eTourPlan: A Knowledge-Based Tourist Route and Activity Planner
Thesis Oral Defence for MCS Degree Program

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1. Introduction
2. Background
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

- Search Engine
  (Routes, Events, Attractions, Accommodations)
- Recommender System
  (Location-centric)
- Travel Planner
  (Event-centric & Attractions-only)
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
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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

- 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)
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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

<table>
<thead>
<tr>
<th></th>
<th>Attraction-Only Planning</th>
<th>Event-Only Planning</th>
<th>Event-Centric Planning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Complete Planning</strong></td>
<td>Planning attractions based on related locations</td>
<td>Planning events based on their dates and locations</td>
<td>Planning events with additional attraction recommendation</td>
</tr>
<tr>
<td><strong>Sequence Planning</strong></td>
<td>System orders the user-specified attractions</td>
<td>System orders the user-specified events</td>
<td>System orders both events and attractions</td>
</tr>
<tr>
<td><strong>Partial Planning</strong></td>
<td>System orders and adds to user-specified attractions</td>
<td>System orders and adds to user’s specified events</td>
<td>System orders and adds to user’s specified events and attractions</td>
</tr>
</tbody>
</table>
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
  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

province(Thimphu:Province\n .
 .
 hs.relatedTo->Punakha:Province).
3.3.3 Events Class

Diagram showing the classification of events in an ontology, including categories such as Festival, Arts, Sport, Adventure, Market, Trade, Nature, Religion, Night life, traditional_festival, national_festival, seasonal_festival, annual_festival, international_festival, film_festival, music_festival, gastronomic_festival, and dance_festival.
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
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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)

<table>
<thead>
<tr>
<th>Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>siteOf(Tashichoe_Dzong:Fortress, Jongshina:Town).</td>
</tr>
<tr>
<td>siteOf(Memorial_Chorten:Temple, Thimphu_City:City).</td>
</tr>
<tr>
<td>siteOf(Hotel_Tandin:Hotel, Thimphu_City:City).</td>
</tr>
<tr>
<td>%partOfBlock(?Subblock:Subblock, ?Block:Block).</td>
</tr>
<tr>
<td>partOfBlock(Jongshina:Town, Chang:Block).</td>
</tr>
<tr>
<td>partOfBlock(Thimphu_City:City, Chang:Block).</td>
</tr>
<tr>
<td>partOfBlock(Chubachu:Town, Chang:Block).</td>
</tr>
<tr>
<td>partOfBlock(Changlimithang:Town, Chang:Block).</td>
</tr>
<tr>
<td>%partOfProvince(?Block:Block, ?Province:Province).</td>
</tr>
<tr>
<td>partOfProvince(Baap:Block, Thimphu:Province).</td>
</tr>
<tr>
<td>partOfProvince(Chang:Block, Thimphu:Province).</td>
</tr>
<tr>
<td>%partOfRegion(?Province:Province, ?Region:Region).</td>
</tr>
<tr>
<td>partOfRegion(Thimphu:Province, Western:Region).</td>
</tr>
<tr>
<td>partOfCountry(Western:Region, Bhutan:Country).</td>
</tr>
</tbody>
</table>
4.2.1.5 Partonomy KB (Rule with Query and Result)

**KB (Rule):**

```
  siteOf(?Location, ?Subblock),
  partOfBlock(?Subblock, ?Block),
  partOfProvince(?Block, ?Province),
  partOfRegion(?Province, ?Region),
```

**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
4.2.2 Route and Distance-time Computation

**Figure:** A connected sample graph

**Table:** POSL representation of the connected graph

<table>
<thead>
<tr>
<th>Route and Distance-time Computation</th>
<th>POSL Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>distanceTime(startPoint-&gt;A; endPoint-&gt;B; bus-&gt;3:Real).</td>
<td></td>
</tr>
<tr>
<td>distanceTime(startPoint-&gt;A; endPoint-&gt;E; bus-&gt;2:Real).</td>
<td></td>
</tr>
<tr>
<td>distanceTime(startPoint-&gt;B; endPoint-&gt;C; bus-&gt;4:Real).</td>
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<td></td>
</tr>
<tr>
<td>distanceTime(startPoint-&gt;C; endPoint-&gt;E; bus-&gt;5:Real).</td>
<td></td>
</tr>
<tr>
<td>distanceTime(startPoint-&gt;D; endPoint-&gt;F; bus-&gt;1:Real).</td>
<td></td>
</tr>
<tr>
<td>distanceTime(startPoint-&gt;E; endPoint-&gt;G; bus-&gt;3:Real).</td>
<td></td>
</tr>
<tr>
<td>distanceTime(startPoint-&gt;F; endPoint-&gt;G; bus-&gt;1:Real).</td>
<td></td>
</tr>
<tr>
<td>distanceTime(startPoint-&gt;G; endPoint-&gt;I; bus-&gt;5:Real).</td>
<td></td>
</tr>
</tbody>
</table>

