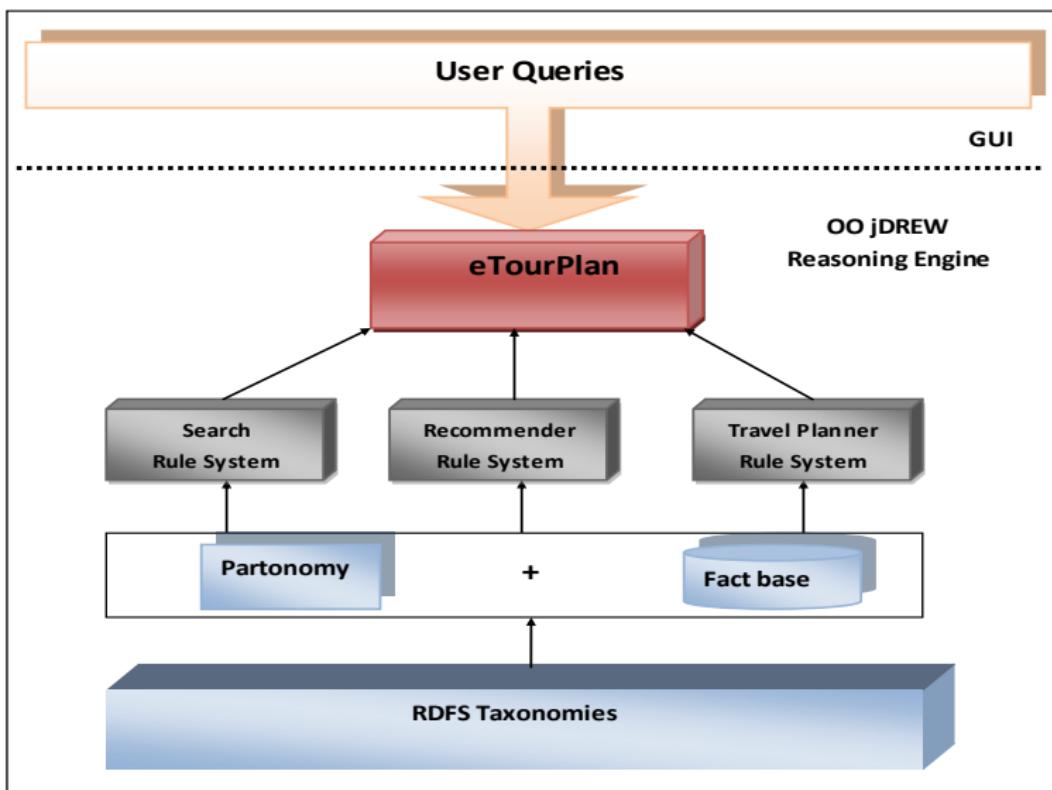
## Facts:

- Object-centric descriptions of tourist entities

## Rules:

- Semantic search against the above facts (formal knowledge) rather than keyword search against texts (natural language)
  - Higher services based on deduction (Travel planning and recommendation)

### 3.1 The eTourPlan Architecture



## 3.2 Ontology Design

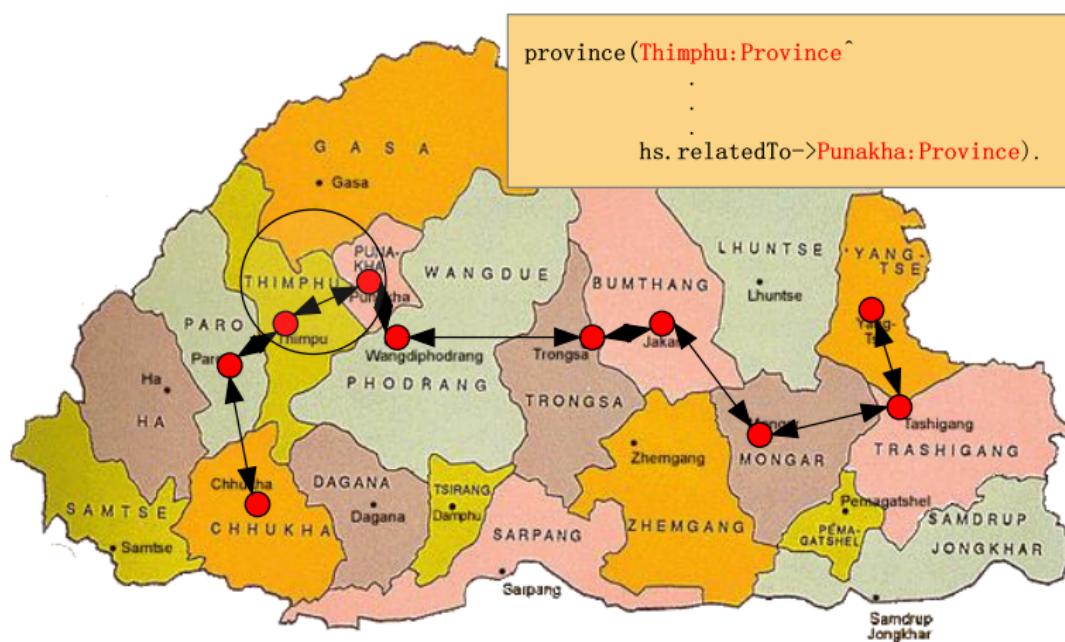
- ‘Reference model’ for a specific domain
- RDFS light-weight ontologies (adapted from the Harmonise eTourism ontology)
- To structure the FOAF-like profiles of tourist entities:
  - province
  - event
  - attraction
  - accommodation
- **Why Harmonise?**
  - Mature and standard ontology
  - Interoperability among many agents and applications
  - Expressed in RDFS (SubClassOf hierarchies are supported by OO jDREW)

### 3.3.1 FOAF-like Province Profile

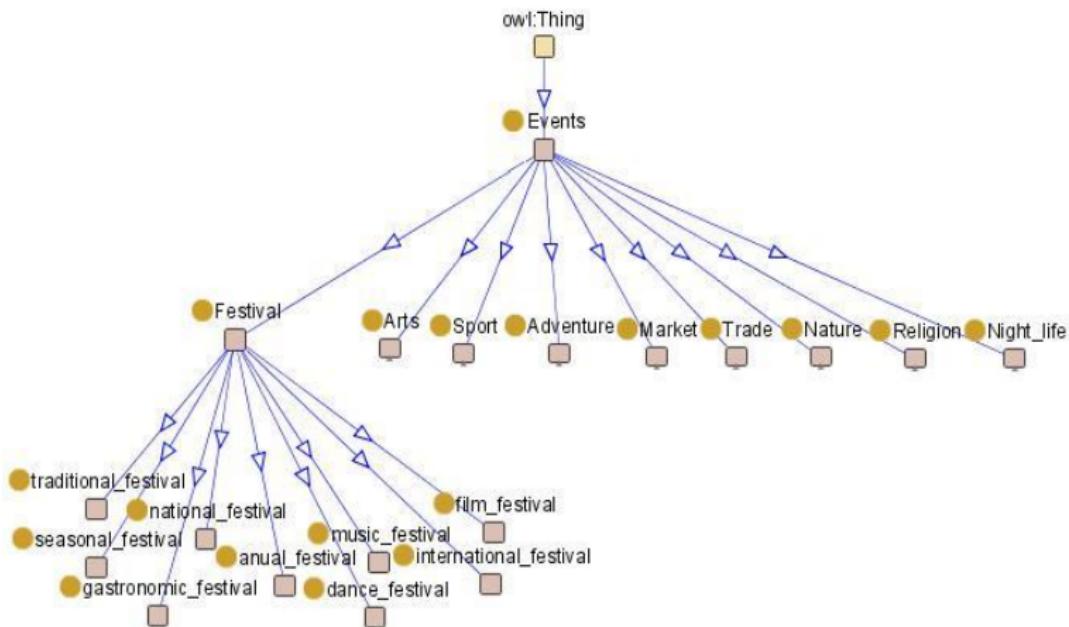
## Profile of Thimphu Province

**province**(Thimphu:Province<sup>^</sup>  
hs.url->“<http://www.thimphu.gov.bt>”;  
et.capital->Thimphu\_City:City;  
et.area->“1,819 sq.km”;  
et.elevation-> “1,300 to 7300 meters”;  
et.numBlocks->10:Integer;  
et.numAttractions->3:Integer;  
et.numEvents->2:Integer;  
et.numAccommodations->0:Integer;  
hs.languagesSpoken->“Dzongkha”;  
hs.description->“Thimphu is the capital of Bhutan”,  
**hs.relatedTo**->Punakha:Province).

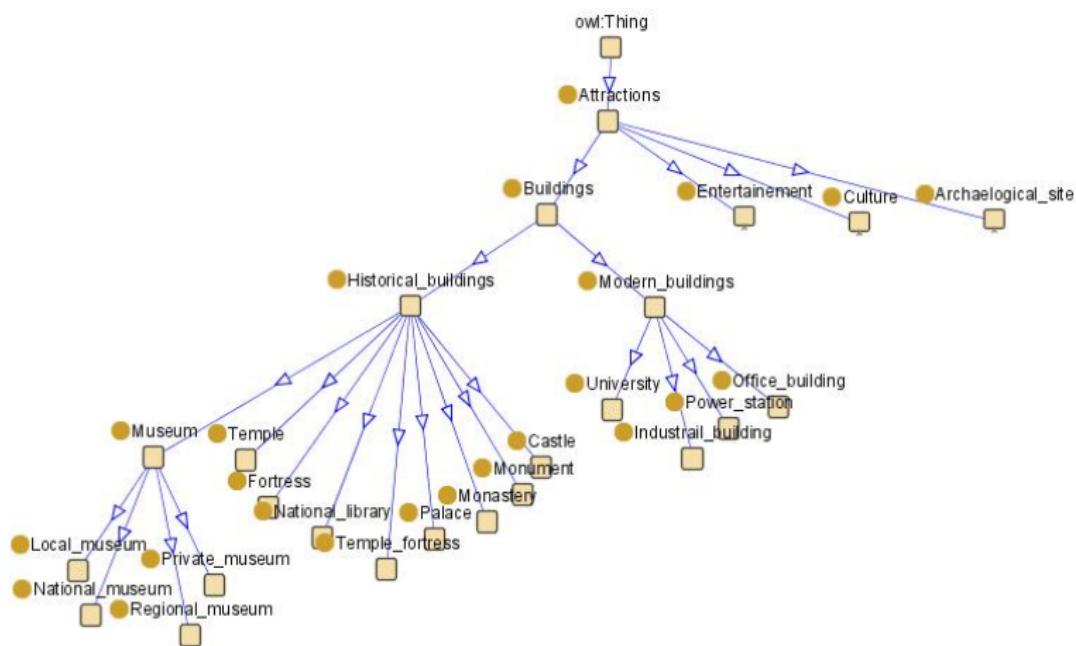
### 3.3.2 Harmonise's "relatedTo" relation between provinces in the KB



### 3.3.3 Events Class



### 3.3.4 Attractions Class



### 3.3.5 FOAF-like Profiles of an Event and an Attraction

#### Profile of Thimphu\_Tshechu

```
event(Thimphu_Tshechu:Annual_festival^
    hs.url->“ ”;
    hs.startDate->date[2008:Real,10:Real,09:Real];
    hs.endDate->date[2008:Real,10:Real,11:Real];
    et.theme->Cultural_Religious_Heritage;
    hs.location->Tashichoe_Dzong:Fortress;
    et.province->Thimphu:Province;
    hs.description->“It is a popular festival in Thimphu”;
    hs.relatedTo->Thimphu_Drupchen:Annual_festival).
```

#### Profile of Ta\_Dzong

```
attraction(Ta_Dzong:National_museum^
    hs.url->“www.nationalmuseum.gov.bt/”;
    et.subblock->Goepay:Village;
    et.province->Paro:Province;
    et.theme->Cultural_Religious_Heritage;
    et.open->Open[DaysOfWeek[Tue, Wed, Thu, Fri, Sat, Sun],
        Period[10:Real, 16:Real]];
    et.capitalDistance->0.5:Real;
    hs.description->“It is the biggest and the oldest museum
        in Bhutan”;
    hs.contact->“ ”;
    hs.schedule->“12 months”;
    hs.relatedTo->Tashichoe_Dzong:Fortress).
```

## 4.1 eTourPlan Rule Subsystems

### ① Partonomy Rules

- Administrative subdivision of a country

### ② Rule System for Route Planning

- Searching routes between Provinces
- System route planning based on Province profiles
- Route planning via user-preferred Provinces

### ③ Rule System for Parametric Search of Tourist Entities

- Provincial information
- Activity opportunities (Events and Attractions)
- Accommodation information

### ④ Rule System for Location-Centric Travel Recommender

- Tour through user-preferred Provinces
- Tour of system-recommended Provinces

### ⑤ Rule Systems for eTourPlan Travel Planner

- Attraction-only Planning
- Event-centric Planning

## 4.1 eTourPlan Rule Subsystems

### ① Partonomy Rules

- Administrative subdivision of a country

### ② Rule System for Route Planning

- Searching routes between Provinces
- System route planning based on Province profiles
- Route planning via user-preferred Provinces

### ③ Rule System for Parametric Search of Tourist Entities

- Provincial information
- Activity opportunities (Events and Attractions)
- Accommodation information

### ④ Rule System for Location-Centric Travel Recommender

- Tour through user-preferred Provinces
- Tour of system-recommended Provinces

### ⑤ Rule Systems for eTourPlan Travel Planner

- Attraction-only Planning
- Event-centric Planning

## 4.1 eTourPlan Rule Subsystems

### ① Partonomy Rules

- Administrative subdivision of a country

### ② Rule System for Route Planning

- Searching routes between Provinces
- System route planning based on Province profiles
- Route planning via user-preferred Provinces

### ③ Rule System for Parametric Search of Tourist Entities

- Provincial information
- Activity opportunities (Events and Attractions)
- Accommodation information

