DIADEM | domain-centric intelligent automated data extraction methodology

European Research Council

erc

OPAL – Real Understanding of Real Estate Forms

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Diversity in Web Form Design

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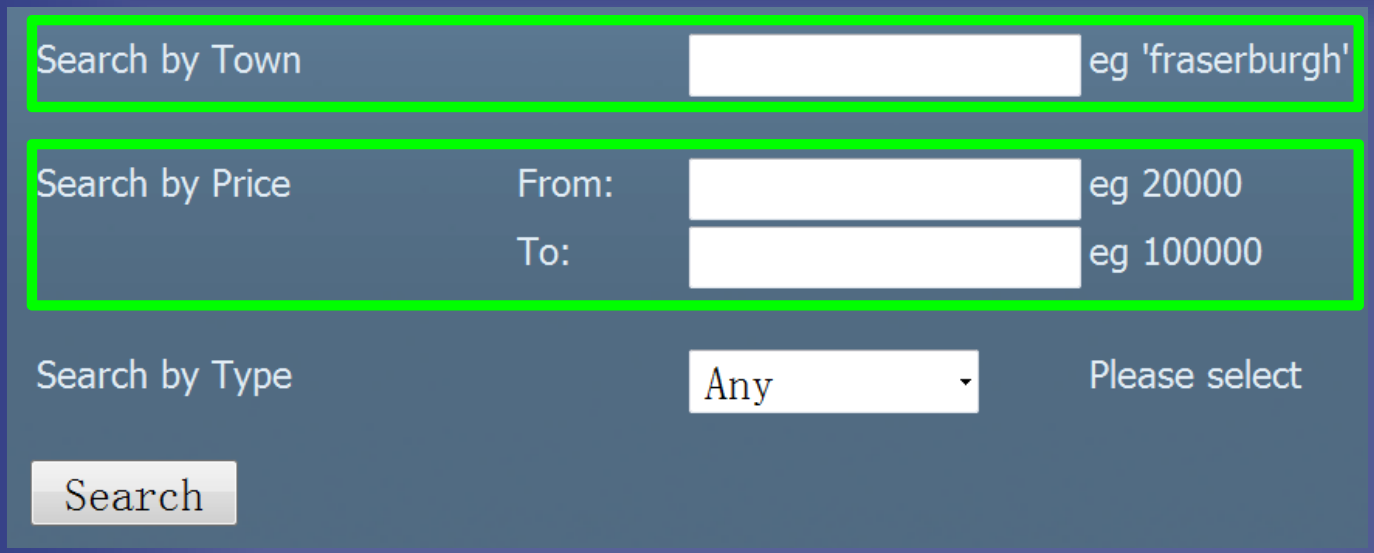
Diversity in Web Form Design



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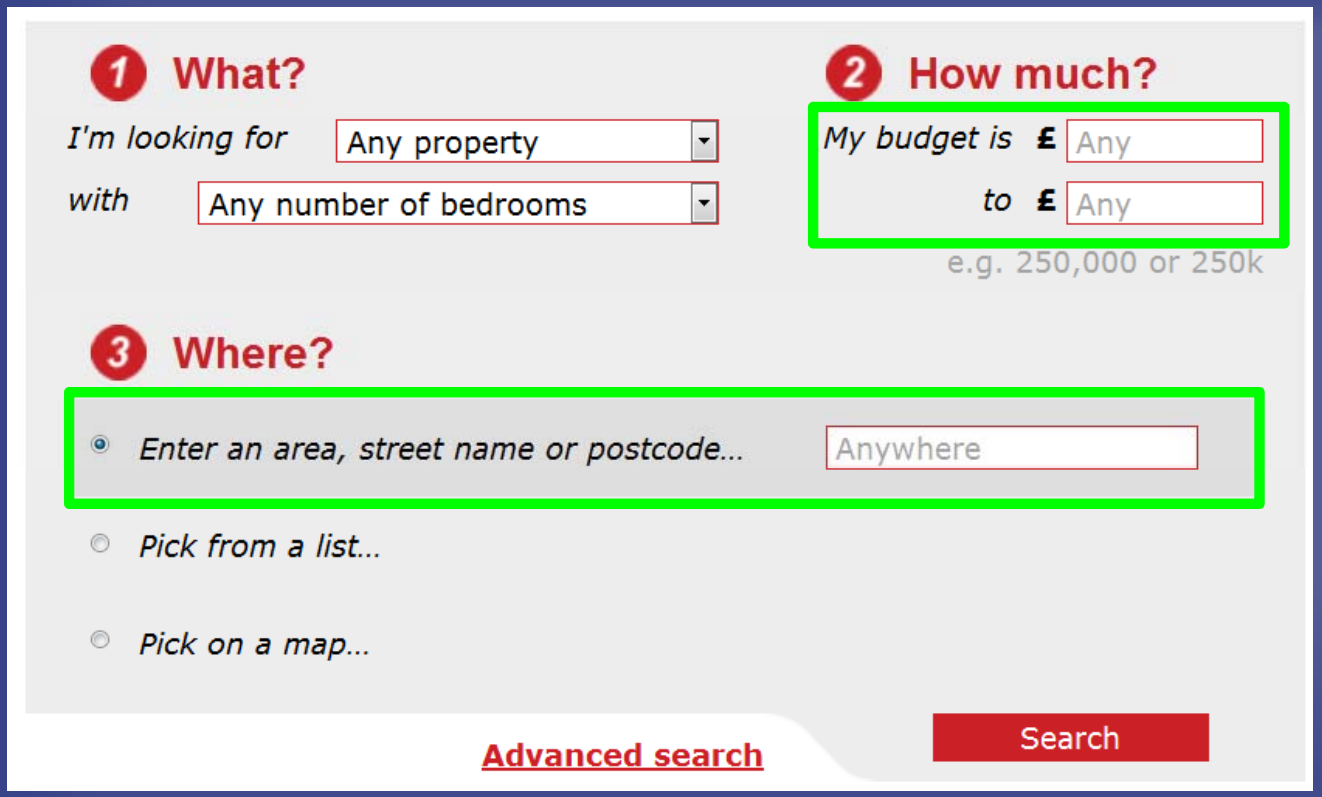
Diversity in Web Form Design



Diversity in Web Form Design

Find a property to buy or rent...

To Buy: ◉ To Rent: ○

Area:
- ○ Nailsea / Backwell
- ○ Portishead / Pill
- ○ Clevedon
- ○ Yatton / Congresbury
- ○ Bristol / Weston-super-mare

Min. beds: Select

Min. price: --- Any Price ---

Max. price: --- Any Price ---

View order: Lowest price first

Find Properties

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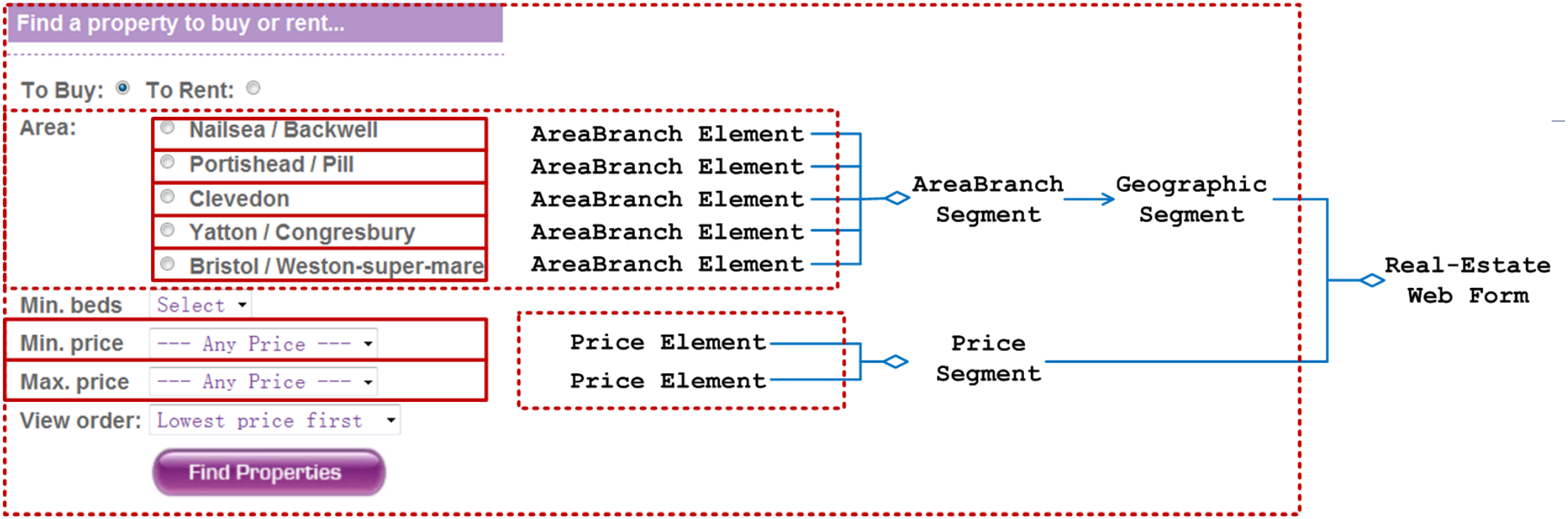
Diversity in Web Form Design