**KB (Rule):**

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

routeCount(startPoint->?Province1; endPoint->?Province2; 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 jDREW 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:

1. 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:
   - maxActivitySightSeeingHoursInADay(12:Real)
   - maxHoursAtAnAttractionSite(4:Real)

3. On successful validation of distance and remaining time, add detailed information of the selected attraction to the travel plan.
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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”).
The planner performs the following steps:

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Rules:

1. **Selection of event from the KB**
   - Event selection is based on the user's travel dates, minimum break, and maximum break.

2. **Date Validation Process**
   - Calculate the difference between the event end date and user start date.
   - Validate based on maximum break and remaining days.

3. **Travel-Time Computation and Validation**
   - Compute travel time and bus hours.
   - Validate based on maximum break and remaining days.

4. **Attraction Recommendation**
   - Retrieve attractions based on the subblock of the selected event.
   - Recommend on-route attractions if selected.

5. **Planner Output**
   - Generate the final travel plan with event details and route information.
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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

<table>
<thead>
<tr>
<th>Query</th>
<th>Variable Bindings</th>
</tr>
</thead>
<tbody>
<tr>
<td>getActivityDetails(?Name: Events;</td>
<td>[ActName-&gt;Yangphel_Archery_Tournament:Sport_archery;</td>
</tr>
<tr>
<td>theme-&gt;Recreation;</td>
<td>WebLink-&gt;“<a href="http://www.bhutanarchery.com/default.asp%E2%80%9D">http://www.bhutanarchery.com/default.asp”</a>;</td>
</tr>
<tr>
<td>address-&gt;[Subblock, Block, Province,</td>
<td>EventDates-&gt;[StartDate-&gt;date[2008:Real, 08:Real, 23:Real];</td>
</tr>
<tr>
<td>Southern:Region, Country]</td>
<td>EndDate-&gt;date[2008:Real, 10:Real, 02:Real]];</td>
</tr>
<tr>
<td></td>
<td>Description-&gt;“11TH Yangphel open archery tournament”;</td>
</tr>
<tr>
<td></td>
<td>Address-&gt;[Phuentsholing_Upper_Town:Town,</td>
</tr>
<tr>
<td></td>
<td>Phuentsholing:Block, Chukha:Province,</td>
</tr>
<tr>
<td></td>
<td>Southern:Region, Bhutan:Country];</td>
</tr>
<tr>
<td></td>
<td>Theme-&gt;Recreation; RelatedTo-&gt;“Thimphu_Drupchen:Annual_festival”]</td>
</tr>
</tbody>
</table>
5.1.2 Sample Activity Search Query and Result

**Query**

```turtle
getActivityDetails(actName-?Name:Events;
    theme->Recreation;
    address->[?Subblock,
        ?Block,
        ?Province,
        Southern:Region,
        ?Country];
    ?ActivityDetails)
```

**Variable Bindings**

<table>
<thead>
<tr>
<th>Output Variables</th>
<th>Variable Bindings</th>
</tr>
</thead>
</table>
| ?ActivityDetails  | [ActName->Yangphel_Archery_Tournament:Sport_archery;
|                   | WebLink->"http://www.bhutanarchery.com/default.asp";
|                   | 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

<table>
<thead>
<tr>
<th>User Input Values</th>
<th>Query Formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <code>typeOfRecommend</code></td>
<td><code>locCentricRecommend(typeOfRecommend-&gt;SystemRecommendation;</code></td>
</tr>
<tr>
<td>2. <code>numProvinces</code></td>
<td><code>userInputs-&gt;[startPoint-&gt;Paro:Province;</code></td>
</tr>
<tr>
<td></td>
<td><code>numProvinces-&gt;3:Integer];</code></td>
</tr>
<tr>
<td></td>
<td><code>[?Routes, ?Recommendations, ?TotalBusHours])</code></td>
</tr>
<tr>
<td>2. <code>typeOfRecommend</code></td>
<td><code>locCentricRecommend(typeOfRecommend-&gt;UserPrefBased;</code></td>
</tr>
<tr>
<td>3. <code>startPoint</code></td>
<td><code>userInputs-&gt;[startPoint-&gt;Paro:Province;</code></td>
</tr>
<tr>
<td>4. <code>userPrefList</code></td>
<td><code>userPrefList-&gt;[Chukha:Province];</code></td>
</tr>
<tr>
<td>5. <code>endPoint</code></td>
<td><code>endPoint-&gt;Thimphu:Province];</code></td>
</tr>
<tr>
<td></td>
<td><code>[?Routes, ?Recommendations, ?TotalBusHours])</code></td>
</tr>
</tbody>
</table>