### ④ Rule System for Location-Centric Travel Recommender

- Tour through user-preferred Provinces
- Tour of system-recommended Provinces

### ⑤ Rule Systems for eTourPlan Travel Planner

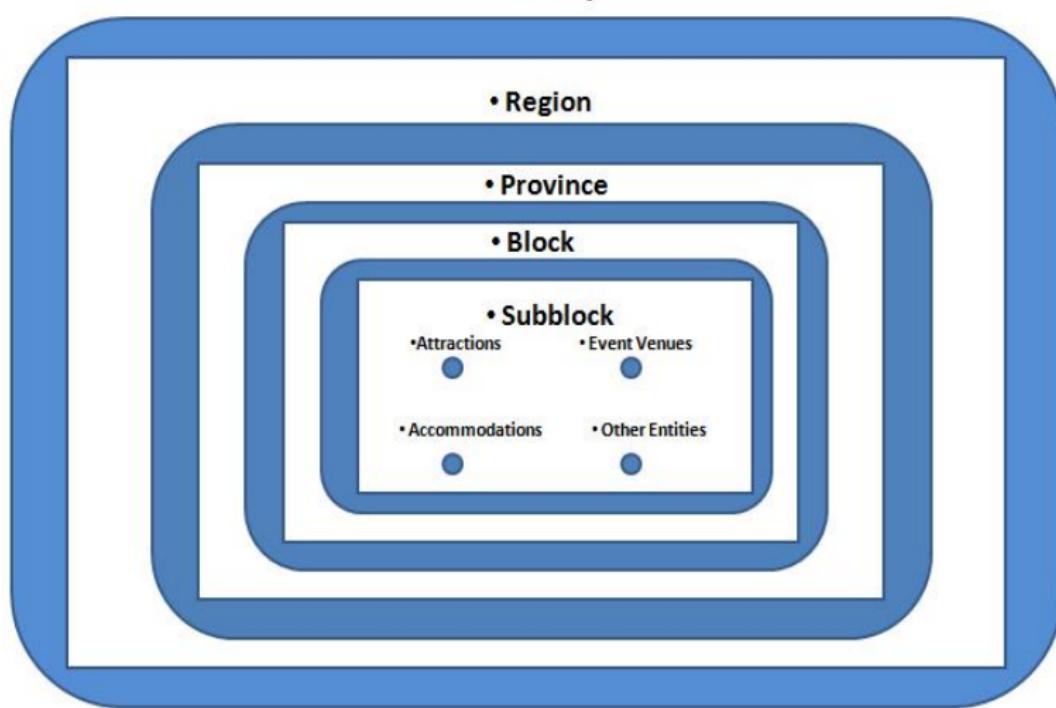
- Attraction-only Planning
- Event-centric Planning

### 4.2.1.1 Partonomy

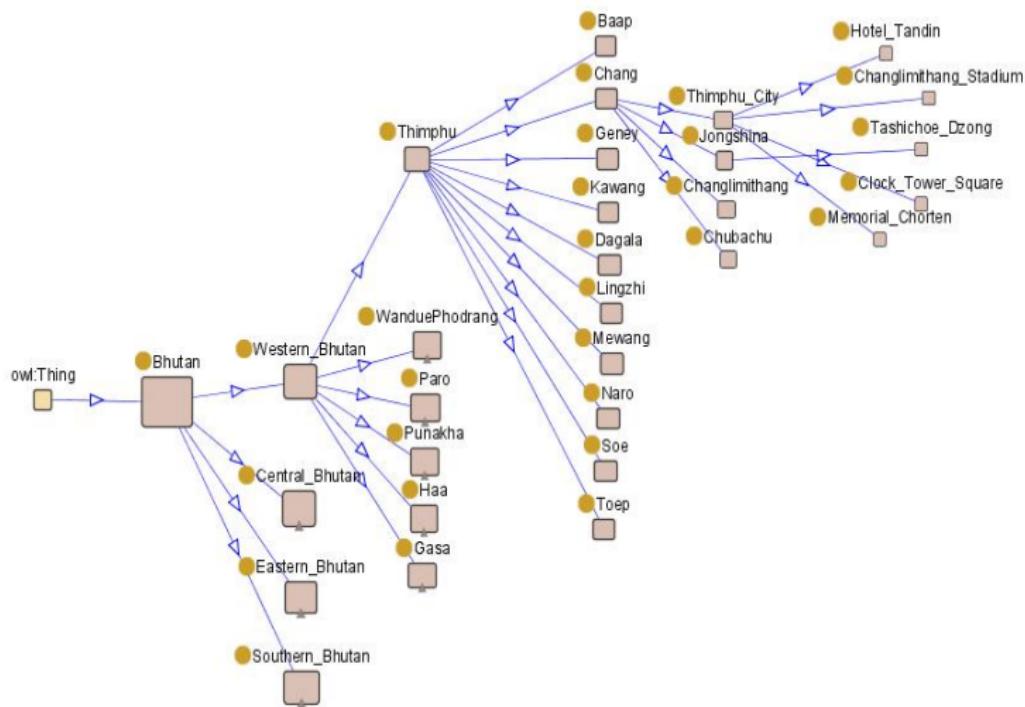
## Classification of Regions subdomain

- Partonomy classifies subparts and superparts based on the “partOf” relation, allowing geographically focused search
  - Enriched domain-specific partonomy rule with taxonomic type definition
    - Clear interrelation between a taxonomy and a partonomy
    - Avoids information ambiguity
  - General partonomy rule
    - A generic definition of the binary “partOf” relation
    - Transitive closure of the “partOf” relation

## 4.2.1.2 Subparts of a Country (e.g. Bhutan)



#### 4.2.1.3 Excerpt from the Partonomy of Bhutan



## 4.2.1.4 Partonomy KB (Ground Facts in RuleML/POSL)

```
%siteOf(?Attraction:Attractions, ?Subblock:Subblock).  
siteOf(Tashichoe_Dzong:Fortress, Jongshina:Town).  
siteOf(Memorial_Chorten:Temple, Thimphu_City:City).  
siteOf(Hotel_Tandin:Hotel, Thimphu_City:City).
```

```
%partOfBlock(?Subblock:Subblock, ?Block:Block).  
partOfBlock(Jongshina:Town, Chang:Block).  
partOfBlock(Thimphu_City:City, Chang:Block).  
partOfBlock(Chubachu:Town, Chang:Block).  
partOfBlock(Changlimithang:Town, Chang:Block).
```

```
%partOfProvince(?Block:Block, ?Province:Province).  
partOfProvince(Baap:Block, Thimphu:Province).  
partOfProvince(Chang:Block, Thimphu:Province).
```

```
partOfProvince(Dagala:Block, Thimphu:Province).  
partOfProvince(Geney:Block, Thimphu:Province).  
partOfProvince(Kawang:Block, Thimphu:Province).  
partOfProvince(Lingzhi:Block, Thimphu:Province).  
partOfProvince(Mewang:Block, Thimphu:Province).  
partOfProvince(Naro:Block, Thimphu:Province).  
partOfProvince(Soe:Block, Thimphu:Province).  
partOfProvince(Toep:Block, Thimphu:Province).
```

```
%partOfRegion(?Province:Province, ?Region:Region).  
partOfRegion(Thimphu:Province, Western:Region).
```

```
%partOfCountry(?Region:Region, ?Country:Country).  
partOfCountry(Western:Region, Bhutan:Country).
```

## 4.2.1.5 Partonomy KB (Rule with Query and Result)

### KB (Rule):

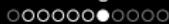
```
getFullAddress(?Location, [?Subblock, ?Block, ?Province, ?Region, ?Country]):-
    siteOf(?Location, ?Subblock),
    partOfBlock(?Subblock, ?Block),
    partOfProvince(?Block, ?Province),
    partOfRegion(?Province, ?Region),
    partOfCountry(?Region, ?Country).
```

### Sample Query:

```
getFullAddress(Ta_Dzong:National_museum, ?Address)
```

### OO jDREW TD Result:

```
?Address= [Hungrel:Village, %Subblock of type "Village"
           Hungrel:Block,   %Block
           Paro:Province,
           Western:Region,
           Bhutan:Country]
```



#### 4.2.1.6 Search Queries and Results

## Sample Queries:

1. getAttraction(?Attraction, Bhutan:Country)
  2. getAttraction(?Attraction, Western:Region)
  3. getAttraction(?Attraction, Bumthang:Province)
  4. getAttraction(?Attraction, Chhoekhor:Block)
  5. getAttraction(?Attraction, Chamkhar:Town)

## OO jDREW TD Results for Query 5:

?Attraction= Bumthang\_Dzong:Fortress

?Attraction= Zugney: [Textiles](#)

?Attraction= Ugyen Chholing Museum:Local museum

?Attraction= Petseling Gompa:Temple

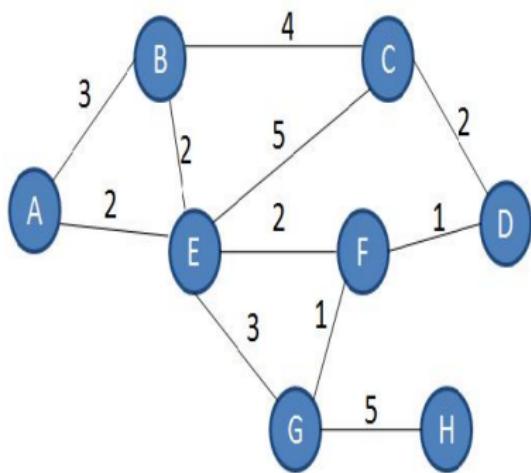


Figure: A connected sample graph

Table: POSL representation of the connected graph

```
distanceTime(startPoint->A; endPoint->B; bus->3:Real).
distanceTime(startPoint->A; endPoint->E; bus->2:Real).
distanceTime(startPoint->B; endPoint->C; bus->4:Real).
distanceTime(startPoint->B; endPoint->E; bus->2:Real).
distanceTime(startPoint->E; endPoint->F; bus->2:Real).
distanceTime(startPoint->C; endPoint->D; bus->2:Real).
distanceTime(startPoint->C; endPoint->E; bus->5:Real).
distanceTime(startPoint->D; endPoint->F; bus->1:Real).
distanceTime(startPoint->E; endPoint->G; bus->3:Real).
distanceTime(startPoint->F; endPoint->G; bus->1:Real).
distanceTime(startPoint->G; endPoint->I; bus->5:Real).
```

### **KB (Rule):**

```

dTRShortest(startPoint->?Province1; endPoint->?Province2;
            route->?AllRoutes; shortestRoute->?ShortestRoute):-  

routeCount(startPoint->?Province1; endPoint->?Province2;
           count->?Count:Integer),  

dTRLList(startPoint->?Province1; endPoint->?Province2;
          visited->[]; currentMinRoute->[R,10000:Real];
          route->?Routes; min->?ShortestRoute;
          count->?Count:Integer).

```

#### 4.2.2 Route and Distance-time Computation (Cont'd)

## Sample Query:

```
dTRShortest(startPoint->A; endPoint->H;  
            route->?AllRoutes;  
            shortestRoute->?ShortestRoute)
```

## OO iDREW TD Result:

```
?AllRoutes= [[[A, E, G, H], 10.0:Real],
           [[A, B, E, G, H], 13.0:Real],
           [[A, E, F, G, H], 10.0 : Real],
           [[A, B, C, E, G, H], 20.0 : Real],
           [[A, B, E, F, G, H], 13.0 : Real],
           [[A, B, C, D, F, G, H], 16.0 : Real],
           [[A, B, C, E, F, G, H], 20.0 : Real],
           [[A, E, C, D, F, G, H], 16.0 : Real],
           [[A, B, C, D, F, E, G, H], 20.0 : Real],
           [[A, B, E, C, D, F, G, H], 19.0 : Real],
           [[A, E, B, C, D, F, G, H], 17.0 : Real]]
?ShortestRoute= [A, E, G, H], 10.0 : Real]
```

## 4.3.1 Rule System for eTourPlan Attraction-only Planning

The planner performs the following steps:

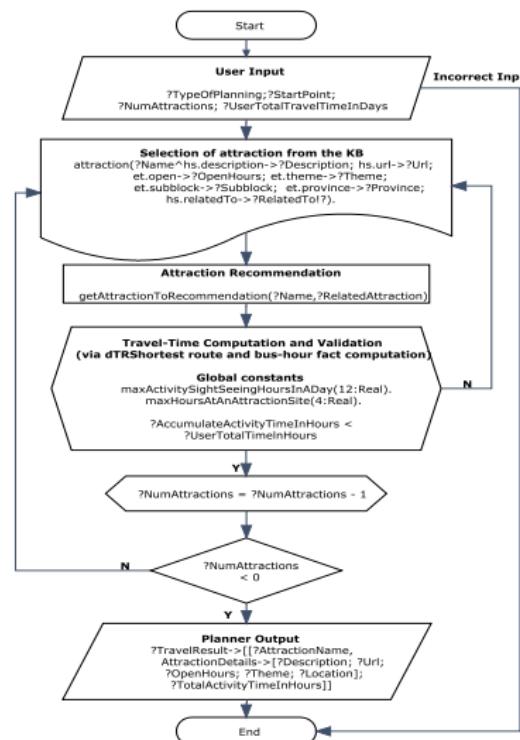
- From the user-specified starting point, an attraction is selected and chains to the next related attraction.

- Compute and validate route and travel-time constrained by global constants:

-maxActivitySightSeeingHoursInADay(12:Real)

-maxHoursAtAnAttractionSite(4:Real)

- On successful validation of distance and remaining time, add detailed information of the selected attraction to the travel plan.

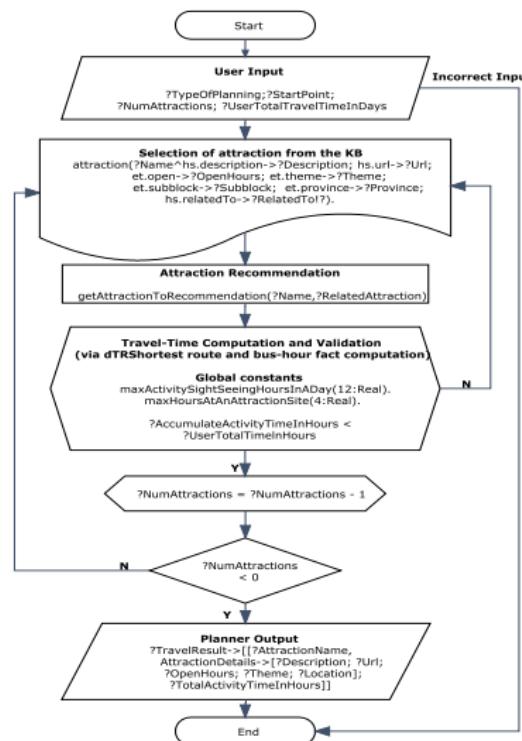


#### 4.3.1 Rule System for eTourPlan Attraction-only Planning

The planner performs the following steps:

- From the user-specified starting point, an attraction is selected and chains to the next related attraction.