Outline

OPAL – **O**ntology-based web **P**attern **A**nalysis with **L**ogic

- Overview
- Data models and Mappings
  - Browser, Segmentation, Annotation, and Domain Model
  - Segmentation and Phenomenological Mapping
- Analysis and Evaluation
- Future Work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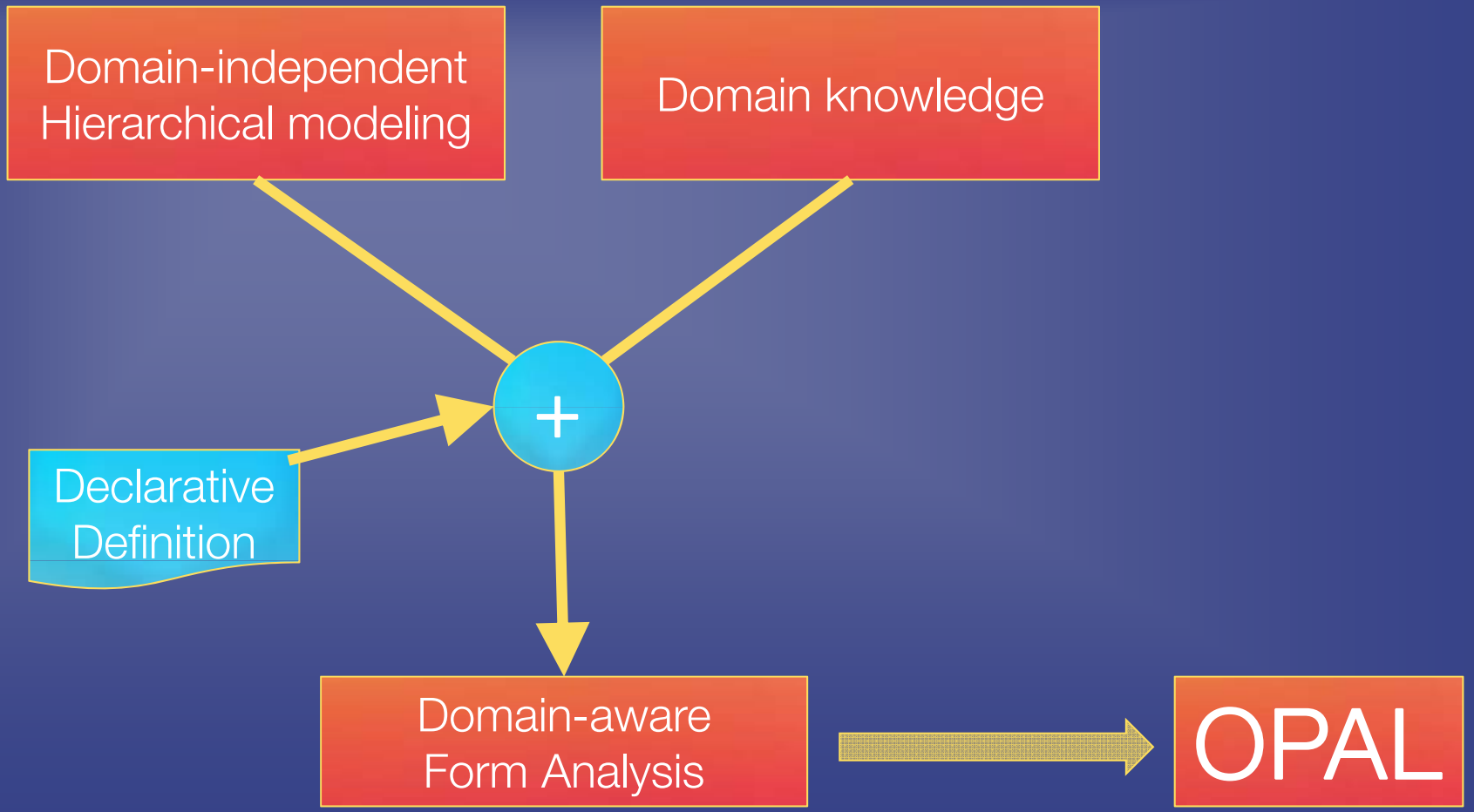
Overview


Domain-independent
Hierarchical modeling
Domain knowledge
+
Declarative
Definition
Domain-aware
Form Analysis
OPAL