**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**

<table>
<thead>
<tr>
<th>Output Variables</th>
<th>Variable Bindings (For Query 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>?Routes</td>
<td>[[Paro, Chuzom, Chukha], 6.5 :Real, [Chukha, Chuzom, Thimphu], 7.0 :Real]</td>
</tr>
<tr>
<td></td>
<td>[Chukha; Recommendations EventList-&gt;]</td>
</tr>
</tbody>
</table>
|                  |   [[eventName->Chukha_Tshechu:Annual_festival; description->“One of the most amazing festivals in Chukha”; address->[Chukha_Town:Town, Gelling:Block, Southern:Region, Bhutan:Country, eventDates->[startDate->date[2008:Real, 03:Real, 19:Real]; endDate->date[2008:Real, 03:Real, 21:Real]], [eventName->Yangphel_Archery_Tournament:Sport_archery; description->“11TH Yangphel open archery tournament”; address->[Phuentsholing_Upper_Town:Town, Phuentsholing:Block, Southern:Region, Bhutan :Country, eventDates->[startDate->date[2008:Real, 08:Real, 23:Real]; endDate->date[2008:Real, 10:Real, 02 :Real]]]];]
<table>
<thead>
<tr>
<th>?Recommendations</th>
<th>AttractionList- &gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chukha_Dzong:Fortress;</td>
</tr>
<tr>
<td></td>
<td>WebLink- &gt;“ ”;</td>
</tr>
<tr>
<td></td>
<td>Description- &gt;“It is one of the most beautiful attractions.”;</td>
</tr>
<tr>
<td>AccommodationList- &gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hotel_Druk_Phuentsholing:Hotel;</td>
</tr>
<tr>
<td></td>
<td>WebLink- &gt;“www.drukhotels.com/”;</td>
</tr>
<tr>
<td></td>
<td>MinPrice- &gt;&quot;2700:Real&quot;;</td>
</tr>
<tr>
<td></td>
<td>Rating- &gt;4:Real];</td>
</tr>
<tr>
<td></td>
<td>Hotel_Namgay:Hotel;</td>
</tr>
<tr>
<td></td>
<td>WebLink- &gt;“www.hotelNamgay.bt/”;</td>
</tr>
<tr>
<td></td>
<td>MinPrice- &gt;&quot;1800:Real&quot;;</td>
</tr>
<tr>
<td></td>
<td>Rating- &gt;3:Real]]</td>
</tr>
</tbody>
</table>

| ?TotalBusHours | 13.5:Real |
5.3.1 eTourPlan Travel Planner

- **Two modes of Travel Planning:**
  1. **AttractionOnly:** Based on "relatedTo" attractions
  2. **EventCentric:** Based on temporal-geographic search criteria

<table>
<thead>
<tr>
<th>User Input Values</th>
<th>Query Formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>typeOfPlanning</strong></td>
<td><code>eTourPlan(typeOfPlanning- &gt; AttractionOnly; userInputs- &gt; [startPoint- &gt; Paro:Province; endPoint- &gt; Thimphu:Province; numAttractions- &gt; 4:Integer; userTotalTravelTimeInDays- &gt; 4:Integer]; ?TravelResult)</code></td>
</tr>
<tr>
<td><strong>startPoint</strong></td>
<td></td>
</tr>
<tr>
<td><strong>endPoint</strong></td>
<td></td>
</tr>
<tr>
<td><strong>numAttractions</strong></td>
<td></td>
</tr>
<tr>
<td><strong>userTotalTravelTimeInDays</strong></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td><strong>typeOfPlanning</strong></td>
<td><code>eTourPlan(typeOfPlanning- &gt; EventCentric; userInputs- &gt; [startPoint- &gt; Paro:Province; endPoint- &gt; Thimphu:Province; userStartDate- &gt; date[2008:Real,10:Real,01:Real]; userEndDate- &gt; date[2008:Real,11:Real,10:Real]; maxBreak- &gt; 10:Real; minBreak- &gt; 0:Real; attractionRecommendation- &gt; No; eventNum- &gt; 3:Integer]; ?TravelResult)</code></td>
</tr>
<tr>
<td><strong>startPoint</strong></td>
<td></td>
</tr>
<tr>
<td><strong>endPoint</strong></td>
<td></td>
</tr>
<tr>
<td><strong>userStartDate</strong></td>
<td></td>
</tr>
<tr>
<td><strong>userEndDate</strong></td>
<td></td>
</tr>
<tr>
<td><strong>maxBreak</strong></td>
<td></td>
</tr>
<tr>
<td><strong>minBreak</strong></td>
<td></td>
</tr>
<tr>
<td><strong>attractionRecommendation</strong></td>
<td></td>
</tr>
<tr>
<td><strong>eventNum</strong></td>
<td></td>
</tr>
</tbody>
</table>