- ② Compute and validate route and travel-time constrained by global constants:



## 4.3.1 Rule System for eTourPlan Attraction-only Planning

The planner performs the following steps:

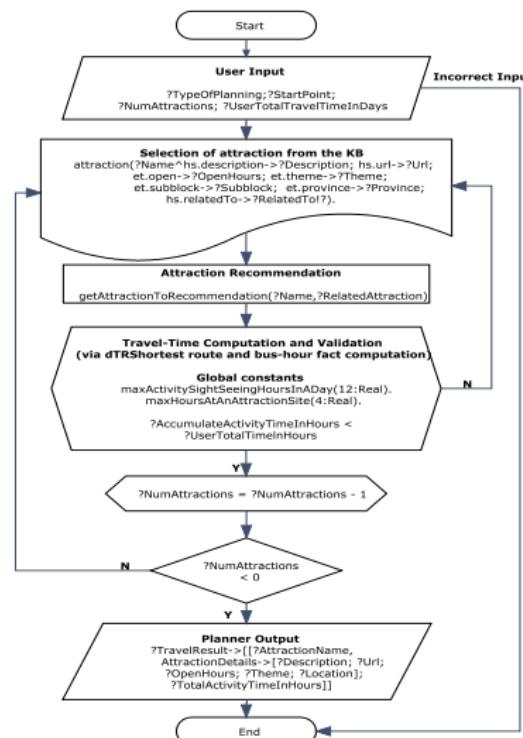
- From the user-specified starting point, an attraction is selected and chains to the next related attraction.

- Compute and validate route and travel-time constrained by global constants:

-maxActivitySightSeeingHoursInADay(12:Real)

-maxHoursAtAnAttractionSite(4:Real)

- On successful validation of distance and remaining time, add detailed information of the selected attraction to the travel plan.



## 4.3.1 Rule System for eTourPlan Attraction-only Planning

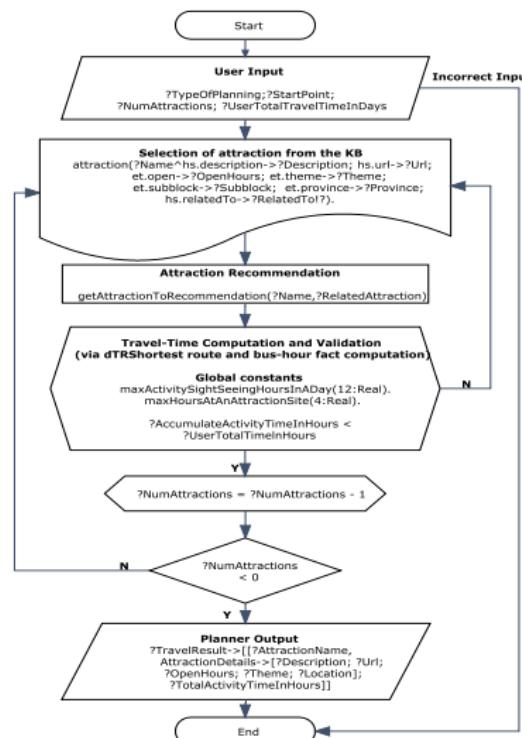
The planner performs the following steps:

- From the user-specified starting point, an attraction is selected and chains to the next related attraction.

- Compute and validate route and travel-time constrained by global constants:

-maxActivitySightSeeingHoursInADay(12:Real)  
 -maxHoursAtAnAttractionSite(4:Real)

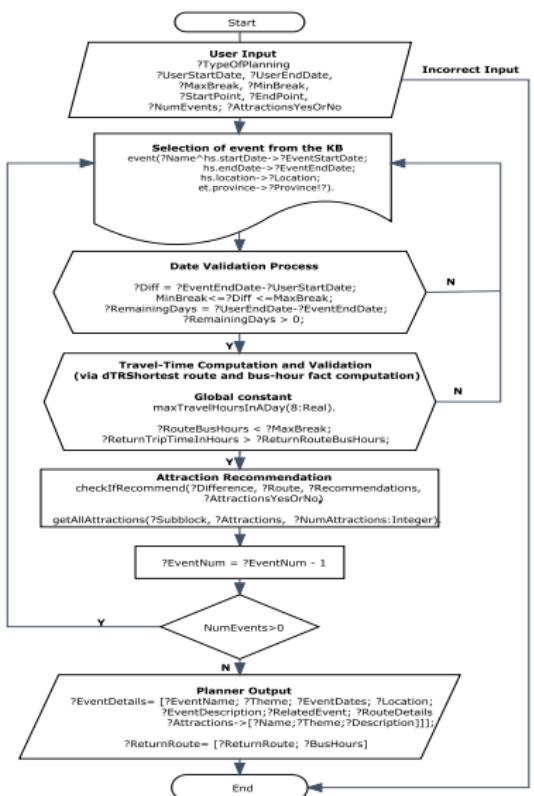
- On successful validation of distance and remaining time, add detailed information of the selected attraction to the travel plan.



## 4.3.2 Rule System for eTourPlan Event-centric Planning

The planner performs the following steps:

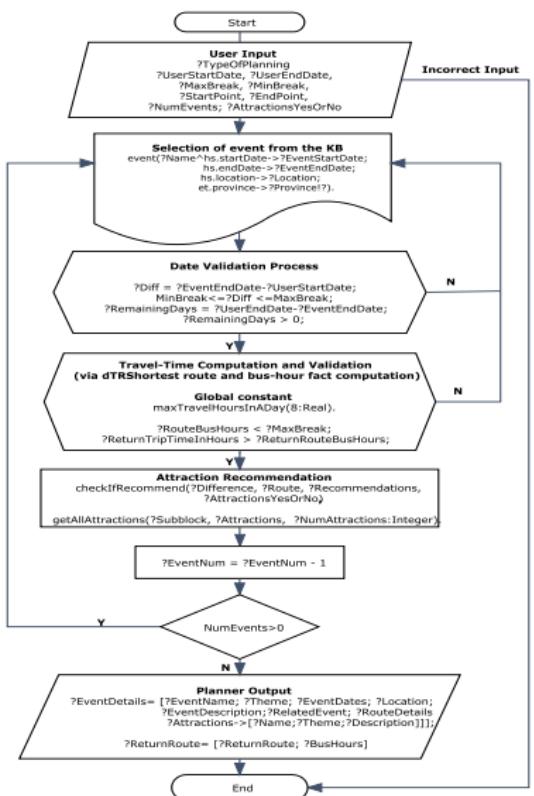
- 1 Events are selected by validating the event dates against the user's travel dates, minimum break, and maximum break.
- 2 Compute and validate route and bus hours constrained by maximum break.
- 3 On successful validation of distance and remaining time, add detailed information of the selected event to the travel plan.
- 4 Recommend attractions located in the subblock of the selected event.
- 5 Provide on-route attraction recommendation if the user selects the option (constrained by the global constant "maxTimeGapBetweenEvents").



## 4.3.2 Rule System for eTourPlan Event-centric Planning

The planner performs the following steps:

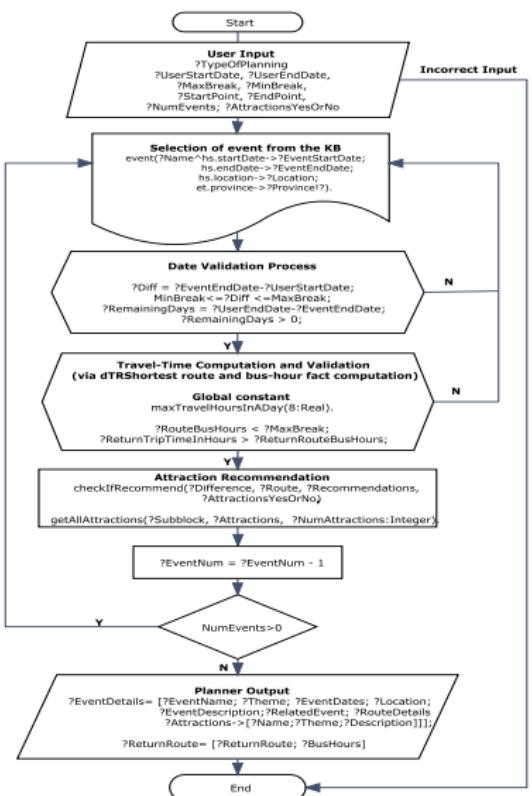
- 1 Events are selected by validating the event dates against the user's travel dates, minimum break, and maximum break.
- 2 Compute and validate route and bus hours constrained by maximum break.
- 3 On successful validation of distance and remaining time, add detailed information of the selected event to the travel plan.
- 4 Recommend attractions located in the subblock of the selected event.
- 5 Provide on-route attraction recommendation if the user selects the option (constrained by the global constant "maxTimeGapBetweenEvents").



## 4.3.2 Rule System for eTourPlan Event-centric Planning

The planner performs the following steps:

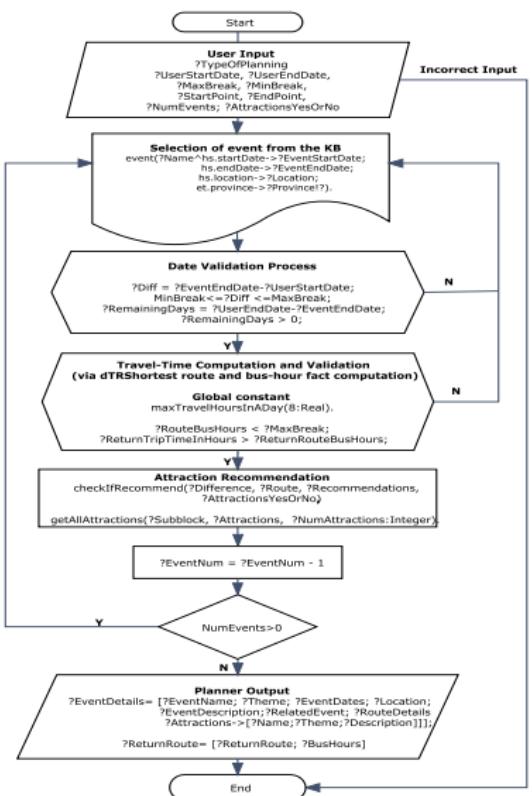
- 1 Events are selected by validating the event dates against the user's travel dates, minimum break, and maximum break.
- 2 Compute and validate route and bus hours constrained by maximum break.
- 3 On successful validation of distance and remaining time, add detailed information of the selected event to the travel plan.
- 4 Recommend attractions located in the subblock of the selected event.
- 5 Provide on-route attraction recommendation if the user selects the option (constrained by the global constant "maxTimeGapBetweenEvents").



## 4.3.2 Rule System for eTourPlan Event-centric Planning

The planner performs the following steps:

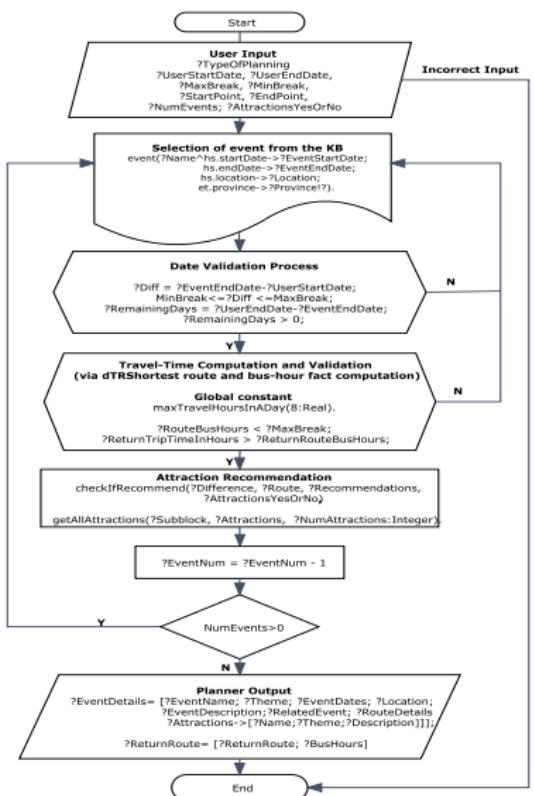
- 1 Events are selected by validating the event dates against the user's travel dates, minimum break, and maximum break.
- 2 Compute and validate route and bus hours constrained by maximum break.
- 3 On successful validation of distance and remaining time, add detailed information of the selected event to the travel plan.
- 4 Recommend attractions located in the subblock of the selected event.
- 5 Provide on-route attraction recommendation if the user selects the option (constrained by the global constant "maxTimeGapBetweenEvents").



## 4.3.2 Rule System for eTourPlan Event-centric Planning

The planner performs the following steps:

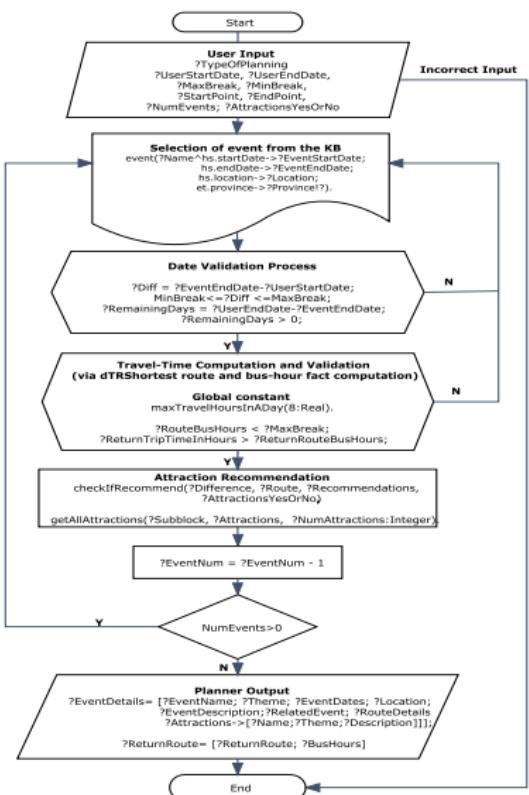
- 1 Events are selected by validating the event dates against the user's travel dates, minimum break, and maximum break.
- 2 Compute and validate route and bus hours constrained by maximum break.
- 3 On successful validation of distance and remaining time, add detailed information of the selected event to the travel plan.
- 4 Recommend attractions located in the subblock of the selected event.
- 5 Provide on-route attraction recommendation if the user selects the option (constrained by the global constant "maxTimeGapBetweenEvents").