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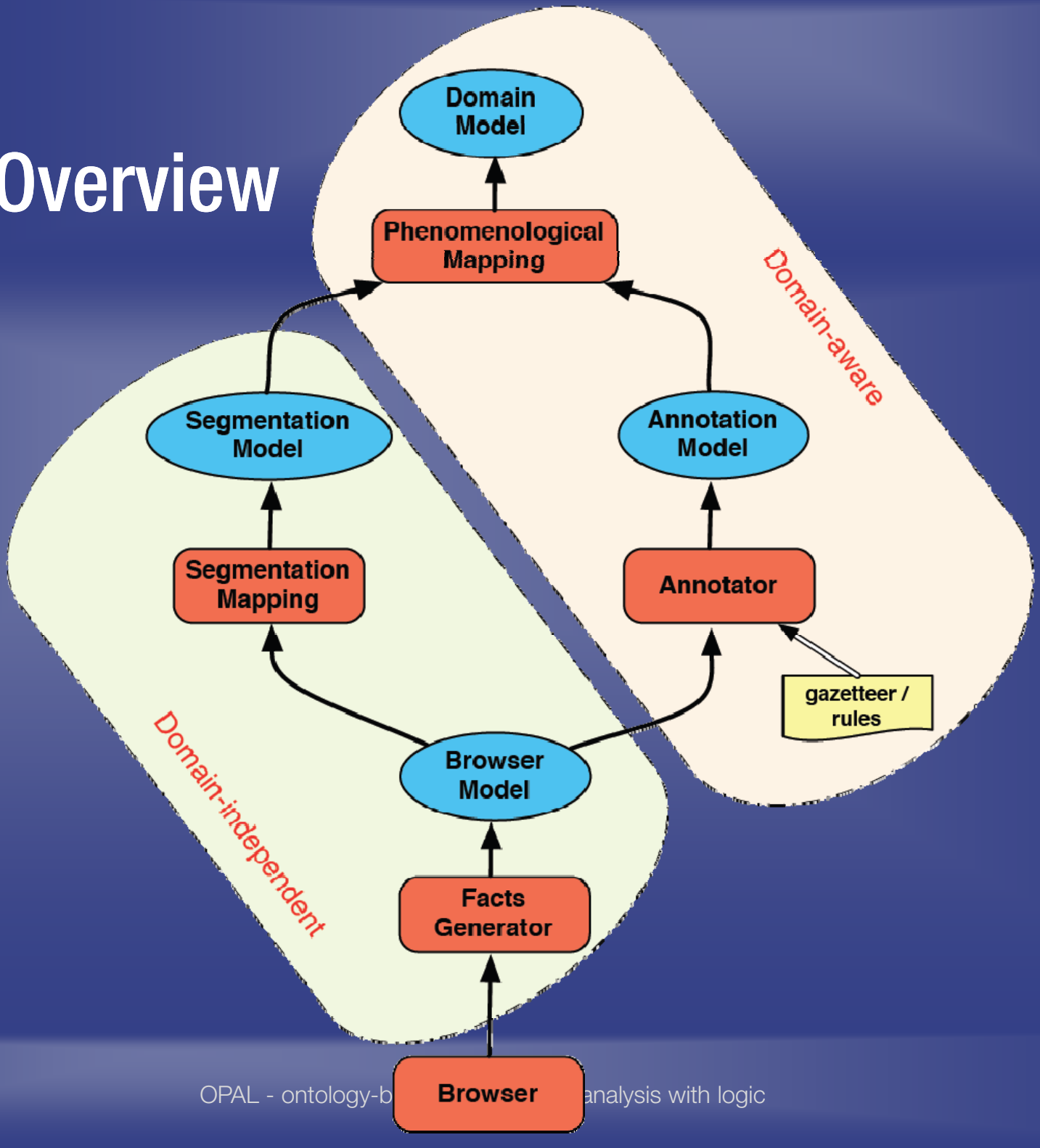
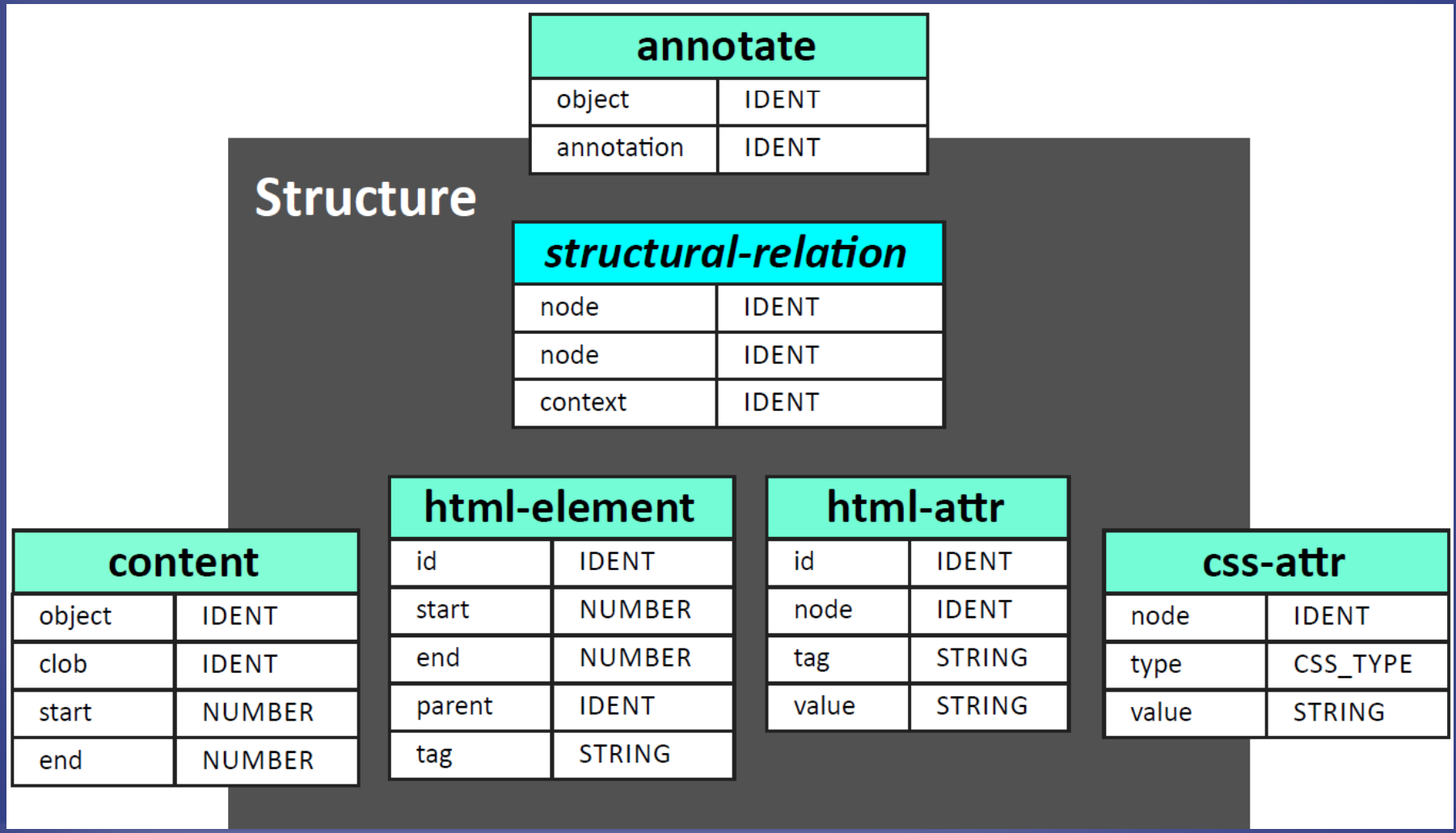
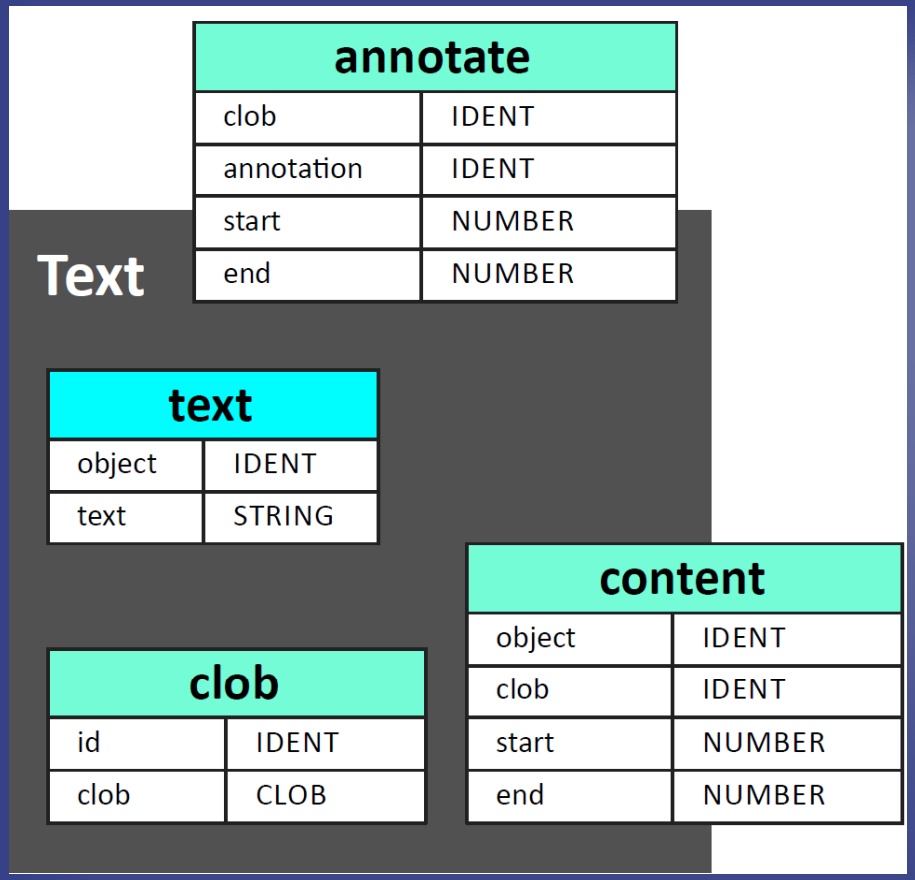
Overview