**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

<table>
<thead>
<tr>
<th>Event</th>
<th>Event Schedules</th>
<th>Event Sequences of length ?EventNum= 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tamshingphala_Choepa:Traditional_festival</td>
<td>1,2,5</td>
</tr>
<tr>
<td></td>
<td>startDate-&gt;date[2008:Real,10:Real,08:Real]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>endDate-&gt;date[2008:Real,10:Real,10:Real]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>province-&gt;Bumthang</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Tangbi_Mani:Traditional_festival</td>
<td>3,2,5</td>
</tr>
<tr>
<td></td>
<td>startDate-&gt;date[2008:Real,10:Real,13:Real]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>endDate-&gt;date[2008:Real,10:Real,15:Real]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>province-&gt;Bumthang</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Thimphu_Drupchen:Annual_festival</td>
<td>3,4,2</td>
</tr>
<tr>
<td></td>
<td>startDate-&gt;date[2008:Real,10:Real,04:Real]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>endDate-&gt;date[2008:Real,10:Real,08:Real]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>province-&gt;Thimphu</td>
<td>3,4,5</td>
</tr>
<tr>
<td>4</td>
<td>Thimphu_Tshechu:Annual_festival</td>
<td>4,2,5</td>
</tr>
<tr>
<td></td>
<td>startDate-&gt;date[2008:Real,10:Real,09:Real]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>endDate-&gt;date[2008:Real,10:Real,11:Real]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>province-&gt;Thimphu</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Wangdue_Tshechu:Annual_festival</td>
<td></td>
</tr>
<tr>
<td></td>
<td>startDate-&gt;date[2008:Real,10:Real,20:Real]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>endDate-&gt;date[2008:Real, 10:Real, 29:Real]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>province-&gt;WangduePhodrang</td>
<td></td>
</tr>
</tbody>
</table>
## 5.3.4 Multiple Travel Plans

**Table:** Options for event-centric travel plans

<table>
<thead>
<tr>
<th>Option</th>
<th>Event Sequences of length “3”</th>
<th>Province</th>
</tr>
</thead>
</table>
| 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**

<table>
<thead>
<tr>
<th>Output Variables</th>
<th>Variable Bindings</th>
</tr>
</thead>
<tbody>
<tr>
<td>?TravelResult</td>
<td>[[[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;[P[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_Tschechu:Annual_festival;]]]</td>
</tr>
</tbody>
</table>
### 5.3.5 Detailed Result of a Travel Plan (Cont’d)

<table>
<thead>
<tr>
<th>?TravelResult</th>
<th>RouteDetails - &gt;[[Bumthang:Province], []; RouteBusHours - &gt;0:Real]];</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RecommendedAttractions - &gt;[Tangbi_Monastery:Monastery</td>
</tr>
<tr>
<td></td>
<td>“Located in upper Tang valley.”)];</td>
</tr>
<tr>
<td></td>
<td>[EventName - &gt;Wangdue_Tshechu:Annual_festival];</td>
</tr>
<tr>
<td></td>
<td>EventDates - &gt;[Startdate - &gt;date[2008:Real, 10:Real, 20:Real];</td>
</tr>
<tr>
<td></td>
<td>Enddate - &gt;date[2008:Real, 10:Real, 29:Real]];</td>
</tr>
<tr>
<td></td>
<td>Theme - &gt;Cultural_Religious_Heritage;</td>
</tr>
<tr>
<td></td>
<td>EventDescription - &gt;“A very popular festival in western Bhutan”</td>
</tr>
<tr>
<td></td>
<td>Location - &gt;[Wangdue_Dzong:Fortress,</td>
</tr>
<tr>
<td></td>
<td>Wangdue_Town:Town,</td>
</tr>
<tr>
<td></td>
<td>WangduePhodrang:Province];</td>
</tr>
<tr>
<td></td>
<td>RouteDetails - &gt;[[Bumthang:Province, Trongsa:Province,</td>
</tr>
<tr>
<td></td>
<td>WangduePhodrang:Province], [];</td>
</tr>
<tr>
<td></td>
<td>[]; RouteBusHours - &gt;0:Real];</td>
</tr>
<tr>
<td></td>
<td>RecommendedAttractions - &gt;[Wangdue_Dzong:Fortress</td>
</tr>
<tr>
<td></td>
<td>“It is one of the most beautiful attractions.”)];</td>
</tr>
<tr>
<td></td>
<td>ReturnRoute - &gt;[[WangduePhodrang:Province, Lobesa:Province,</td>
</tr>
<tr>
<td></td>
<td>Thimphu:Province];</td>
</tr>
<tr>
<td></td>
<td>Returntime - &gt;12.2:Real]</td>
</tr>
</tbody>
</table>
5.3.6 Travel Plan (Option 4) - At the starting point
5.3.6 Travel Plan - Event 1 found