## 4.3.2 Rule System for eTourPlan Event-centric Planning

The planner performs the following steps:

- 1 Events are selected by validating the event dates against the user's travel dates, minimum break, and maximum break.
- 2 Compute and validate route and bus hours constrained by maximum break.
- 3 On successful validation of distance and remaining time, add detailed information of the selected event to the travel plan.
- 4 Recommend attractions located in the subblock of the selected event.
- 5 Provide on-route attraction recommendation if the user selects the option (constrained by the global constant "maxTimeGapBetweenEvents").



## 5.1.1 Parametric Search Operations

### ① Search for Provincial Information

- name
- region

### ② Search for Route Information

- startPoint, endPoint
- list of user-specified provinces

### ③ Search for Activities (Events and Attractions)

- name:type
- \_:type (refers to the classification of activity)
- theme

at (Subblock, Block, Province, Region, Country) of Partonomy

### ④ Search for Accommodations

- name:type (refers to the type of accommodation)
- \_:type
- price

at (Subblock, Block, Province, Region, Country) of Partonomy

## 5.1.1 Parametric Search Operations

### ① Search for Provincial Information

- name
- region

### ② Search for Route Information

- startPoint, endPoint
- list of user-specified provinces

### ③ Search for Activities (Events and Attractions)

- name:type
- \_:type (refers to the classification of activity)
- theme

at (Subblock, Block, Province, Region, Country) of Partonomy

### ④ Search for Accommodations

- name:type (refers to the type of accommodation)
- \_:type
- price

at (Subblock, Block, Province, Region, Country) of Partonomy

## 5.1.1 Parametric Search Operations

### ① Search for Provincial Information

- name
- region

### ② Search for Route Information

- startPoint, endPoint
- list of user-specified provinces

### ③ Search for Activities (Events and Attractions)

- name:type
- \_:type (refers to the classification of activity)
- theme

at (Subblock, Block, Province, Region, Country) of Partonomy

### ④ Search for Accommodations

- name:type (refers to the type of accommodation)
- \_:type
- price

at (Subblock, Block, Province, Region, Country) of Partonomy

## 5.1.1 Parametric Search Operations

### ① Search for Provincial Information

- name
- region

### ② Search for Route Information

- startPoint, endPoint
- list of user-specified provinces

### ③ Search for Activities (Events and Attractions)

- name:type
- \_:type (refers to the classification of activity)
- theme

at (Subblock, Block, Province, Region, Country) of Partonomy

### ④ Search for Accommodations

- name:type (refers to the type of accommodation)
- \_:type
- price

at (Subblock, Block, Province, Region, Country) of Partonomy

### 5.1.1 Parametric Search Operations

### ① Search for Provincial Information

- name
  - region

## ② Search for Route Information

- startPoint, endPoint
  - list of user-specified provinces

### ③ Search for Activities (Events and Attractions)

- **name:type**
  - **\_:type** (refers to the classification of activity)
  - **theme**

at (Subblock, Block, Province, Region, Country) of Partonomy

#### ④ Search for Accommodations

- **name:type** (refers to the type of accommodation)
  - **\_:type**
  - **price**

at (Subblock, Block, Province, Region, Country) of Partonomy

## 5.1.2 Sample Activity Search Query and Result

Query
<pre>getActivityDetails(actName-&gt;?Name:<b>Events</b>;                   theme-&gt;<b>Recreation</b>;                   address-&gt;[?Subblock,                              ?Block,                              ?Province,                              <b>Southern:Region</b>,                              ?Country];                   <b>?ActivityDetails</b>)</pre>

Output Variables	Variable Bindings
<b>?ActivityDetails</b>	[ActName->Yangphel_Archery_Tournament:Sport_archery; WebLink->" <a href="http://www.bhutanarchery.com/default.asp">http://www.bhutanarchery.com/default.asp</a> "; EventDates->[StartDate->date[2008:Real, 08:Real, 23:Real]; EndDate->date[2008:Real, 10:Real, 02:Real]]; Description->"11TH Yangphel open archery tournament"; Address->[Phuentsholing_Upper_Town:Town, Phuentsholing:Block, Chukha:Province, Southern:Region, Bhutan:Country]; Theme->Recreation; RelatedTo->"Thimphu_Drupchen:Annual_festival"]

## 5.1.2 Sample Activity Search Query and Result

Query
<pre>getActivityDetails(actName-&gt;?Name:<b>Events</b>;                    theme-&gt;<b>Recreation</b>;                    address-&gt;[?Subblock,                                ?Block,                                ?Province,                                <b>Southern:Region</b>,                                ?Country];                    ?ActivityDetails)</pre>

Output Variables	Variable Bindings
<b>?ActivityDetails</b>	[ActName->Yangphel_Archery_Tournament:Sport_archery; WebLink->" <a href="http://www.bhutanarchery.com/default.asp">http://www.bhutanarchery.com/default.asp</a> "; EventDates->[StartDate->date[2008:Real, 08:Real, 23:Real]; EndDate->date[2008:Real, 10:Real, 02:Real]]; Description->"11TH Yangphel open archery tournament"; Address->[Phuentsholing_Upper_Town:Town, Phuentsholing:Block, Chukha:Province, Southern:Region, Bhutan:Country]; Theme->Recreation; RelatedTo->"Thimphu_Drupchen:Annual_festival"]

### 5.2.1 Location-centric Recommender

- Provides route and tourism information for
    - ① **SystemRecommendation**: Number of 'N' "relatedTo" provinces
    - ② **UserPrefBased**: User-specified list of provinces

	User Input Values	Query Formats (Input values are blue bold-faced)
1	typeOfRecommend numProvinces	locCentricRecommend(typeOfRecommend-> <b>SystemRecommendation</b> ; userInputs->[startPoint-> <b>Paro:Province</b> ; numProvinces-> <b>3:Integer</b> ]; [?Routes, ?Recommendations, ?TotalBusHours])
2	typeOfRecommend startPoint userPrefList endPoint	locCentricRecommend(typeOfRecommend-> <b>UserPrefBased</b> ; userInputs->[startPoint-> <b>Paro:Province</b> ; userPrefList-> <b>[Chukha:Province]</b> ; endPoint-> <b>Thimphu:Province</b> ]; [?Routes, ?Recommendations, ?TotalBusHours])

Table: Queries of different input/output modes for location-centric Recommendation

## 5.2.2 Recommendation Results for Query 2

**Table:** Location-centric recommendation for user-preferred Provinces

Output Variables	Variable Bindings (For Query 2)
?Routes	[[Paro, Chuzom, Chukha], 6.5 :Real, [Chukha, Chuzom, Thimphu], 7.0 :Real]
?Recommendations	<p>Chukha;  <b>EventList-&gt;</b></p> <p>[[EventName-&gt;Chukha_Tshechu:Annual_festival;      Description-&gt;"One of the most amazing festivals in Chukha";      Address-&gt;[Chukha_Town:Town,      Gelling:Block,      Southern:Region,      Bhutan:Country,      EventDates-&gt;[StartDate-&gt;date[2008:Real, 03:Real, 19:Real];      EndDate-&gt;date[2008:Real, 03:Real, 21:Real]]],      [EventName-&gt; Yangphel_Archery_Tournament:Sport_archery;      Description-&gt;"11TH Yangphel open archery tournament";      Address-&gt;[Phuentsholing_Upper_Town:Town,      Phuentsholing:Block,,      Southern:Region,      Bhutan :Country,      EventDates-&gt;[StartDate-&gt;date[2008:Real, 08:Real, 23:Real];      EndDate-&gt;date[2008:Real, 10:Real, 02 :Real]]]];</p>

### 5.2.2 Recommendation Results (Cont'd)

?Recommendations	<b>AttractionList-&gt;</b> [[AttractionName->Chukha_Dzong:Fortress; WebLink-> "", Description->"It is one of the most beautiful attractions."; <b>AccommodationList-&gt;</b> [[Hotel_Druk_Phuentsholing:Hotel; WebLink->"www.drukhotels.com/"; MinPrice->"2700:Real"; Rating->4:Real], [Hotel_Namgay:Hotel; WebLink->"www.hotelNamgay.bt/"; MinPrice->"1800:Real"; Rating->3:Real]]]]
?TotalBusHours	13.5:Real

## 5.3.1 eTourPlan Travel Planner

- Two modes of Travel Planning:

- AttractionOnly: Based on "relatedTo" attractions
- EventCentric: Based on temporal-geographic search criteria

	User Input Values	Query Formats (Input values are bold-faced)
1	typeOfPlanning startPoint endPoint numAttractions userTotalTravelTimeInDays	eTourPlan(typeOfPlanning-> <b>AttractionOnly</b> ; userInputs->[startPoint-> <b>Paro:Province</b> ; endPoint-> <b>Thimphu:Province</b> ; numAttractions-> <b>4:Integer</b> ; userTotalTravelTimeInDays-> <b>4:Integer</b> ]; <b>?TravelResult</b> )
2	typeOfPlanning  startPoint endPoint userStartDate userEndDate maxBreak minBreak attractionRecommendation eventNum	eTourPlan(typeOfPlanning-> <b>EventCentric</b> ; userInputs->[ startPoint-> <b>Paro:Province</b> ; endPoint-> <b>Thimphu:Province</b> ; userStartDate-> <b>date[2008:Real,10:Real,01:Real]</b> ; userEndDate-> <b>date[2008:Real,11:Real,10:Real]</b> ; maxBreak-> <b>10:Real</b> ; minBreak-> <b>0:Real</b> ; attractionRecommendation-> <b>No</b> ; eventNum-> <b>3:Integer</b> ]; <b>?TravelResult</b> )

Table: Queries of different input/output modes for Travel Planning

### 5.3.2 Travel Planning Scenario

User queries for an event-centric plan of 3 events between the 1st of October and the 10th of November and specifies a "maxBreak" of 10 days and "minBreak" of 0 days between main events. User also specifies the starting province, "Paro:Province", and the final destination province, as "Thimphu:Province". User checks "No" for on-route attraction recommendation, knowing that the planner provides recommendation of attractions at the subblock of event location.

## 5.3.3 Event Schedules

Table: Evaluation of event-centric travel results

Event	Event Schedules	Event Sequences of length ?EventNum= 3
1	Tamshingphala_Choepa:Traditional_festival startDate->date[2008:Real,10:Real,08:Real] endDate->date[2008:Real,10:Real,10:Real] province->Bumthang	1,2,5
2	Tangbi_Mani:Traditional_festival startDate->date[2008:Real,10:Real,13:Real] endDate->date[2008:Real,10:Real,15:Real] province->Bumthang	
3	Thimphu_Drupchen:Annual_festival startDate->date[2008:Real,10:Real,04:Real] endDate->date[2008:Real,10:Real,08:Real] province->Thimphu	3,2,5 3,4,2 3,4,5
4	Thimphu_Tshechu:Annual_festival startDate->date[2008:Real,10:Real,09:Real] endDate->date[2008:Real,10:Real,11:Real] province->Thimphu	4,2,5
5	Wangdue_Tshechu:Annual_festival startDate->date[2008:Real,10:Real,20:Real] endDate->date[2008:Real, 10:Real, 29:Real] province->WangduePhodrang	

## 5.3.4 Multiple Travel Plans

Table: Options for event-centric travel plans

Option	Event Sequences of length "3"	Province
1	Tamshingphala_Choepa:Traditional_festival Tangbi_Mani:Traditional_festival Wangdue_Tshechu:Annual_festival	Bumthang Bumthang WangduePhodrang
2	Thimphu_Drupchen:Annual_festival Tangbi_Mani:Traditional_festival Wangdue_Tshechu:Annual_festival	Thimphu Bumthang WangduePhodrang
3	Thimphu_Drupchen:Annual_festival Thimphu_Tshechu:Annual_festival Tangbi_Mani:Traditional_festival	Thimphu Thimphu Bumthang
4	Thimphu_Drupchen:Annual_festival Thimphu_Tshechu:Annual_festival Wangdue_Tshechu:Annual_festival	Thimphu Thimphu WangduePhodrang
5	Thimphu_Tshechu:Annual_festival Tangbi_Mani:Traditional_festival Wangdue_Tshechu:Annual_festival	Thimphu Bumthang WangduePhodrang