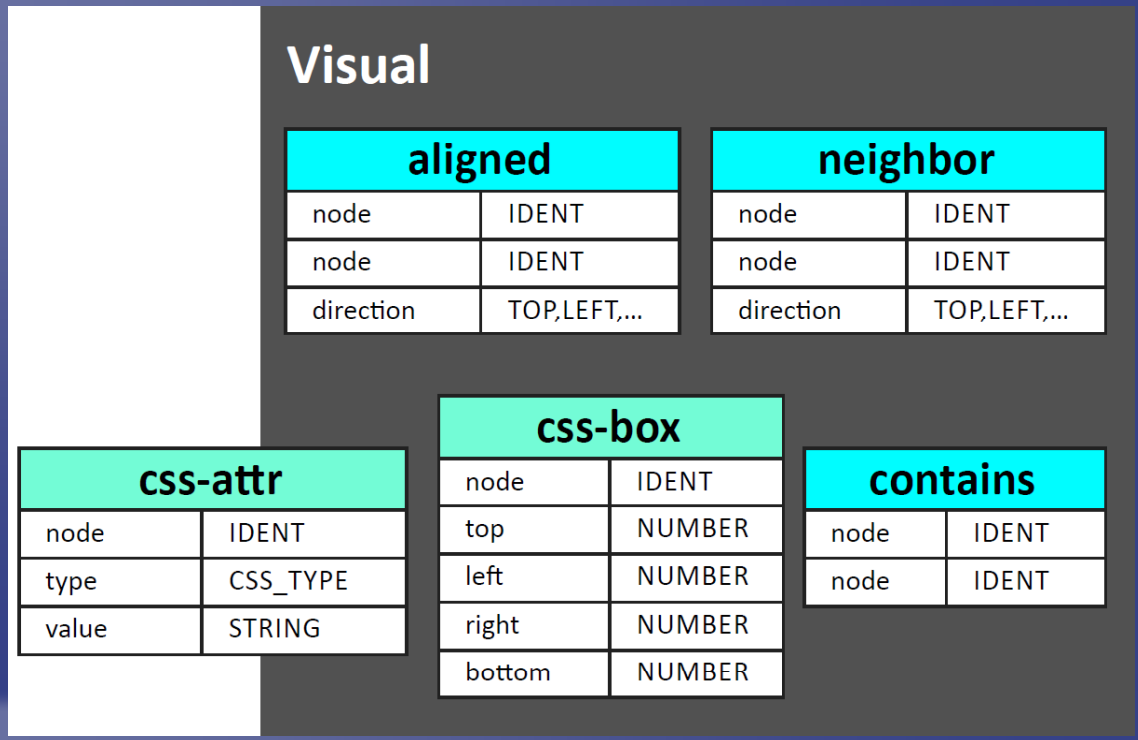


Browser Model



Browser Model





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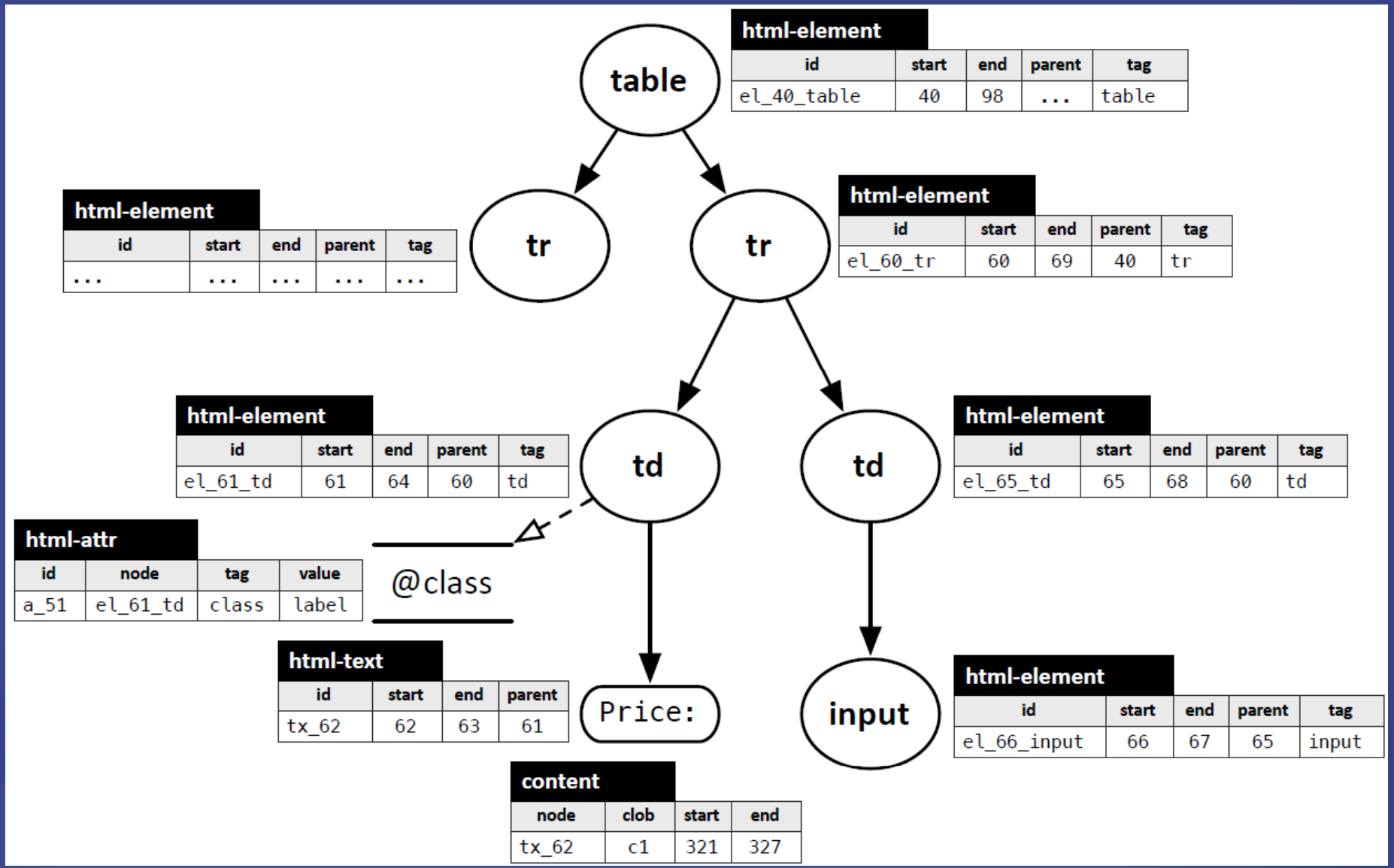
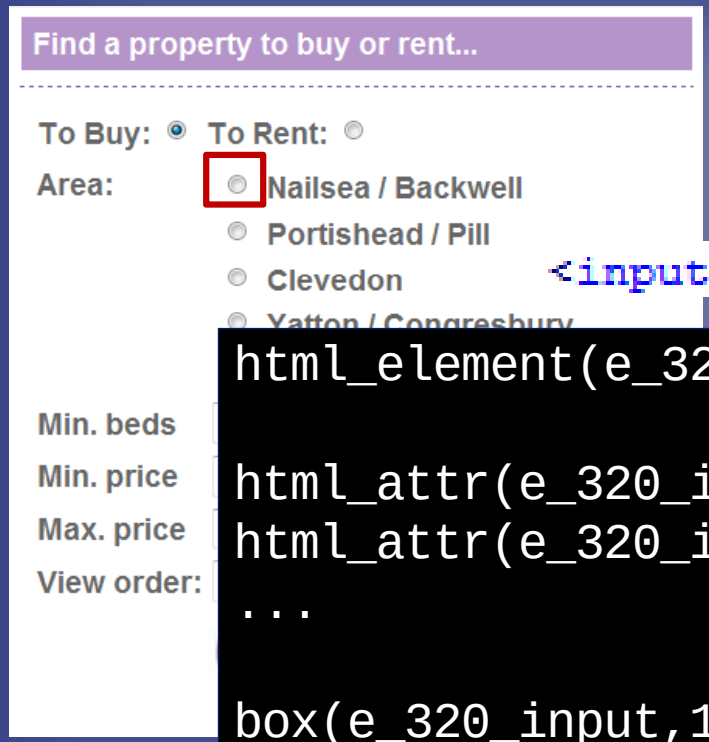
Browser Model



Browser Model




```
<input type="radio" value="nailsea" name="location">
```

```
html_element(e_320_input,320,321,319,input,d1).

html_attr(e_320_input_name,e_320_input,name,"location“,d1).
html_attr(e_320_input_type,e_320_input,type,"radio“,d1).
...

box(e_320_input,106,253,120,267,14,14).

css_attr(e_320_input,bottom,"auto").
css_attr(e_320_input,clear,"none").
css_attr(e_320_input,color,"rgb(0,0,0)").
...
```

Segmentation Model

- grouping of related form elements, e.g. fields, labels
- achieved via Segmentation Mapping, which
  - groups form fields
  - assigns labels to fields and groups