Thimphu_Drubchen:Annual_Festival

- startDate - 2008.10.04
- endDate - 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

Thimphu_Tshechu:Annual_Festival

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

Attractions:
Trashichoe_dzong:Fortress
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.”

5.3.6 Travel Plan - Return route to the end point
5.3.6 Travel Planning - On-route attraction recommendation (Optional)

On-route Attraction Recommendation

Bumthang ->
[[Bumthang_Dzong:Fortress, Chamkhar:Town],
[Ugyen_Chholing_Museum:Local_museum]]

Trongsa ->
[[Trongsa_Dzong:Fortress, Samchholing:Village],
[Samchholing_Palace:Popular_architecture]]

Wangdue ->
[[Wangdue_Dzong:Fortress, Wangdue_Town:Town],
[Trongsa_Dzong:Fortress, Samchholing:Village]]

Lobesa ->
[[Thimphu_Tashichoe_Dzong:Fortress, Jongshina:Town],
[Memorial_Chorten:Temple, Thimphu_City:City]]
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 lightweight 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
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  - 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
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  - 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):-

%—–at a block level—-getAttraction(?Attraction:Attractions, ?Block:Block):-
   partOfBlock(?Attraction:Attractions, ?Block:Block).
   getAttraction(?Attraction:Attractions, ?Block:Block):-
   partOfBlock(?Subblock:Subblock, ?Block:Block),

%—–at a province level—-getAttraction(?Attraction:Attractions, ?Province:Province):-
   getAttraction(?Attraction:Attractions, ?Province:Province):-
   partOfProvince(?Block:Block, ?Province:Province),
   getAttraction(?Attraction:Attractions, ?Block:Block).
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 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),

%—-at a country level-----------------------------------------%
getAttraction(?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)
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:**

```
  getLatitude(?Location, ?Latitude),
  getLongitude(?Location, ?Longitude),
  siteOf(?Location, ?Subblock),
  partOfBlock(?Subblock, ?Block),
  partOfProvince(?Block, ?Province),
  partOfRegion(?Province, ?Region),
```
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

<table>
<thead>
<tr>
<th>Query</th>
<th>Entity</th>
<th>Search Query</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Province</td>
<td><code>getProvinceDetails(region-&gt; Region; name-&gt; Bumthang: Province; ?ProvinceDetails)</code></td>
</tr>
<tr>
<td>2</td>
<td>Route</td>
<td><code>getRouteDetails(startPoint-&gt; Chukha: Province; endPoint-&gt; Punakha: Province; ?RouteDetails, ?ShortestRoute)</code></td>
</tr>
<tr>
<td>4</td>
<td>Accommodation</td>
<td><code>getAccommodationDetails(accName-&gt; ?Name: Resort; address-&gt;[Tsento_Shari: Village, ?Block, ?Province, ?Region, ?Country];</code></td>
</tr>
<tr>
<td></td>
<td></td>
<td><code>setMaxPrice-&gt;[Yes, 1500: Real]; ?AccommodationDetails)</code></td>
</tr>
</tbody>
</table>
5.1.1 Search for Provincial Information (Input Modes and Search Result for Query 1)

<table>
<thead>
<tr>
<th>Query</th>
<th>User Input Values</th>
<th>Query Formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>name</td>
<td>getProvinceDetails(region-＞?Region:Region; name-＞<strong>Bumthang</strong>:Province; ?ProvinceDetails)</td>
</tr>
<tr>
<td>2</td>
<td>region</td>
<td>getProvinceDetails(region-＞<strong>Central</strong>:Region; name-＞?Name:Province; ?ProvinceDetails)</td>
</tr>
<tr>
<td>3</td>
<td>None</td>
<td>getProvinceDetails(region-＞?Region:Region; name-＞?Name:Province; ?ProvinceDetails)</td>
</tr>
</tbody>
</table>