## 5.3.5 Complete Result of the First Travel Plan Option (Events 1, 2 and 5)

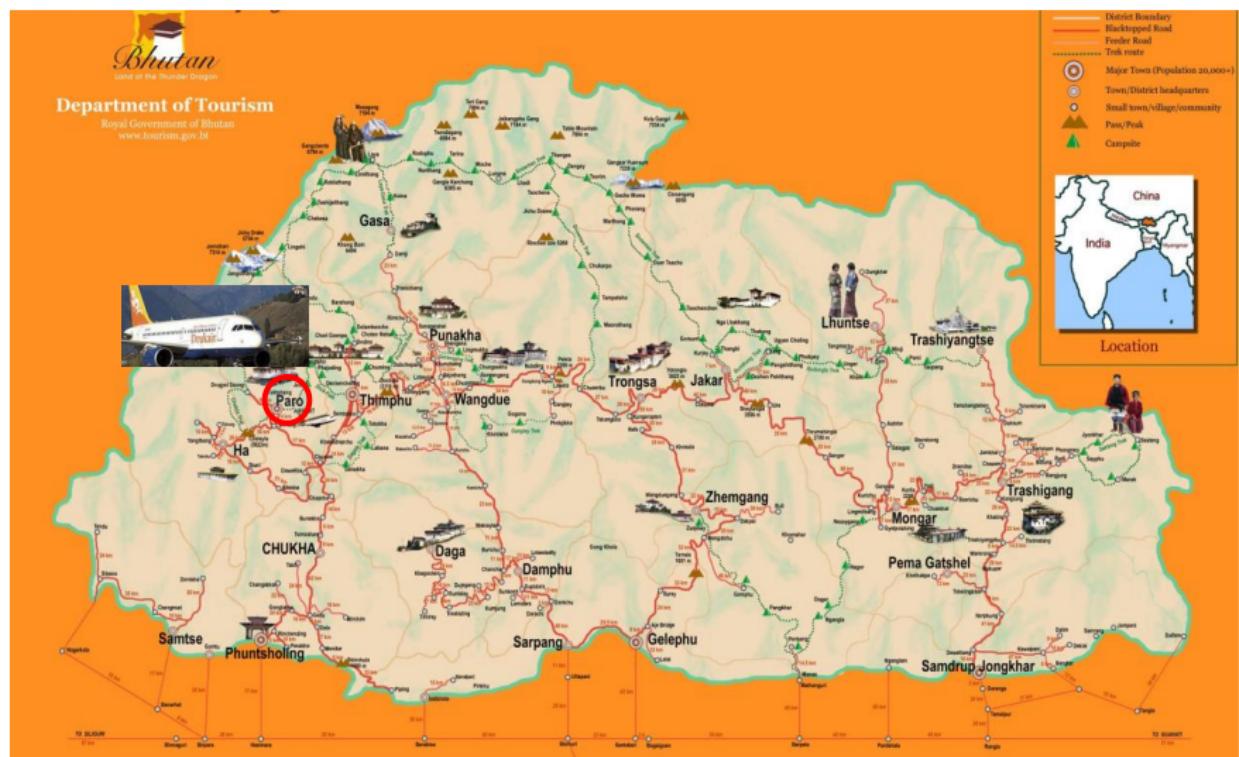
Table: Event-centric travel results

Output Variables	Variable Bindings
<b>?TravelResult</b>	<pre>[[[EventName-&gt;Tamshingphala_Choepa:Traditional_festival;   EventDates-&gt;[Startdate-&gt;date[2008:Real, 10:Real, 08:Real];                Enddate-&gt;date[2008:Real, 10:Real, 10:Real]];   Theme-&gt;Cultural_Religious_Heritage;   EventDescription-&gt;"One of the most amazing festivals in Bumthang"   Location-&gt;[Tamshing_Lhakhang:Temple,               Tamshing_Village:Village,               Bumthang:Province];   RelatedEvent-&gt;Tangbi_Mani:Traditional_festival;   RouteDetails-&gt;[[Paro:Province, Chuzom:Province, Thimphu:Province,                   Lobesa:Province, WangduePhodrang:Province,                   Trongsa:Province, Bumthang:Province],                  []];   RouteBusHours-&gt;16.7:Real];   RecommendedAttractions-&gt;[Tamshing_Lhakhang:Temple,                             "It was built by Pema Lingpa,the Treasure Revealer in 1505."]];   [EventName-&gt;Tangbi_Mani:Traditional_festival;    EventDates-&gt;[Startdate-&gt;date[2008:Real, 10:Real, 13:Real];                  Enddate-&gt;date[2008:Real, 10:Real, 15:Real]];    Theme-&gt;Cultural_Religious_Heritage;    EventDescription-&gt;"A prestigious annual festival in Bumthang"    Location-&gt;[Tangbi_Monastery:Monastery,               Tangbi:Village,               Bumthang:Province];    RelatedEvent-&gt;Wangdue_Tshechu:Annual_festival];</pre>

## 5.3.5 Detailed Result of a Travel Plan (Cont'd)

?TravelResult	<pre> RouteDetails-&gt;[[Bumthang:Province], []; RouteBusHours-&gt;0:Real]]; RecommendedAttractions-&gt;[Tangbi_Monastery:Monastery "Located in upper Tang valley."], [EventName-&gt;Wangdue_Tshechu:Annual_festival; EventDates-&gt;[Startdate-&gt;date[2008:Real, 10:Real, 20:Real]; Enddate-&gt;date[2008:Real, 10:Real, 29:Real]]; Theme-&gt;Cultural_Religious_Heritage; EventDescription-&gt;"A very popular festival in western Bhutan" Location-&gt;[Wangdue_Dzong:Fortress, Wangdue_Town:Town, WangduePhodrang:Province]; RouteDetails-&gt;[[Bumthang:Province, Trongsa:Province, WangduePhodrang:Province], []; []; RouteBusHours-&gt;0:Real]; RecommendedAttractions-&gt;[Wangdue_Dzong:Fortress "It is one of the most beautiful attractions."], ReturnRoute-&gt;[[WangduePhodrang:Province, Lobesa:Province, Thimphu:Province]; Returntime-&gt;12.2:Real]] </pre>
---------------	--

## 5.3.6 Travel Plan (Option 4) -At the starting point



## 5.3.6 Travel Plan -Event 1 found

**Bhutan**  
Land of the Thunder Dragon  
**Department of Tourism**  
Royal Government of Bhutan  
www.tourism.gov.bt

**Thimphu\_Drubchen:Annual\_Festival**

start Date - 2008. 10. 04  
end Date - 2008. 10. 08  
route - [Paro, Chuzom, Thimphu], 4.5  
location -  
Tashichoe\_Dzong:Fortress  
Subblock - Jongshina:Town

Attractions:  
Trashichoe\_dzong:Fortress

## 5.3.6 Travel Plan -Event 2 found

**Bhutan**  
Land of the Thunder Dragon

**Department of Tourism**  
Royal Government of Bhutan  
[www.tourism.gov.bt](http://www.tourism.gov.bt)

**Thimphu\_Tshechu:Annual\_Festival**

startDate - 2008.10.09  
endDate - 2008.10.11  
route - [Thimphu], 0.5]  
location -  
Tashichhoe\_Dzong:Fortress  
Subblock - Jongshina:Town

Attractions:  
Trashichoe\_dzong:Fortress

**Tshering Dema**

## 5.3.6 Travel Plan -Event 3 found



**Tangbi\_Mani:Traditional\_festival**

startDate - 2008.10.13  
endDate - 2008.10.15

route - [Thimphu, Lobesa, Wangdue, Trongsa, Bumthang, 12.2]

location -  
[Tangbi\_Monastery:Monastery,  
Subblock- Tangbi:Village,

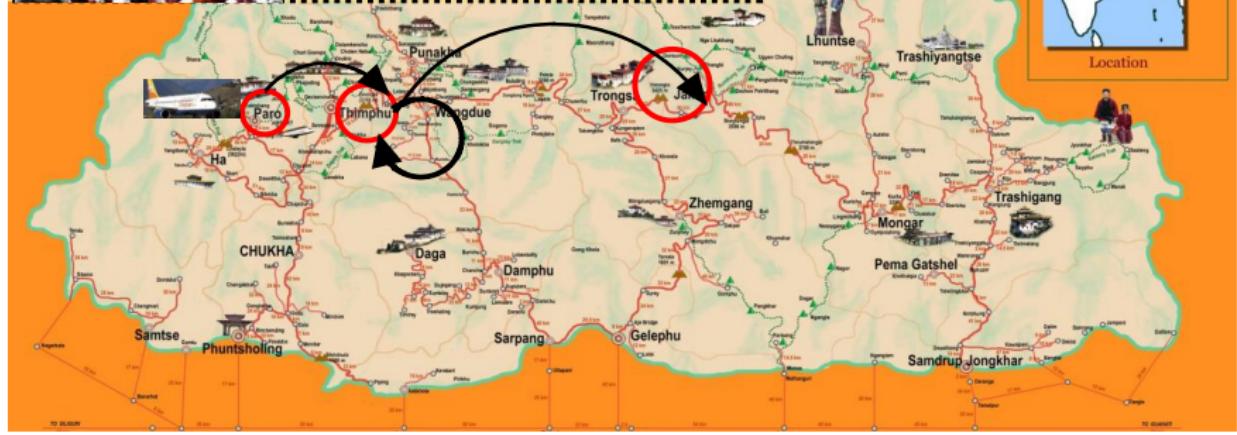
Attractions:

Tangbi\_Monastery:Monastery,  
“Located in upper Tang valley.”

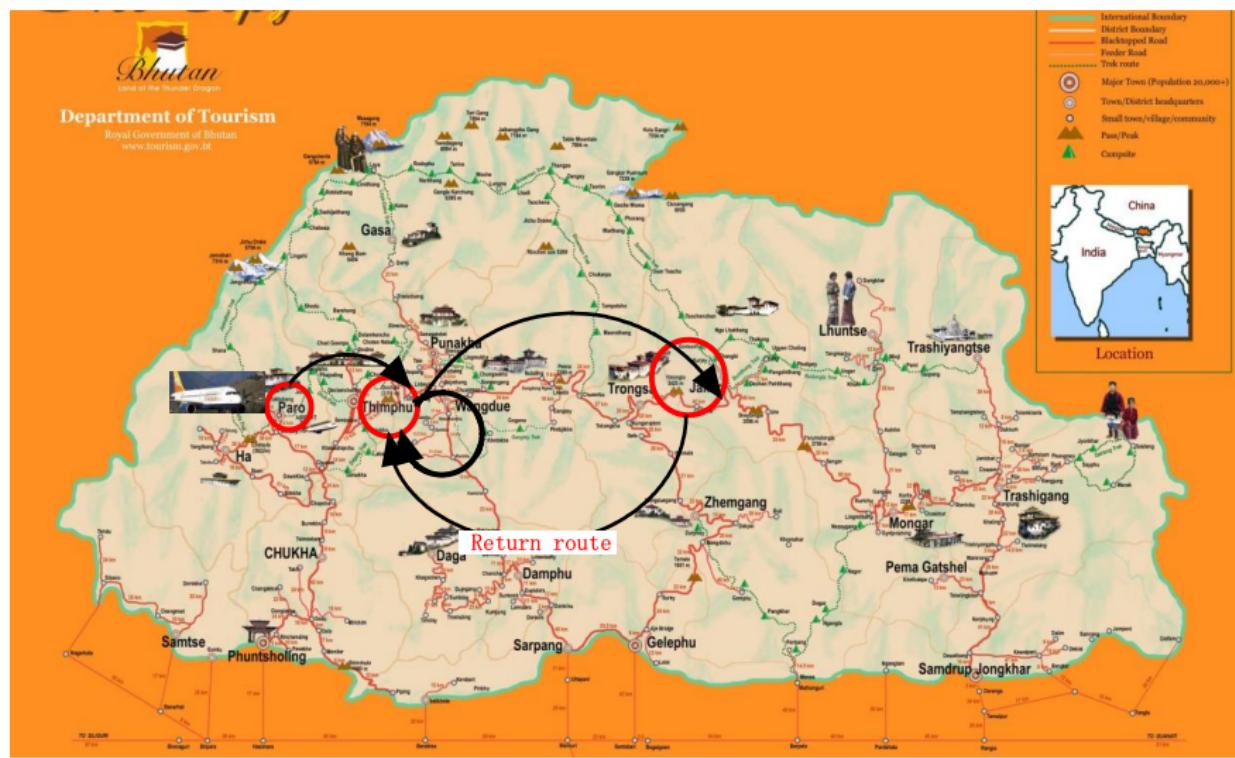
- International Boundary
- District Boundary
- Blackened Road
- Forest Reserve
- Trek route
- Major Town (Population 20,000+)
- Town/District headquarters
- Pass/Peak
- Compass



Location



## 5.3.6 Travel Plan -Return route to the end point



## 5.3.6 Travel Planning -On-route attraction recommendation (Optional)

**Return route -** [[Bumthang, Trongsa, Wangdue, Lobesa Thimphu], 12, 2]

**On-route Attraction Recommendation**

- Bumthang->
  - [[Bumthang\_Dzong:Fortress, Chamkar:Town], [Ugyen\_Chholing\_Museum:Local\_museum]]
- Trongsa->
  - [[Trongsa\_Dzong:Fortress, Samcholing:Village], [Samcholing\_Palace:Popular\_architecture]]
- Wangdue->
  - [[Wangdue\_Dzong:Fortress, Wangdue\_Town:Town], [Trongsa\_Dzong:Fortress, Samcholing:Village]]
- Lobesa->
  - [[Thimphu\_Tashichhoe\_Dzong:Fortress, Jongshina:Town], [Memorial\_Chorten:Temple, Thimphu\_City:City]]

**Tshering Dema**

**eTourPlan: A Knowledge-Based Tourist Route and Activity Planner**

### 5.4.1 Execution times

- Development & Test environment:
    - OO jDREW engine version 0.96
    - On Windows XP with Intel Core 2 Duo 2.66 GHz
  - eTourPlan KB:
    - 115 classes, 73 facts, and 37 rules
  - Low OO jDREW execution times for retrieving subdomain information:
    - Object-centric profile descriptions for each of the subdomains are well-structured with RDFS type definitions and partonomy rules
    - Search rules are object-centric; therefore search is localised to a specific domain

## 5.4.2 Execution times

- High OO jDREW execution times for recursive search predicates:
    - Incorporation of recursive predicates such as "getAllAttractions", "getAllEvents", and "getAllAccommodations"
    - The textual order between rules is not exploited by our pure logic programs (simulate exhaustive breadth-first parallel execution with iterative deepening)
    - For the recursive search predicates, execution times grow exponentially with the number of candidate activities

## 6.1 Contributions

### eTourPlan: A knowledge-based tourist route and activity planner

- Designed and implemented a KB comprised of object-centric facts of Bhutan tourist information, structured by light weight ontologies
- Realized rule subsystems for various tourist services
  - Semantic searches
  - Tour recommendation
  - Travel planning
- Iterated through a step-wise "model and test" cycle to obtain the executable specification of the eTourPlan prototype
- Tested and evaluated the eTourPlan KB (115 classes, 73 facts, and 37 rules) in the OO jDREW reasoning engine:
  - Constitutes a real world use case (based on Bhutan tourism information)
  - Offers multiple options for a diversity of travel plans
  - Provides precise parametric search results for various queries on the tourism KB
- Demo can be given on demand