Segmentation Model – groups

- Form elements are grouped if
  - they occur in sequence
  - they have similarities in attribute values or appearances
  - their least common ancestor contains no other elements

```
group(Es) :- similarFieldSequence(Es),
     leastCommonAncestor(A,Es), not hasAdditionalField(A,Es).

leastCommonAncestor(A,Es) :- commonAncestor(A,Es),
     not ( child(C,A), commonAncestor(C,Es) ).

partOf(E,A) :-
     group(Es), member(E,Es), leastCommonAncestor(A,Es).
```

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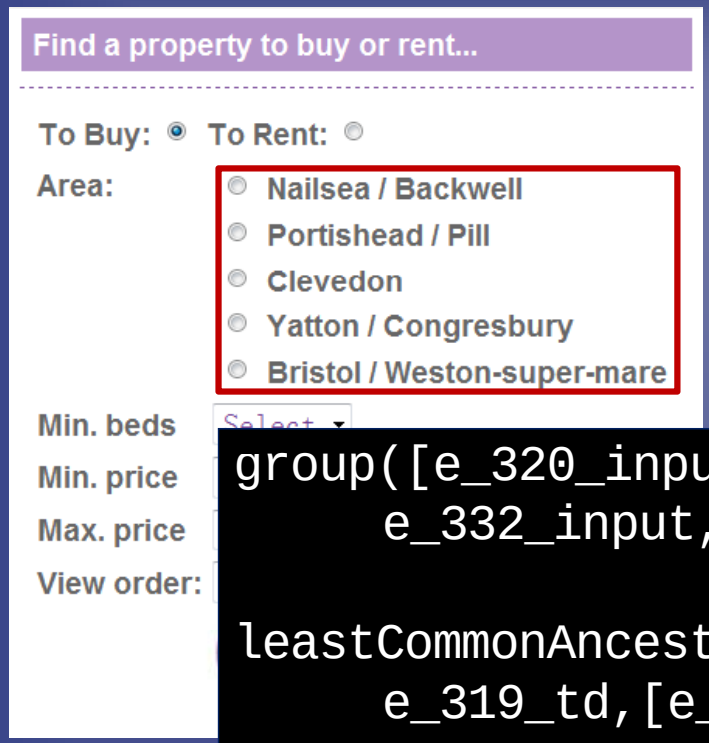
Segmentation Model – groups




```
group([e_320_input,e_326_input,
     e_332_input,e_338_input,e_344_input]).

leastCommonAncestor(
     e_319_td,[e_320_input,e_326_input,...,e_344_input]).

partOf(e_320_input,e_319_td).
partOf(e_326_input,e_319_td).
partOf(e_332_input,e_319_td).
partOf(e_338_input,e_319_td).
partOf(e_344_input,e_319_td).
```

Segmentation Model – labels

- Texts are assigned to fields and groups using
  - Field: HTML <label>, Greatest unique ancestor
  - Segment: Text-field alignment in groups
  - Page: Visual alignment

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Segmentation Model – labels

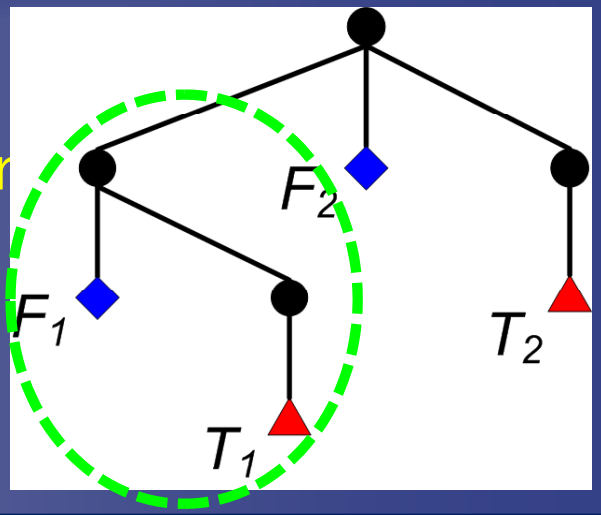
- Texts are assigned to fields and groups using
  - Field: HTML <label>, Greatest unique ancestor
  - Segment: Text-field alignment in groups
  - Page: Visual alignment

```
hasBasicLabel(E,L,T) :-
     html_element(E,_,_,_,input,_),html_attr(_,E,id,ID,_),
     html_element(N,_,_,_,label,_),html_attr(_,N,for,ID,_),
     child(L,N), html_text(L,T,_).
```

```
<input id="srchBuy" class="radio" type
<label for="srchBuy">Buy</label>
```

Segmentation Model – labels

- Texts are assigned to fields and groups using
  - Field: HTML <label>, Greatest unique ancestor
  - Segment: Text-field alignment in groups
  - Page: Visual alignment

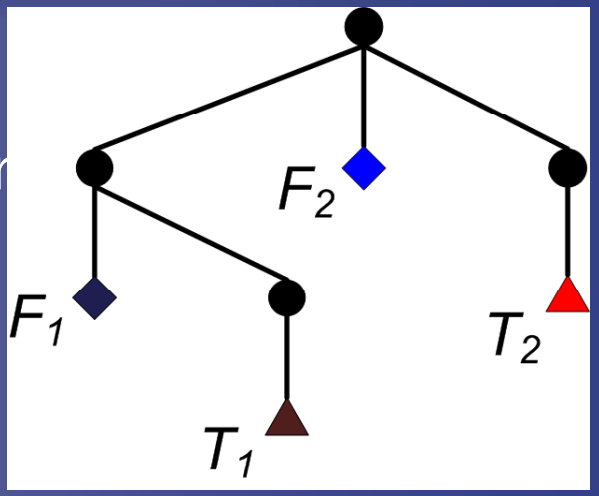



```
greatestUniqueAncestor(A,E) :- uniqueDescendant(E,A),
     not ( parent(P,A), uniqueDescendant(E,P) ).

hasBasicLabel(E,L,T) :-
     group(E), greatestUniqueAncestor(A,E),
     descendant(L,A), html_text(L,T,_).
```

Segmentation Model – labels

- Texts are assigned to fields and groups using
  - Field: HTML <label>, Greatest unique ancestor
  - Segment: Text-field alignment in groups
  - Page: Visual alignment




```
hasLabel(E,L,T) :-
     partOf(E,G), leastCommonAncestor(G,Es), group(Es),
     hasNoLabel(Es), textLists(LLs,G),
     sameLength(Es,LLs),
     labelOneToOne(E,Ls,Es,LLs),
     member(L,Ls),
     html_text(L,T,_).
```