Output Variables  | Variable Bindings
--- | ---
?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 Provinicial Information (Input Modes and Search Result for Query 1)

<table>
<thead>
<tr>
<th>Query</th>
<th>User Input Values</th>
<th>Query Formats (Input values are bold-faced)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>name</td>
<td>getProvinceDetails(region-&gt; ?Region:Region; name-&gt; <strong>Bumthang</strong>:Province; ?ProvinceDetails)</td>
</tr>
<tr>
<td>2</td>
<td>region</td>
<td>getProvinceDetails(region-&gt; <strong>Central</strong>:Region; name-&gt; ?Name:Province; ?ProvinceDetails)</td>
</tr>
<tr>
<td>3</td>
<td>None</td>
<td>getProvinceDetails(region-&gt; ?Region:Region; name-&gt; ?Name:Province; ?ProvinceDetails)</td>
</tr>
</tbody>
</table>

**Output Variables**

<table>
<thead>
<tr>
<th>Variable Bindings (For Query 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>?ProvinceDetails</td>
</tr>
<tr>
<td>[WebLink-&gt;“<a href="http://www.bumthang.gov.bt">http://www.bumthang.gov.bt</a>&quot;; Description-&gt;“Bumthang is one of the most attractive touristic province with several festivals throughout the year”; Capital-&gt;Chamkhar:Town; Geography-&gt;[Area-&gt;&quot;1,819 sq.km&quot;; Elevation-&gt;&quot;1,300 to 7300 meters&quot;]; TouristInfo-&gt;[NumAttractions-&gt;16:Integer; NumEvents-&gt;13:Integer; NumAccommodations-&gt;10 :Integer]; Contact-&gt;&quot;<a href="mailto:admbumthang@druknet.bt">admbumthang@druknet.bt</a>&quot;]</td>
</tr>
<tr>
<td>?Region:Region</td>
</tr>
<tr>
<td>Central:Region</td>
</tr>
</tbody>
</table>
5.1.2 Search for Route Details (Input/Output Modes)

<table>
<thead>
<tr>
<th>Query</th>
<th>User Input Values</th>
<th>Query Formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>startPoint endPoint</td>
<td>getRouteDetails(startPoint-&gt; <strong>Chukha:Province</strong>; endPoint-&gt; <strong>Punakha:Province</strong>; ?RouteDetails, ?ShortestRoute)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output Variables</th>
<th>Variable Bindings</th>
</tr>
</thead>
<tbody>
<tr>
<td>?RouteDetails</td>
<td>[[[Chukha, Chuzom, Thimphu, Lobesa, Punakha], 11.2:Real], [[Chukha, Chuzom, Thimphu, Lobesa, WangduePhodrang, Punakha], 11.90:Real]]; numRoutes-&gt;2:Integer]</td>
</tr>
<tr>
<td>?ShortestRoute</td>
<td>[[[Chukha, Chuzom, Thimphu, Lobesa, Punakha], 11.2 : Real]</td>
</tr>
</tbody>
</table>
5.1.2 Search for Route Details (Input/Output Modes)

<table>
<thead>
<tr>
<th>Query</th>
<th>User Input Values</th>
<th>Query Formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>startPoint</td>
<td>getRouteDetails(startPoint-＞Chukha:Province; endPoint-＞Punakha:Province; ?RouteDetails, ?ShortestRoute)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output Variables</th>
<th>Variable Bindings</th>
</tr>
</thead>
<tbody>
<tr>
<td>?RouteDetails</td>
<td>[[[Chukha, Chuzom, Thimphu, Lobesa, Punakha], 11.2:Real], [[Chukha, Chuzom, Thimphu, Lobesa, WangduePhodrang, Punakha], 11.90:Real]]; numRoutes-＞2:Integer]</td>
</tr>
<tr>
<td>?ShortestRoute</td>
<td>[[[Chukha, Chuzom, Thimphu, Lobesa, Punakha], 11.2 : Real]</td>
</tr>
</tbody>
</table>
### 5.1.3 Search for Activity Opportunities (Input/Output Modes)