## 6.1 Contributions

### eTourPlan: A knowledge-based tourist route and activity planner

- Designed and implemented a KB comprised of object-centric facts of Bhutan tourist information, structured by light weight ontologies
- Realized rule subsystems for various tourist services
  - Semantic searches
  - Tour recommendation
  - Travel planning
- Iterated through a step-wise "model and test" cycle to obtain the executable specification of the eTourPlan prototype
- Tested and evaluated the eTourPlan KB (115 classes, 73 facts, and 37 rules) in the OO jDREW reasoning engine:
  - Constitutes a real world use case (based on Bhutan tourism information)
  - Offers multiple options for a diversity of travel plans
  - Provides precise parametric search results for various queries on the tourism KB
- Demo can be given on demand

## 6.1 Contributions

### eTourPlan: A knowledge-based tourist route and activity planner

- Designed and implemented a KB comprised of object-centric facts of Bhutan tourist information, structured by light weight ontologies
- Realized rule subsystems for various tourist services
  - Semantic searches
  - Tour recommendation
  - Travel planning
- Iterated through a step-wise "model and test" cycle to obtain the executable specification of the eTourPlan prototype
- Tested and evaluated the eTourPlan KB (115 classes, 73 facts, and 37 rules) in the OO jDREW reasoning engine:
  - Constitutes a real world use case (based on Bhutan tourism information)
  - Offers multiple options for a diversity of travel plans
  - Provides precise parametric search results for various queries on the tourism KB
- Demo can be given on demand

## 6.1 Contributions

### eTourPlan: A knowledge-based tourist route and activity planner

- Designed and implemented a KB comprised of object-centric facts of Bhutan tourist information, structured by light weight ontologies
- Realized rule subsystems for various tourist services
  - Semantic searches
  - Tour recommendation
  - Travel planning
- Iterated through a step-wise "model and test" cycle to obtain the executable specification of the eTourPlan prototype
- Tested and evaluated the eTourPlan KB (115 classes, 73 facts, and 37 rules) in the OO jDREW reasoning engine:
  - Constitutes a real world use case (based on Bhutan tourism information)
  - Offers multiple options for a diversity of travel plans
  - Provides precise parametric search results for various queries on the tourism KB
- Demo can be given on demand

## 6.1 Contributions

### eTourPlan: A knowledge-based tourist route and activity planner

- Designed and implemented a KB comprised of object-centric facts of Bhutan tourist information, structured by light weight ontologies
- Realized rule subsystems for various tourist services
  - Semantic searches
  - Tour recommendation
  - Travel planning
- Iterated through a step-wise "model and test" cycle to obtain the executable specification of the eTourPlan prototype
- Tested and evaluated the eTourPlan KB (115 classes, 73 facts, and 37 rules) in the OO jDREW reasoning engine:
  - Constitutes a real world use case (based on Bhutan tourism information)
  - Offers multiple options for a diversity of travel plans
  - Provides precise parametric search results for various queries on the tourism KB
- Demo can be given on demand

## 6.1 Contributions

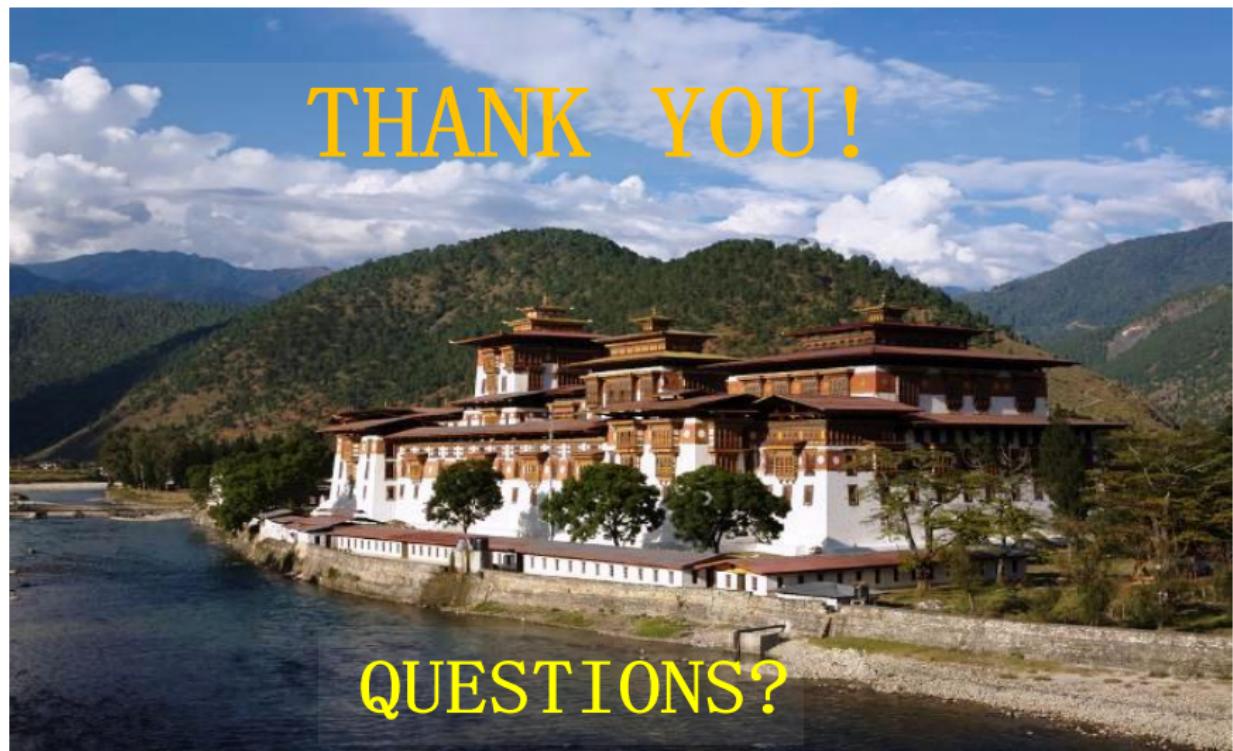
### eTourPlan: A knowledge-based tourist route and activity planner

- Designed and implemented a KB comprised of object-centric facts of Bhutan tourist information, structured by light weight ontologies
- Realized rule subsystems for various tourist services
  - Semantic searches
  - Tour recommendation
  - Travel planning
- Iterated through a step-wise "model and test" cycle to obtain the executable specification of the eTourPlan prototype
- Tested and evaluated the eTourPlan KB (115 classes, 73 facts, and 37 rules) in the OO jDREW reasoning engine:
  - Constitutes a real world use case (based on Bhutan tourism information)
  - Offers multiple options for a diversity of travel plans
  - Provides precise parametric search results for various queries on the tourism KB
- Demo can be given on demand

6.2 Future Work

- Other planning strategies such as partial planning and sequence planning
  - Cost estimation for the total travel
  - The current executable specification can be integrated with a database or could be translated to a self-contained database application
  - A user-friendly GUI would increase the utility of the key operations of the eTourPlan prototype
  - The semantic model and search of eTourPlan can be extended to a "Semantic Bhutan" portal (and transferred to other regions such as New Brunswick)

Thank You



# BACKUP SLIDES

### 4.3.1.9 Search Rules

## **KB (Rules):**

%—at a subblock level—————%

getAttraction(?Attraction:Attractions, ?Subblock:Subblock):  
siteOf(?Attraction:Attractions, ?Subblock:Subblock)

%—at a block level—————%

**getAttraction(?Attraction:Attractions, ?Block:Block):-  
partOfBlock(?Attraction:Attractions, ?Block:Block).**

```
getAttraction(?Attraction:Attractions, ?Block:Block):-  
    partOfBlock(?Subblock:Subblock, ?Block:Block),  
    getAttraction(?Attraction:Attractions, ?Subblock:Subblock).
```

%—at a province level—————%

```
getAttraction(?Attraction:Attractions, ?Province:Province):-  
    partOfProvince(?Attraction:Attractions, ?Province:Province).
```

```
getAttraction(?Attraction:Attractions, ?Province:Province):-  
    partOfProvince(?Block:Block, ?Province:Province),  
    getAttraction(?Attraction:Attractions, ?Block:Block).
```

## 4.3.1 Screenshots

**OO jDREW Top-Down Engine**

**File**

**Type Definition** **Knowledge Base** **Query** **Type Query**

**Query:**

```
eTourPlan(typeOfPlanning->EventCentric; ?TravelResult;
    userInputs->[userStartDate->date[2008:Real, 10:Real, 01:Real]; userEndDate->date[2008:Real, 11:Real, 10:Real];
    maxBreak->10:Real; minBreak->0:Real; startPoint->Paro:Province; endPoint->Thimphu:Province;
    attractionRecommendation->[no:chuzomthang,>?Interest])
```

RuleML query  POSL Query

**Solution:**

```
greaterThan("$jdrew-gt-2>0^ 2 : Integer, 0: Integer).
event(Tamshingphala_Choepa : Traditional_festival^ hs.name->[Tamshingphala_Choepa, 1 : String], date[2008:Real, 10 : Real, 08 : Real], date[2008:Real, 11 : Real, 01 : Real], [Paro, Thimphu] : Province, [Chuzom, ChortenKora] : Attraction, [Cultural_Religious, Religious] : Theme).
diff(7.0 : Real, date[2008 : Real, 10 : Real, 08 : Real], date[2008 : Real, 11 : Real, 01 : Real]) >= 0^ 7.0 : Real, 0 : Integer.
greaterThan("$jdrew-gt-7.0>0^ 7.0 : Real, 0 : Integer).
lessThanOrEqual("$jdrew-gte-7.0=>0^ 7.0 : Real, 0 : Real).
lessThanOrEqual("$jdrew-lte-7.0=<0^ 7.0 : Real, 10 : Real).
diff(30.0 : Real, date[2008 : Real, 11 : Real, 10 : Real], date[2008 : Real, 10 : Real, 01 : Real]) <= 0^ 30.0 : Real, 0 : Integer.
greaterThan("$jdrew-gt-30.0>0^ 30.0 : Real, 0 : Integer).
shortestRoute([Paro : Province, Bumthang : Province, [[Paro, Bumthang] : Route]] : Path).
getCapitalDistance(Tamshing_Lhakhang : Temple, 0.5 : Real).
add("$jdrew-add+16.7*0.5^ 17.2 : Real, 16.7 : Real, 0.5 : Real).
multiply("$jdrew-mul-7.0x0^ 56.0 : Real, 7.0 : Real, 8 : Real).
greaterThan("$jdrew-gt-56.0>17.2^ 56.0 : Real, 17.2 : Real).
multiply("$jdrew-mul-30.0x8.0^ 240.0 : Real, 30.0 : Real, 8 : Real).
shortestRoute([Bumthang : Province, Thimphu : Province, [[Bumthang, Thimphu] : Route]] : Path).
greaterThan("$jdrew-gt-240.0>12.2^ 240.0 : Real, 12.2 : Real).
checkIfRecommend([7.0 : Real, [Paro, Chuzom, Thimphu] : Province, [ChortenKora, Tamshing_Village] : Attraction, [Cultural_Religious, Religious] : Theme] : Recommendation).
siteOf(Tamshing_Lhakhang : Temple, Tamshing_Village : Village).
getAllAttractions([Tamshing_Village : Village, [Tamshing_Lhakhang] : Attraction]).
subtract("$jdrew-subtract-2-1^ 1 : Integer, 2 : Integer, 1 : Integer).
systemEventPlanner(hs.startDate->date[2008 : Real, 10 : Real, 01 : Real], hs.endDate->date[2008 : Real, 11 : Real, 10 : Real], hs.attraction->[no:chuzomthang,>?Interest], hs.theme->[Cultural_Religious, Religious], hs.route->[[Paro, Thimphu] : Route], hs.maxBreak->10:Real, hs.minBreak->0:Real, hs.startPoint->Paro:Province, hs.endPoint->Thimphu:Province, hs.attractionRecommendation->[no:chuzomthang,>?Interest], hs.systemEventPlanner->[no:chuzomthang,>?Interest]).
```

**Variable Bindings:**

Variable	Binding
?TravelResult	[[[Theme->Cultural_Religious, Religious], [Attraction->Chuzomthang, Interest], [Route->[Paro, Thimphu]] : Path]]