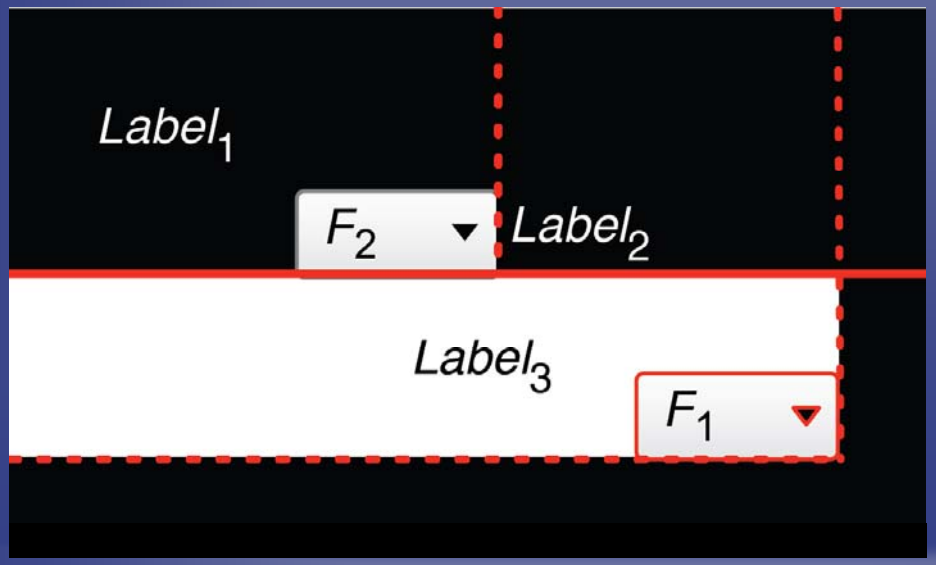
Segmentation Model – labels

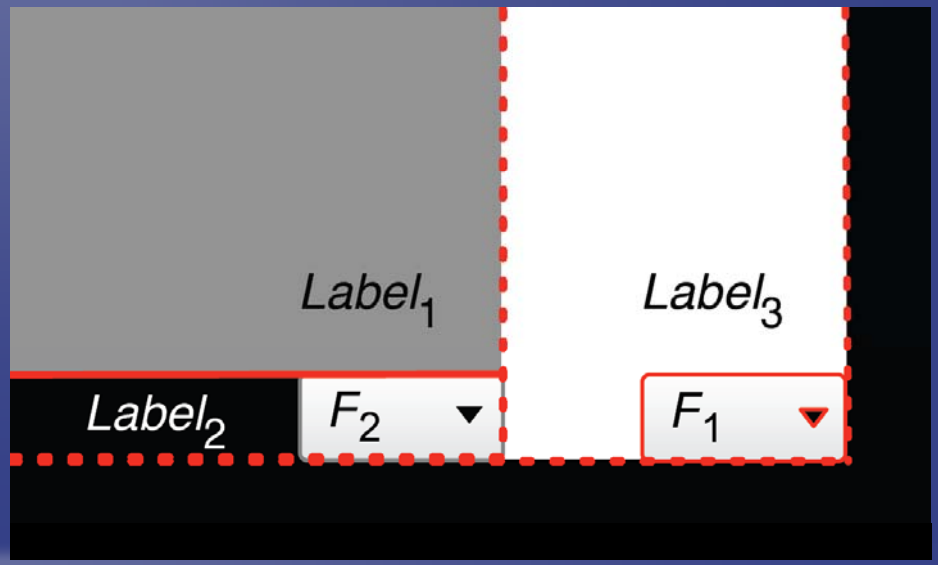
- Texts are assigned to fields and groups using
  - Field: HTML <label>, Greatest unique ancestor
  - Segment: Text-field alignment in groups
  - Page: Visual alignment

```
hasLabel(E,L,LText) :-
     hasTextBox(F,B),
     descendantTextOf(L,B),
     html_text(L,_,_,_,_),
     node_text(L,LText,true)
```

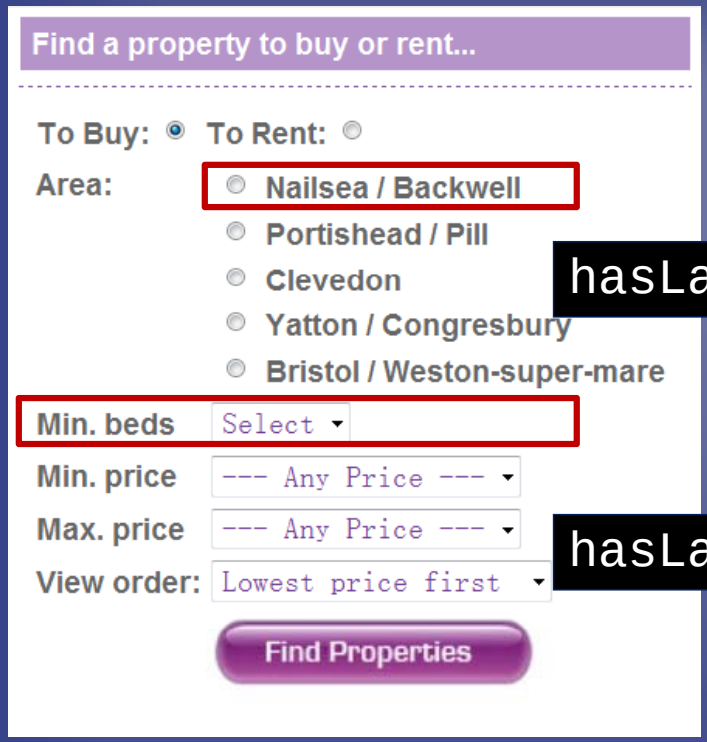
Segmentation Model – labels

- Texts are assigned to fields and groups using
  - Field: HTML <label>, Greatest unique ancestor
  - Segment: Text-field alignment in groups
  - Page: Visual alignment





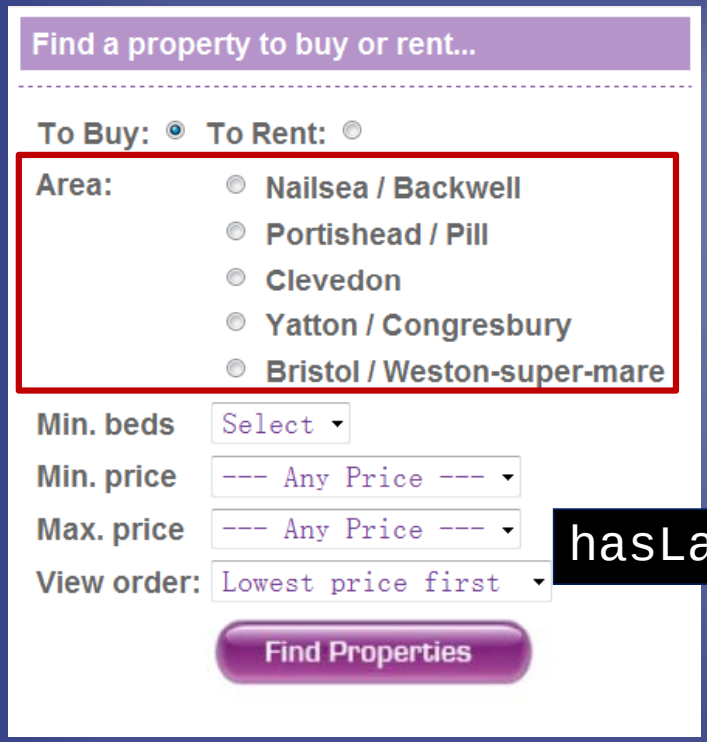
Segmentation Model – labels




```
hasLabel(e_320_input,t_322,"Nailsea / Backwell").
```

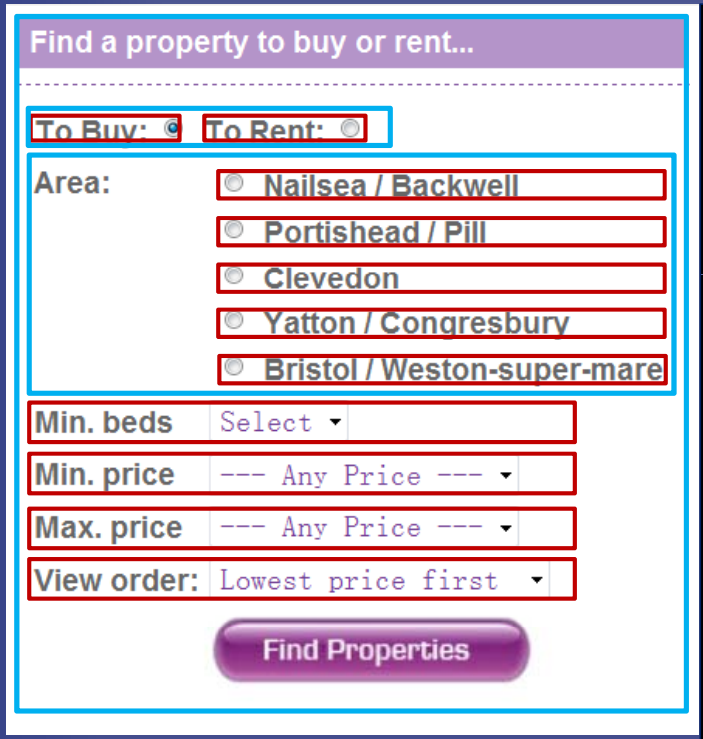
```
hasLabel(e_358_select,t_354,"Min. beds").
```