<table>
<thead>
<tr>
<th>Query</th>
<th>User Input Values</th>
<th>Query Formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>actName</td>
<td>getActivityDetails(actName- &gt; Paro_Tshechu:Events; theme- &gt; ?Theme; address- &gt; ?Address; ?ActivityDetails)</td>
</tr>
<tr>
<td>2</td>
<td>actName: type and/or address element</td>
<td>getActivityDetails(actName- &gt; ?Name: Festivals; theme- &gt; ?Theme; address- &gt; [?Subblock, Chhoekhor:Block, ?Province, ?Region, ?Country]; ?ActivityDetails)</td>
</tr>
<tr>
<td>3</td>
<td>theme and/or address element</td>
<td>getActivityDetails(actName- &gt; ?Name; theme- &gt; Cultural_Religious_Heritage; address- &gt; [?Subblock, ?Block, Paro:Province, ?Region, ?Country]; ?ActivityDetails)</td>
</tr>
<tr>
<td>4</td>
<td>theme actName: type address element</td>
<td>getActivityDetails(actName- &gt; ?Name: Events; theme- &gt; Recreation; address- &gt; [?Subblock, ?Block, ?Province, Southern:Region, ?Country]; ?ActivityDetails)</td>
</tr>
<tr>
<td>5</td>
<td>None</td>
<td>getActivityDetails(actName- &gt; ?Name; theme- &gt; Theme; address- &gt; ?Address; ?ActivityDetails)</td>
</tr>
</tbody>
</table>
5.1.4 Activity Search Result of Query 4

<table>
<thead>
<tr>
<th>Output Variables</th>
<th>Variable Bindings (For Query 4)</th>
</tr>
</thead>
</table>
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

<table>
<thead>
<tr>
<th>Query</th>
<th>User Input Values</th>
<th>Query Formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>accName</td>
<td><code>getAccommodationDetails(accName-&gt; Aman_Resort:Resort; address-&gt; ?Address; setMaxPrice-&gt; ?SetMaxPrice; ?AccommodationDetails)</code></td>
</tr>
<tr>
<td>2</td>
<td>accName:type and/or address element</td>
<td><code>getAccommodationDetails(accName-&gt; ?Name:Guest_house; address-&gt;[Chamkhar:Town, ?Block, ?Province, ?Region, ?Country]; setMaxPrice-&gt; ?SetMaxPrice; ?AccommodationDetails)</code></td>
</tr>
<tr>
<td>3</td>
<td>setMaxPrice and/or address element</td>
<td><code>getAccommodationDetails(accName-&gt; ?Name; address-&gt;[Chamkhar:Town, ?Block, ?Province, ?Region, ?Country]; setMaxPrice-&gt; [Yes, 2000:Real]; ?AccommodationDetails)</code></td>
</tr>
<tr>
<td>4</td>
<td>accName:type setMaxPrice address element</td>
<td><code>getAccommodationDetails(accName-&gt; ?Name:Resort; address-&gt;[Tsento_Shari:Village, ?Block, ?Province, ?Region, ?Country]; setMaxPrice-&gt; [Yes, 1500:Real]; ?AccommodationDetails)</code></td>
</tr>
<tr>
<td>5</td>
<td>None</td>
<td><code>getAccommodationDetails(accName-&gt; ?Name; address-&gt; ?Address; setMaxPrice-&gt; ?SetMaxPrice; ?AccommodationDetails)</code></td>
</tr>
<tr>
<td>Output Variables</td>
<td>Variable Bindings (For Query 4)</td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------</td>
<td></td>
</tr>
<tr>
<td>?AccommodationDetails</td>
<td>[AccName-&gt;Rangen:Resort; WebLink-&gt;&quot;www.rangnen.bt &quot;; Address-&gt;[Tsento_Shari:Village, Tsento:Block, Paro:Province, Western:Region, Bhutan:Country]; Standard-&gt;[StarRating-&gt;2:Real; MinPrice-&gt;1000:Real]; ContactDetails-&gt;[Telecoms-&gt;[Landline-&gt;9758211452; Cell-&gt;97517682948]; Email-&gt;&quot;<a href="mailto:manager@rangen.bt">manager@rangen.bt</a>&quot;]; RelatedTo-&gt;“Holiday_Home:Hotel&quot;]</td>
<td></td>
</tr>
</tbody>
</table>
### Location-centric recommendation by the system

<table>
<thead>
<tr>
<th>Output Variables</th>
<th>Variable Bindings</th>
</tr>
</thead>
<tbody>
<tr>
<td>?Routes</td>
<td>[[Paro, Chuzom, Thimphu], 6.5 :Real], [[Thimphu, Lobesa, Punakha], 4.2:Real]</td>
</tr>
<tr>
<td>?TotalBusHours</td>
<td>8.7:Real</td>
</tr>
</tbody>
</table>
### Table: Evaluation of event-centric travel results