**Issue Query** **Next Solution**

**Show Debug Console**

Figure: Results

## 4.3.1 Screenshots

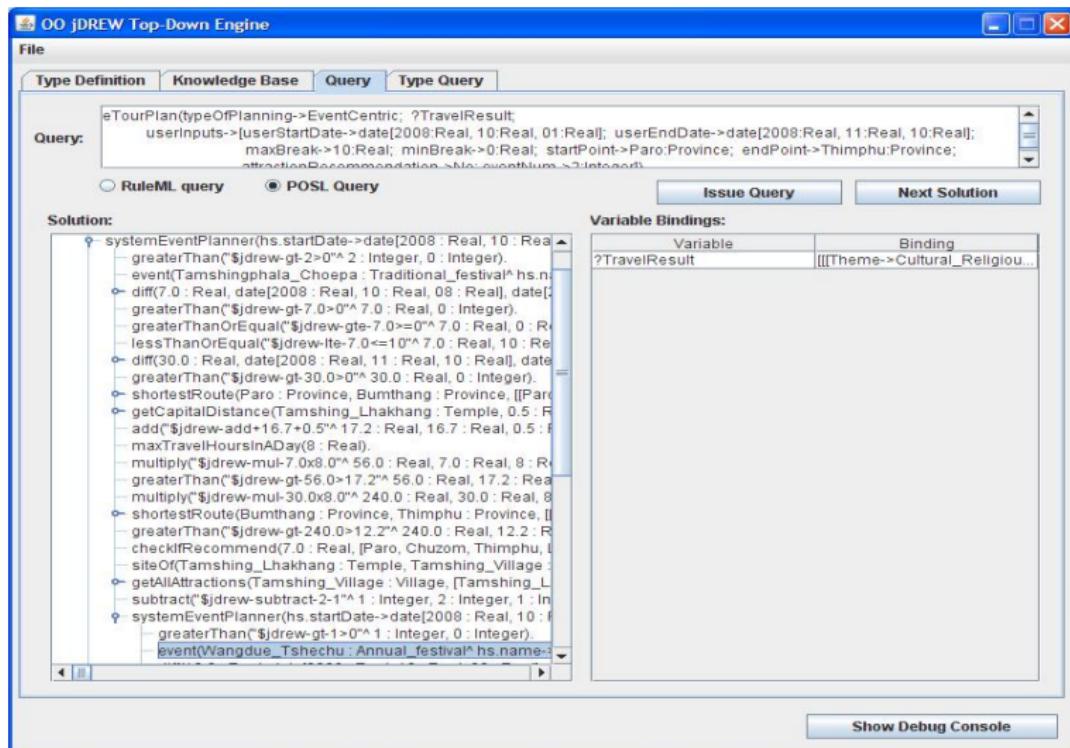


Figure: Results

## 4.3.1 Screenshots

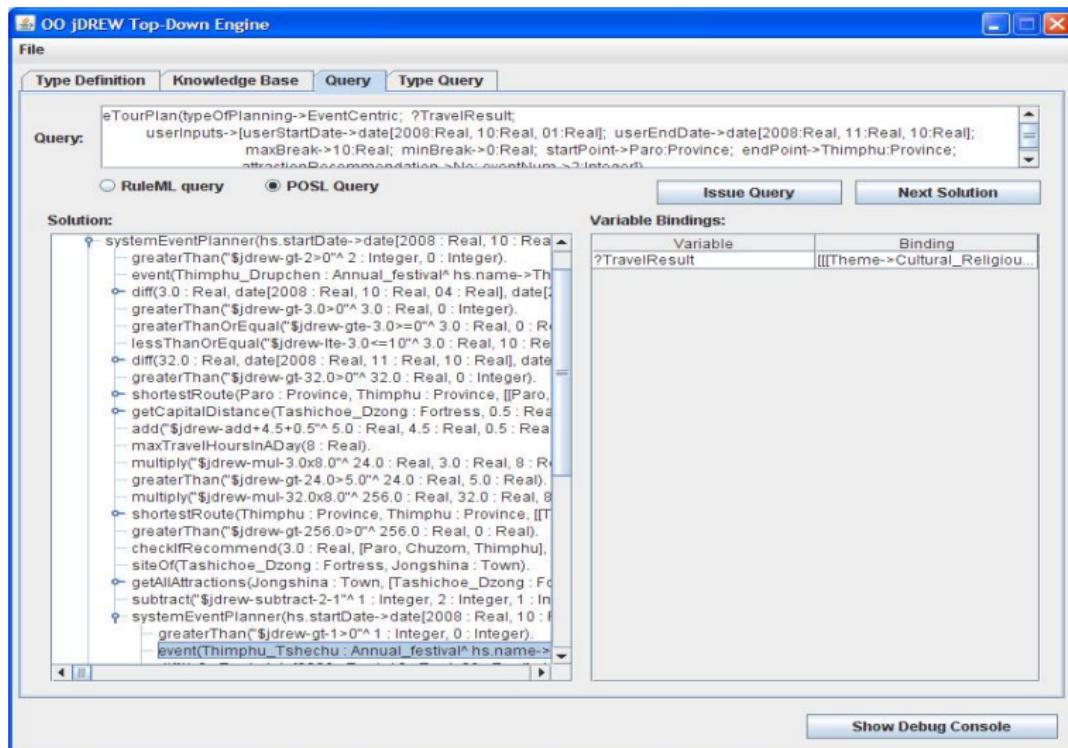


Figure: Results

## 4.3.1 Screenshots

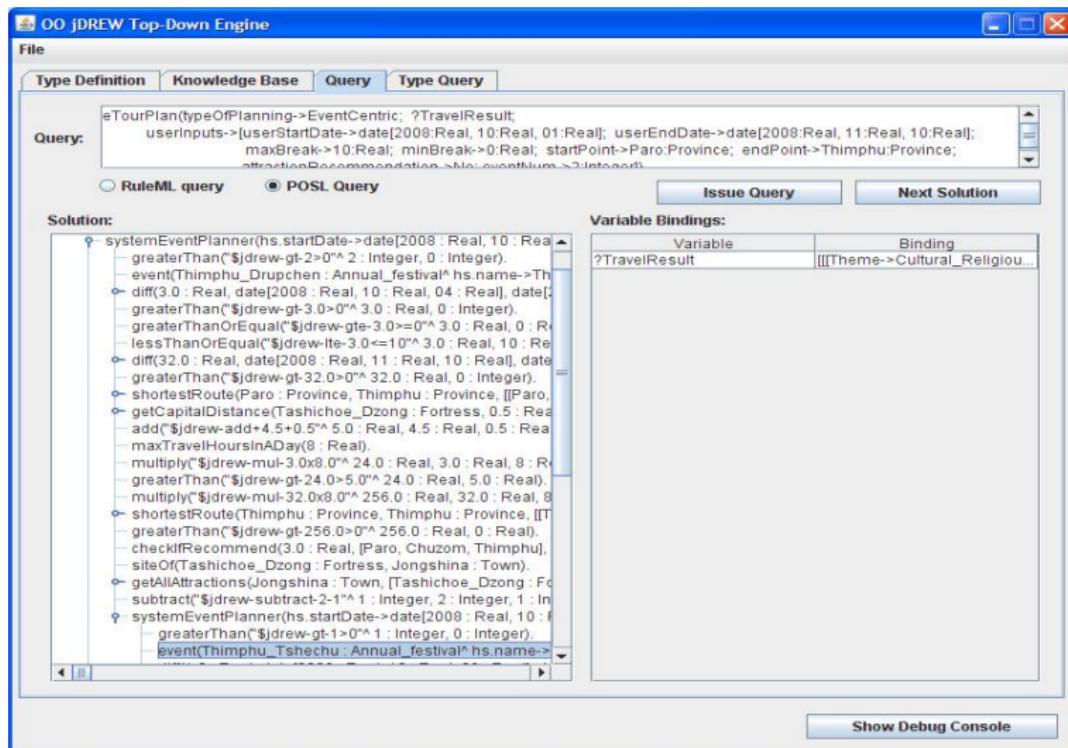


Figure: Results

## 4.3.1 Screenshots

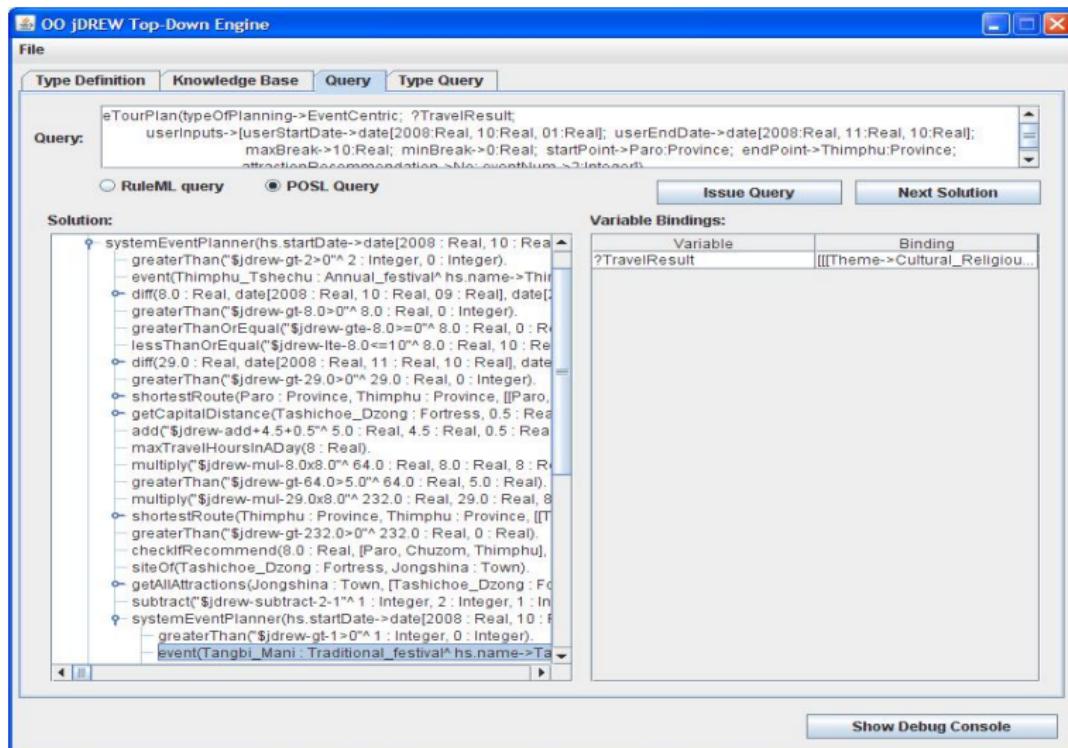


Figure: Results

## 4.3.1 Screenshots

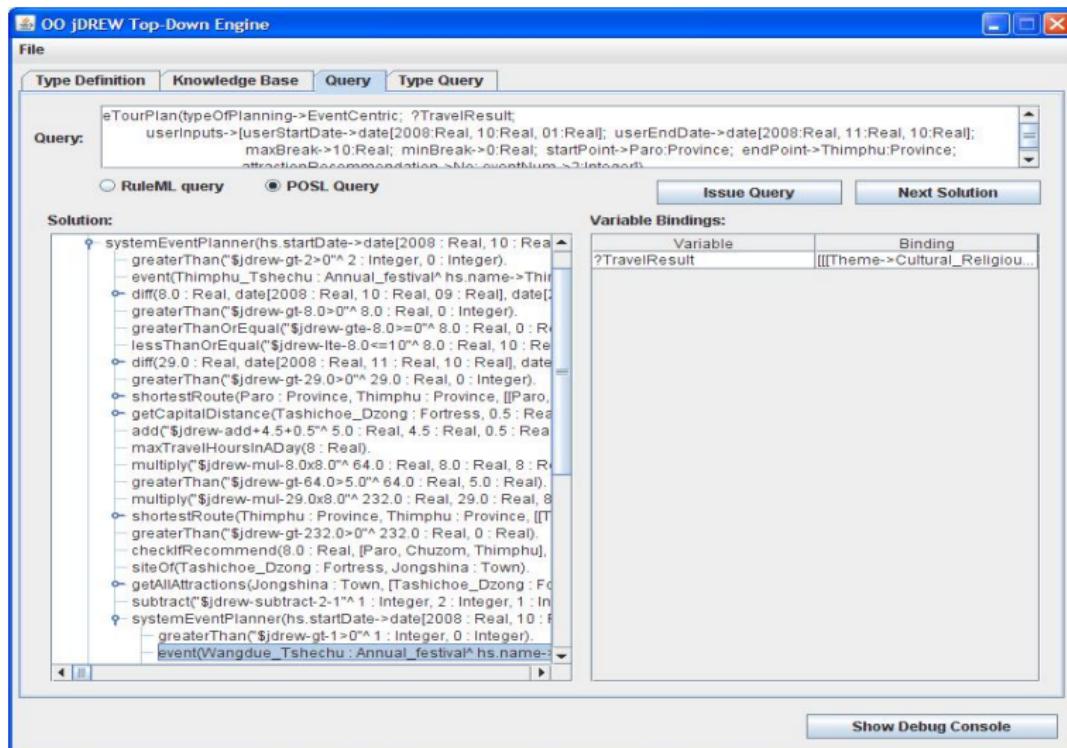


Figure: Results

#### 4.3.1.10 Search Rules

KB

```
%—at a region level——————%
getAttraction(?Attraction:Attractions, ?Region:Region):-
    partOfRegion(?Attraction:Attractions, ?Region:Region).

getAttraction(?Attraction:Attractions, ?Region:Region):-
    partOfRegion(?Province:Province, ?Region:Region),
    getAttraction(?Attraction:Attractions, ?Province:Province).

%—at a country level——————%
getAttraction(?Attraction:Attractions, ?Country:Country):-
    partOfCountry(?Attraction:Attractions, ?Country:Country).
getAttraction(?Attraction:Attractions, ?Country:Country):-
    partOfCountry(?Region:Region, ?Country:Country),
    getAttraction(?Attraction:Attractions, ?Region:Region).
```

## Sample Queries:

```
getAttraction(?Attraction:Attractions, Bhutan:Country)
getAttraction(?Attraction:Attractions, Western:Region)
getAttraction(?Attraction:Attractions, Bumthang:Province)
getAttraction(?Attraction:Attractions, Chhoekhor:Block)
getAttraction(?Attraction:Attractions, Chamkhar:Town)
```

#### 4.3.2.1 Route and Distance Time Computation

#### **Facilitates the Transportation subdomain**

- Two-level Computation
    - Precomputation of all routes (“`dTR` predicate)
    - Optimal route (i.e. shortest distance by “`dTRShortest`” predicate)
  - Implemented in the OO jDREW Top-Down FindAll Solutions architecture
  - Stored as precomputed facts in the KB

## 4.3.3 Precomputation of Route and Distance-time Facts

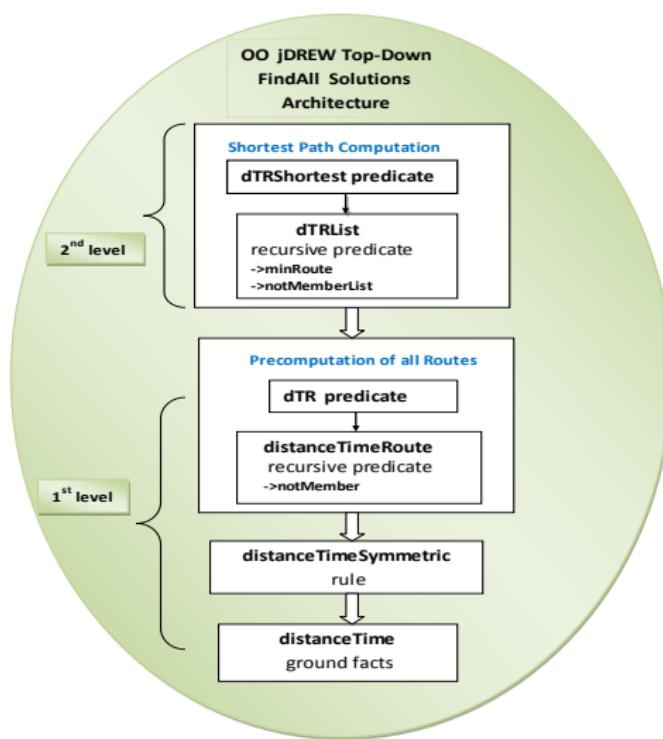


Figure: Two-level Computation

## 4.3.1.6 Partonomy Extensions (Sample KB)

- “**getFullAddress**” Rule extended

- Computes a location based on GPS coordinates
- Precise addressing scheme

### Sample GPS Facts:

```
address(Bumthang_Dzong:Fortress,  
        Loc[latitude->Detail[degree->48:Real; minute->0:Real];  
              longitude->Detail[degree->66:Real; minute->40:Real]]).
```