Segmentation Model – labels




```
hasLabel(e_319_td,t_316,"Area: ").
```

Segmentation Model – labels




```
hasLabel (e_304_input,t_302,"To Buy:").
hasLabel (e_308_input,t_306,"To Rent:").

hasLabel(e_320_input,t_322,"Nailsea / Backwell").
hasLabel(e_326_input,t_328,"Portishead / Pill").
hasLabel(e_338_input,t_340,"Yatton / Congresbury").
hasLabel(e_332_input,t_334,"Clevedon").
hasLabel(e_344_input,t_346,"Bristol / Weston-super-mare").

hasBasicLabel(e_358_select,t_354,"Min Beds").
hasBasicLabel(e_515_select,t_400,"Min Price").
hasBasicLabel(e_705_select,t_594,"Max Price").
hasBasicLabel(e_788_select,t_784,"View Order").

hasLabel(e_319_td,t_316,"Area").
hasLabel(e_297_tbody,t_290,"Find a property to buy or rent…").
```

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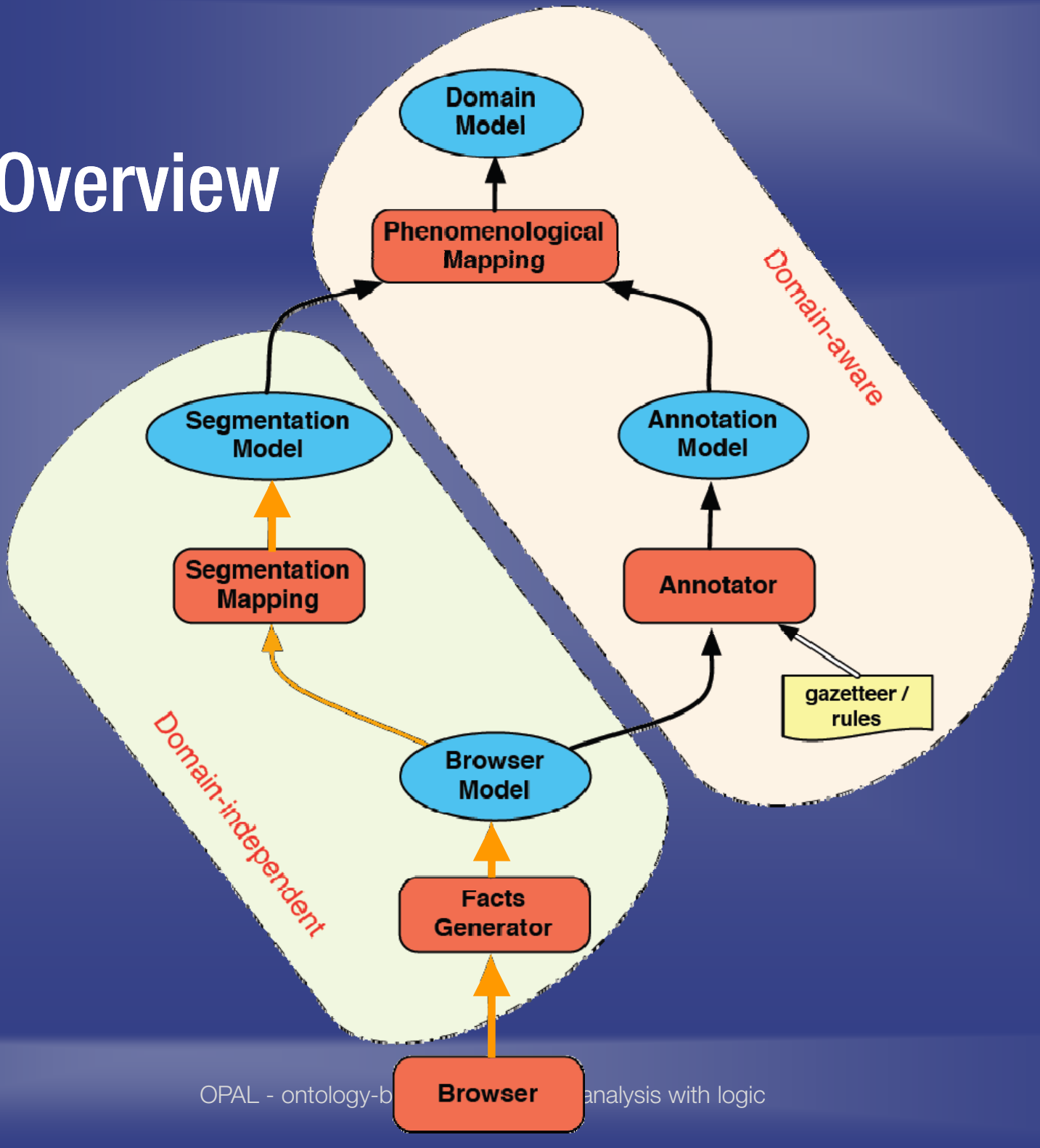
Overview



Annotation Model

- Obtained from Browser model
- Relying on domain-specific knowledge, represents
  - linguistic annotations
  - machine learning based classifications

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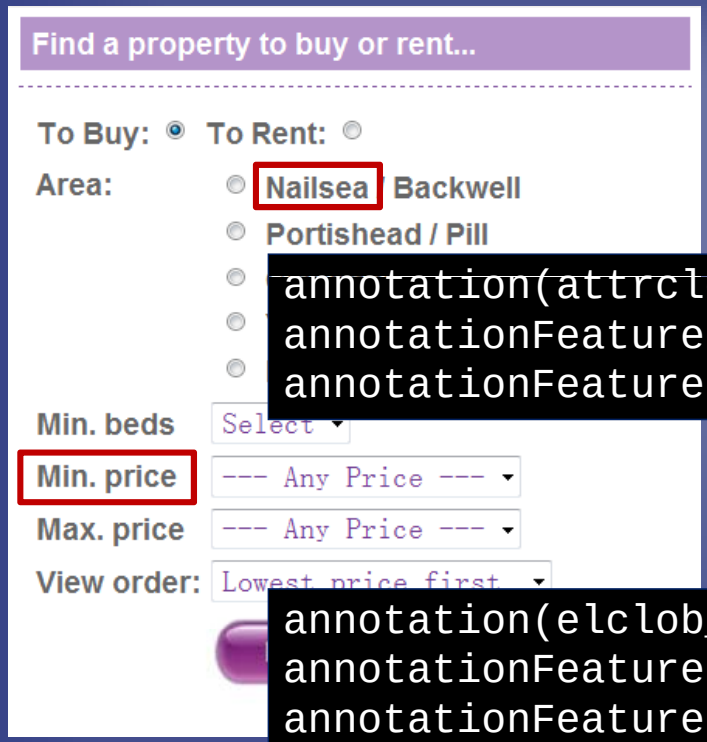
Annotation Model



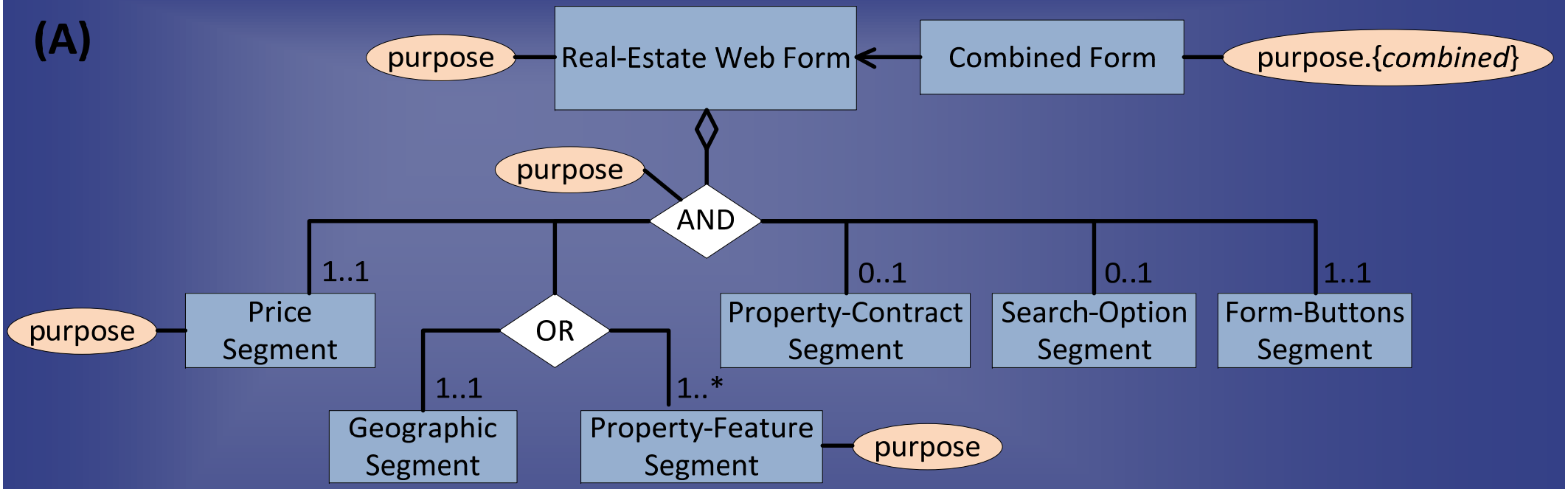

```
annotation(attrclob_d1_5560,attrclob_d1,80,87,"Nailsea").
annotationFeature(attrclob_d1_5560,"majorType","location").
annotationFeature(attrclob_d1_5560,"minorType","district_county_etc").
```

```
annotation(elclob_d1_1707,elclob_d1,2028,2038,"Min. price").
annotationFeature(elclob_d1_1707,"modifier","min").
annotationFeature(elclob_d1_1707,"minorType","price").
annotationFeature(elclob_d1_1707,"majorType","reform.label").
```