<table>
<thead>
<tr>
<th>Event</th>
<th>Event Schedules</th>
<th>Event Sequences of length ?EventNum= 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tamshingphala_Choepa:Traditional_festival&lt;br&gt; startDate -&gt; date[2008:Real, 10:Real, 08:Real]&lt;br&gt; endDate -&gt; date[2008:Real, 10:Real, 10:Real]&lt;br&gt; province -&gt; Bumthang</td>
<td>1,2&lt;br&gt; 1,5</td>
</tr>
<tr>
<td>2</td>
<td>Tangbi_Mani:Traditional_festival&lt;br&gt; startDate -&gt; date[2008:Real, 10:Real, 13:Real]&lt;br&gt; endDate -&gt; date[2008:Real, 10:Real, 15:Real]&lt;br&gt; province -&gt; Bumthang</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Thimphu_Drupchen:Annual_festival&lt;br&gt; startDate -&gt; date[2008:Real, 10:Real, 04:Real]&lt;br&gt; endDate -&gt; date[2008:Real, 10:Real, 08:Real]&lt;br&gt; province -&gt; Thimphu</td>
<td>3,2&lt;br&gt; 3,4</td>
</tr>
<tr>
<td>4</td>
<td>Thimphu_Tshechu:Annual_festival&lt;br&gt; startDate -&gt; date[2008:Real, 10:Real, 09:Real]&lt;br&gt; endDate -&gt; date[2008:Real, 10:Real, 11:Real]&lt;br&gt; province -&gt; Thimphu</td>
<td>4,2&lt;br&gt; 4,5</td>
</tr>
<tr>
<td>5</td>
<td>Wangdue_Tshechu:Annual_festival&lt;br&gt; startDate -&gt; date[2008:Real, 10:Real, 20:Real]&lt;br&gt; endDate -&gt; date[2008:Real, 10:Real, 29:Real]&lt;br&gt; province -&gt; WangduePhodrang</td>
<td></td>
</tr>
</tbody>
</table>
### 5.3.5 Travel Planning Results (Cont’d)

**Table: Evaluation of event-centric travel results**

<table>
<thead>
<tr>
<th>Event</th>
<th>Event Schedules</th>
<th>Event Sequences of length ?EventNum= 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tamshingphala.Choepa:Traditional_festival startDate-&gt;date[2008:Real,10:Real,08:Real] endDate-&gt;date[2008:Real,10:Real,10:Real] province-&gt;Bumthang</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Tangbi_Mani:Traditional_festival startDate-&gt;date[2008:Real,10:Real,13:Real] endDate-&gt;date[2008:Real,10:Real,15:Real] province-&gt;Bumthang</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Thimphu_Drupchen:Annual_festival startDate-&gt;date[2008:Real,10:Real,04:Real] endDate-&gt;date[2008:Real,10:Real,08:Real] province-&gt;Thimphu</td>
<td>3,4,2,5</td>
</tr>
<tr>
<td>4</td>
<td>Thimphu_Tshechu:Annual_festival startDate-&gt;date[2008:Real,10:Real,09:Real] endDate-&gt;date[2008:Real,10:Real,11:Real] province-&gt;Thimphu</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Wangdue_Tshechu:Annual_festival startDate-&gt;date[2008:Real,10:Real,20:Real] endDate-&gt;date[2008:Real,10:Real,29:Real] province-&gt;WangduePhodrang</td>
<td></td>
</tr>
</tbody>
</table>
5.3.6 Illustration of a Travel Plan (Option 3)

**eTourPlan Travel Planner**

- **s**->[2008.10.01]; **e**->[2008.11.10]
- ?MaxBreak->10;
- ?MinBreak->0;
- ?NumEvents->3

**startPoint**->Paro

**route**->[[Paro, Chuzom, Thimphu], 4.5]

**Endpoint**->Thimphu

**Attraction Recommender**

At event subblock

**On route** if

?TimeGap = S2-E1;
?TimeGap > 5 days

**Event Scheduler**

Date Validation
Route and distance validation

**Route Planner**

*?AllRoutes

[?ShortestRoute, Time]

**Event Locations**

- Provinces
- Routes

**E** Events

**s** startDate

**e** endDate

*Optional

**Domain-specific TourismFactBase**

[S2->[2008.10.09];
 e2->[2008.10.11]]

[S1->[2008.10.04];
 e1->[2008.10.08]]

route->[Thimphu, 0.5]

*route->[Thimphu, Lobesa, Wangdue], 4.7]

**E3**

[S3->[2008.10.20];
 e3->[2008.10.29]]

*route->[Wangdue, Lobesa, Thimphu], 4.7]