### Rule:

```
getFullAddress(?Location, [?Subblock, ?Block, ?Province, ?Region, ?Country,  
                         ?Latitude, ?Longitude]) :-  
    getLatitude(?Location, ?Latitude),  
    getLongitude(?Location, ?Longitude),  
    siteOf(?Location, ?Subblock),  
    partOfBlock(?Subblock, ?Block),  
    partOfProvince(?Block, ?Province),  
    partOfRegion(?Province, ?Region),  
    partOfCountry(?Region, ?Country).
```

## 4.3.1.7 Partonomy KB (Query and Result)

### Sample Query:

```
getFullAddress(Bumthang_Dzong:Fortress, ?Address)
```

### OO jDREW TD Result:

```
?Address= [4800.0:Real,  
6666.666666666667:Real,  
Chamkhar:Town,  
Chhoekhor:Block,  
Bumthang:Province,  
Central:Region,  
Bhutan:Country]
```

## 5.1.2 Sample Search Queries

Query	Entity	Search Query
1	Province	getProvinceDetails(region->?Region:Region; name-> <b>Bumthang:Province</b> ; <b>?ProvinceDetails</b> )
2	Route	getRouteDetails(startPoint-> <b>Chukha:Province</b> ; endPoint-> <b>Punakha:Province</b> ; <b>?RouteDetails</b> , <b>?ShortestRoute</b> )
3	Activity	getActivityDetails(actName->?Name: <b>Events</b> ; theme-> <b>Recreation</b> ; address->[?Subblock, ?Block, ?Province, <b>Southern:Region</b> , <b>?Country</b> ]; <b>?ActivityDetails</b> )
4	Accommodation	getAccommodationDetails(accName->?Name: <b>Resort</b> ; address->[ <b>Tsento_Shari:Village</b> , ?Block, ?Province, ?Region, ?Country]; setMaxPrice->[ <b>Yes</b> , <b>1500:Real</b> ]; <b>?AccommodationDetails</b> )

## 5.1.1 Search for Provincial Information (Input Modes and Search Result for Query 1)

Query	User Input Values	Query Formats (Input values are bold-faced)
1	name	getProvinceDetails(region->?Region:Region; name-> <b>Bumthang:Province</b> ; <b>?ProvinceDetails</b> )
2	region	getProvinceDetails(region-> <b>Central:Region</b> ; name->?Name:Province; <b>?ProvinceDetails</b> )
3	None	getProvinceDetails(region->?Region:Region; name->?Name:Province; <b>?ProvinceDetails</b> )

Output Variables	Variable Bindings (For Query 1)
?ProvinceDetails	[WebLink->"http://www.bumthang.gov.bt/"; Description->"Bumthang is one of the most attractive touristic province with several festivals throughout the year"; Capital->Chamkhar:Town; Geography->[Area->"1,819 sq.km"; Elevation->"1,300 to 7300 meters"]; TouristInfo->[NumAttractions->16:Integer; NumEvents->13:Integer; NumAccommodations->10 :Integer]; Contact->"admbumthang@druknet.bt"]
?Region:Region	Central:Region

## 5.1.1 Search for Provincial Information (Input Modes and Search Result for Query 1)

Query	User Input Values	Query Formats (Input values are bold-faced)
1	name	getProvinceDetails(region->?Region:Region; name-> <b>Bumthang:Province</b> ; <b>?ProvinceDetails</b> )
2	region	getProvinceDetails(region-> <b>Central:Region</b> ; name->?Name:Province; <b>?ProvinceDetails</b> )
3	None	getProvinceDetails(region->?Region:Region; name->?Name:Province; <b>?ProvinceDetails</b> )

Output Variables	Variable Bindings (For Query 1)
<b>?ProvinceDetails</b>	[WebLink->"http://www.bumthang.gov.bt"; Description->"Bumthang is one of the most attractive touristic province with several festivals throughout the year"; Capital->Chamkhar:Town; Geography->[Area->"1,819 sq.km"; Elevation->"1,300 to 7300 meters"]; TouristInfo->[NumAttractions->16:Integer; NumEvents->13:Integer; NumAccommodations->10 :Integer]; Contact->"admbumthang@druknet.bt"]
<b>?Region:Region</b>	Central:Region

## 5.1.2 Search for Route Details (Input/Output Modes)

Query	User Input Values	Query Formats (Input values are bold-faced)
1	startPoint endPoint	getRouteDetails(startPoint-> <b>Chukha:Province</b> ; endPoint-> <b>Punakha:Province</b> ; <b>?RouteDetails</b> , <b>?ShortestRoute</b> )

Output Variables	Variable Bindings (For Query 1)
?RouteDetails	[[[[Chukha, Chuzom, Thimphu, Lobesa, Punakha], 11.2:Real], [[Chukha, Chuzom, Thimphu, Lobesa, WangduePhodrang, Punakha], 11.90:Real]]; numRoutes->2:Integer]
?ShortestRoute	[[[Chukha, Chuzom, Thimphu, Lobesa, Punakha], 11.2 : Real]

## 5.1.2 Search for Route Details (Input/Output Modes)

Query	User Input Values	Query Formats (Input values are bold-faced)
1	startPoint endPoint	getRouteDetails(startPoint-> <b>Chukha:Province</b> ; endPoint-> <b>Punakha:Province</b> ; <b>?RouteDetails</b> , <b>?ShortestRoute</b> )

Output Variables	Variable Bindings (For Query 1)
?RouteDetails	[[[[Chukha, Chuzom, Thimphu, Lobesa, Punakha], 11.2:Real], [[Chukha, Chuzom, Thimphu, Lobesa, WangduePhodrang, Punakha], 11.90:Real]]; numRoutes->2:Integer]
?ShortestRoute	[[[Chukha, Chuzom, Thimphu, Lobesa, Punakha], 11.2 : Real]

## 5.1.3 Search for Activity Opportunities (Input/Output Modes)

Query	User Input Values	Query Formats (Input values are bold-faced)
1	actName	getActivityDetails(actName-> <b>Paro_Tshechu:Events</b> ; theme-> ?Theme; address-> ?Address; <b>?ActivityDetails</b> )
2	actName: <b>type</b> and/or address element	getActivityDetails(actName-> ?Name: <b>Festivals</b> ; theme-> ?Theme; address-> [?Subblock, <b>Chhoekhor:Block</b> , ?Province, ?Region, ?Country]; <b>?ActivityDetails</b> )
3	theme and/or address element	getActivityDetails(actName-> ?Name; theme-> <b>Cultural_Religious_Heritage</b> ; address-> [?Subblock, ?Block, <b>Paro:Province</b> , ?Region, ?Country]; <b>?ActivityDetails</b> )
4	theme actName: <b>type</b> address element	getActivityDetails(actName-> ?Name: <b>Events</b> ; theme-> <b>Recreation</b> ; address-> [?Subblock, ?Block, ?Province, <b>Southern:Region</b> , ?Country]; <b>?ActivityDetails</b> )
5	None	getActivityDetails(actName-> ?Name; theme-> Theme; address-> ?Address; <b>?ActivityDetails</b> )

## 5.1.4 Activity Search Result of Query 4

Output Variables	Variable Bindings (For Query 4)
<b>?ActivityDetails</b>	<pre>[ActName-&gt;Yangphel_Archery_Tournament:Sport_archery; WebLink-&gt;"http://www.bhutanarchery.com/default.asp"; EventDates-&gt;[StartDate-&gt;date[2008:Real, 08:Real, 23:Real];              EndDate-&gt;date[2008:Real, 10:Real, 02:Real]]; Description-&gt;"11TH Yangphel open archery tournament"; Address-&gt;[Phuentsholing_Upper_Town:Town,             Phuentsholing:Block,             Chukha:Province,             Southern:Region,             Bhutan:Country]; Theme-&gt;Recreation; RelatedTo-&gt;"Thimphu_Drupchen:Annual_festival"]</pre>

### 3.3.6 Accommodations Class

#### Profile of Wangdicholing\_Lodge

```
accommodation(Wangdicholing_Lodge:Lodge^
    hs.url->"http://www.wangdicholing.bt";
    et.rating->3:Real;
    et.minPrice->800:Real;
    et.subblock->Chamkhar:Town;
    et.province->Bumthang:Province;
    hs.telecoms->Telecoms[
        et.landline->9753631452;
        et.cell->97517682948];
    hs.contact->"manager@wangdicholing.bt";
    hs.relatedTo->Yangphel_Guest_house:Guest_house).
```

## 5.1.5 Search for Accommodation Details

Query	User Input Values	Query Formats (Input values are bold-faced)
1	accName	getAccommodationDetails(accName-> <b>Aman_Resort:Resort</b> ; address-> ?Address; setMaxPrice-> ?SetMaxPrice; <b>?AccommodationDetails</b> )
2	accName:type and/or address element	getAccommodationDetails(accName-> ?Name: <b>Guest_house</b> ; address-> <b>[Chamkhar:Town</b> , ?Block, ?Province, ?Region, ?Country]; setMaxPrice-> ?SetMaxPrice; <b>?AccommodationDetails</b> )
3	setMaxPrice and/or address element	getAccommodationDetails(accName-> ?Name; address-> <b>[Chamkhar:Town</b> , ?Block, ?Province, ?Region, ?Country]; setMaxPrice-> <b>[Yes</b> , <b>2000:Real</b> ]; <b>?AccommodationDetails</b> )
4	accName:type setMaxPrice address element	getAccommodationDetails(accName-> ?Name: <b>Resort</b> ; address-> <b>[Tsento_Shari:Village</b> , ?Block, ?Province, ?Region, ?Country]; setMaxPrice-> <b>[Yes</b> , <b>1500:Real</b> ]; <b>?AccommodationDetails</b> )
5	None	getAccommodationDetails(accName-> ?Name; address-> ?Address; setMaxPrice-> ?SetMaxPrice; <b>?AccommodationDetails</b> )

## 5.1.6 Accommodation Search Result of Query 4

Output Variables	Variable Bindings (For Query 4)
<b>?AccommodationDetails</b>	[AccName->Rangen:Resort; WebLink->"www.rangnen.bt "; Address->[Tsento_Shari:Village, Tsento:Block, Paro:Province, Western:Region, Bhutan:Country]; Standard->[StarRating->2:Real; MinPrice->1000:Real]; ContactDetails-> [Telecoms->[ Landline->9758211452; Cell->97517682948]; Email->"manager@rangnen.bt"]; RelatedTo->"Holiday_Home:Hotel"]

# Location-centric recommendation by the system

Output Variables	Variable Bindings
?Routes	[[[Paro, Chuzom, Thimphu], 6.5 :Real], [[Thimphu, Lobesa, Punakha], 4.2:Real]]
?Recommendations	[[Paro:Province; WebLink->"http://www.paro.gov.bt/"; TouristInfo-> NumAttractions->3:Integer; NumEvents->1:Integer; NumAccommodations->3:Integer]], [Thimphu:Province; WebLink->"http://www.thimphu.gov.bt/"; TouristInfo-> NumAttractions->3:Integer; NumEvents->1:Integer; NumAccommodations->3:Integer]], [Punakha:Province; WebLink->"http://www.punakha.gov.bt/"; TouristInfo-> NumAttractions->2:Integer; NumEvents->1:Integer; NumAccommodations->0:Integer]]
?TotalBusHours	8.7:Real

## 5.3.2 Resulting Multiple Travel Plans

Table: Evaluation of event-centric travel results

Event	Event Schedules	Event Sequences of length ?EventNum= 2
1	Tamshingphala_Choepa:Traditional_festival startDate->date[2008:Real,10:Real,08:Real] endDate->date[2008:Real,10:Real,10:Real] province->Bumthang	1,2 1,5
2	Tangbi_Mani:Traditional_festival startDate->date[2008:Real,10:Real,13:Real] endDate->date[2008:Real,10:Real,15:Real] province->Bumthang	
3	Thimphu_Drupchen:Annual_festival startDate->date[2008:Real,10:Real,04:Real] endDate->date[2008:Real,10:Real,08:Real] province->Thimphu	3,2 3,4
4	Thimphu_Tshechu:Annual_festival startDate->date[2008:Real,10:Real,09:Real] endDate->date[2008:Real,10:Real,11:Real] province->Thimphu	4,2 4,5
5	Wangdue_Tshechu:Annual_festival startDate->date[2008:Real,10:Real,20:Real] endDate->date[2008:Real, 10:Real, 29:Real] province->WangduePhodrang	

## 5.3.5 Travel Planning Results (Cont'd)

Table: Evaluation of event-centric travel results

Event	Event Schedules	Event Sequences of length ?EventNum= 4
1	Tamshingphala_Choepa:Traditional_festival startDate->date[2008:Real,10:Real,08:Real] endDate->date[2008:Real,10:Real,10:Real] province->Bumthang	
2	Tangbi_Mani:Traditional_festival startDate->date[2008:Real,10:Real,13:Real] endDate->date[2008:Real,10:Real,15:Real] province->Bumthang	
3	Thimphu_Drupchen:Annual_festival startDate->date[2008:Real,10:Real,04:Real] endDate->date[2008:Real,10:Real,08:Real] province->Thimphu	3,4,2,5
4	Thimphu_Tshechu:Annual_festival startDate->date[2008:Real,10:Real,09:Real] endDate->date[2008:Real,10:Real,11:Real] province->Thimphu	
5	Wangdue_Tshechu:Annual_festival startDate->date[2008:Real,10:Real,20:Real] endDate->date[2008:Real, 10:Real, 29:Real] province->WangduePhodrang	

## 5.3.6 Illustration of a Travel Plan (Option 3)