Domain Model

- Describes conceptual entities on forms as in domain ontology
- Achieved via phenomenological mapping, which
  - correlates labels with annotations
  - classifies form elements

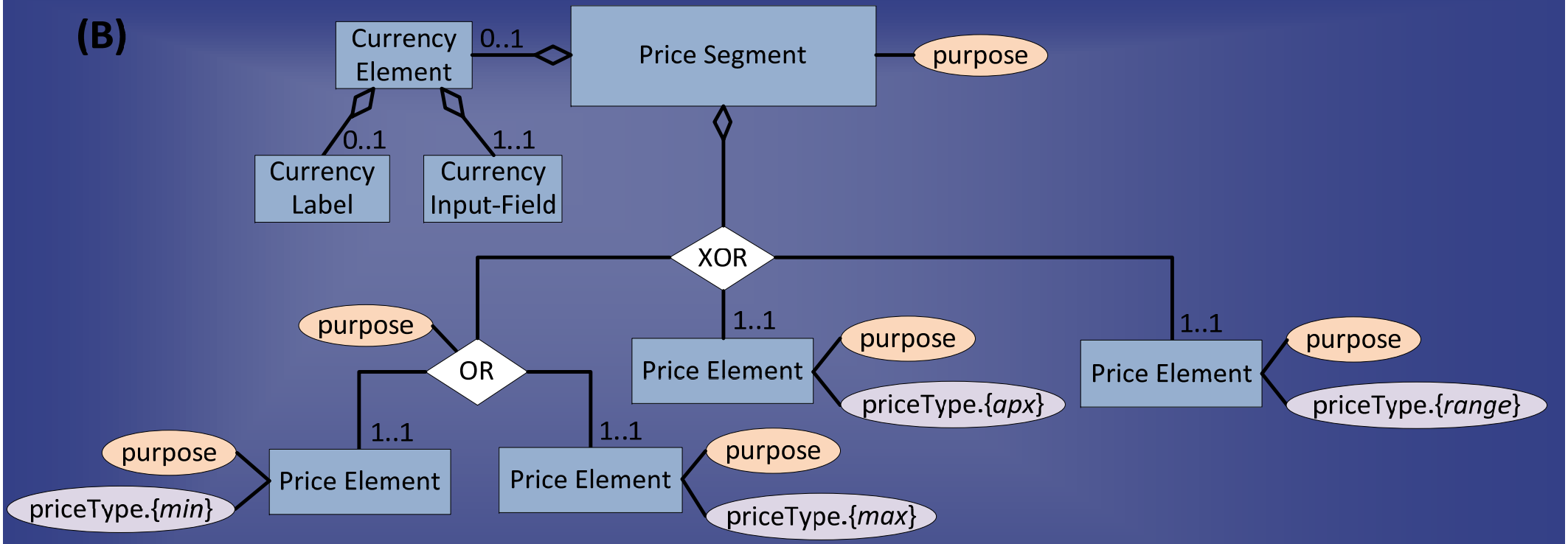
Domain Model – Ontology



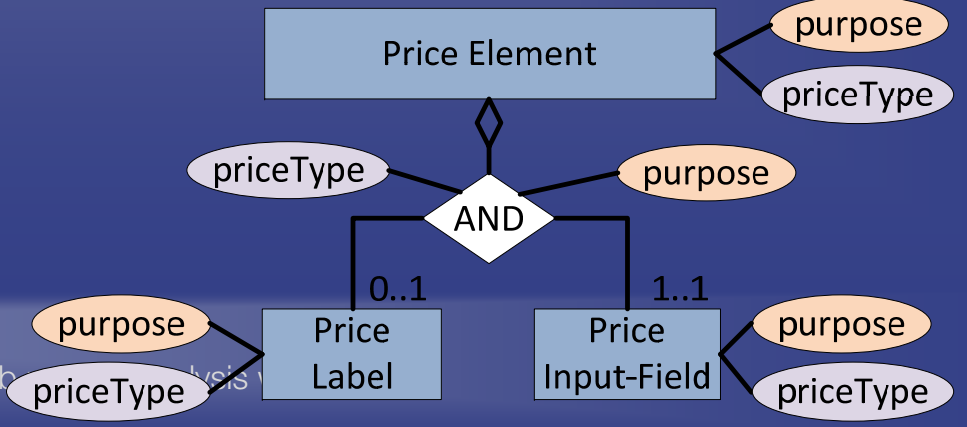
purpose={buy, rent, combined}

Domain Model – Ontology

(B)



priceType={min, max, approximate, range}



Domain Model – Classification

- Form elements are annotated as follows

```
hasAnnotation(E,A) :-
      hasLabel(E,_,T),
      annotation(Aid,_,_,_,T),
      annotationFeature(Aid,_,Anno).
```

- Form elements are classified with Concept C

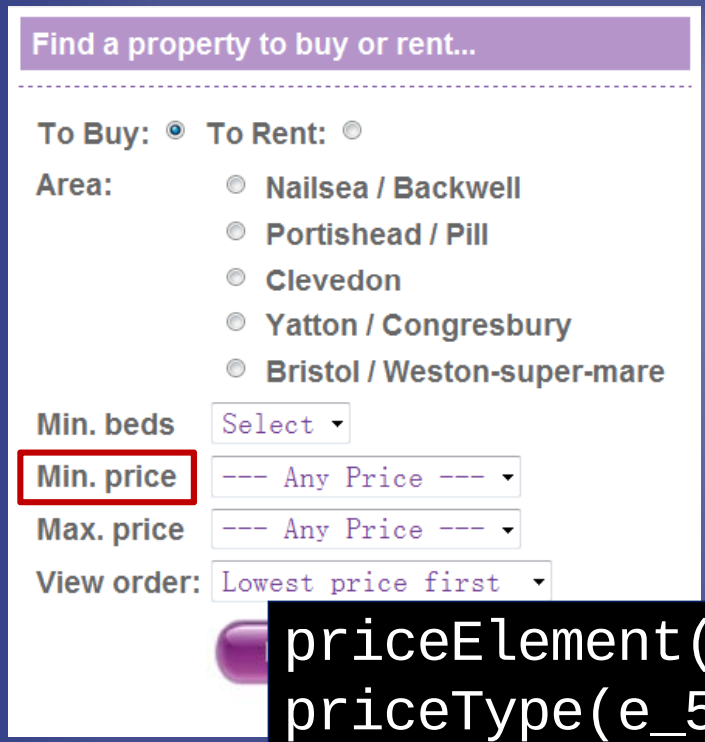
```
C(X) :- leafSegment(X), hasAnnotation(X,A), Clabel(A).
```

- and Facets C_F

```
C_F(X,F) :- C(X), hasAnnotation(X,F), C_FLabel(F).

C_F(X,F) :- C(X), hasValueAnnotation(X,F), C_FValue(F)
```

Domain Model – Classification




```
priceElement(e_515_select,e_286_form).
priceType(e_515_select,"min").
```

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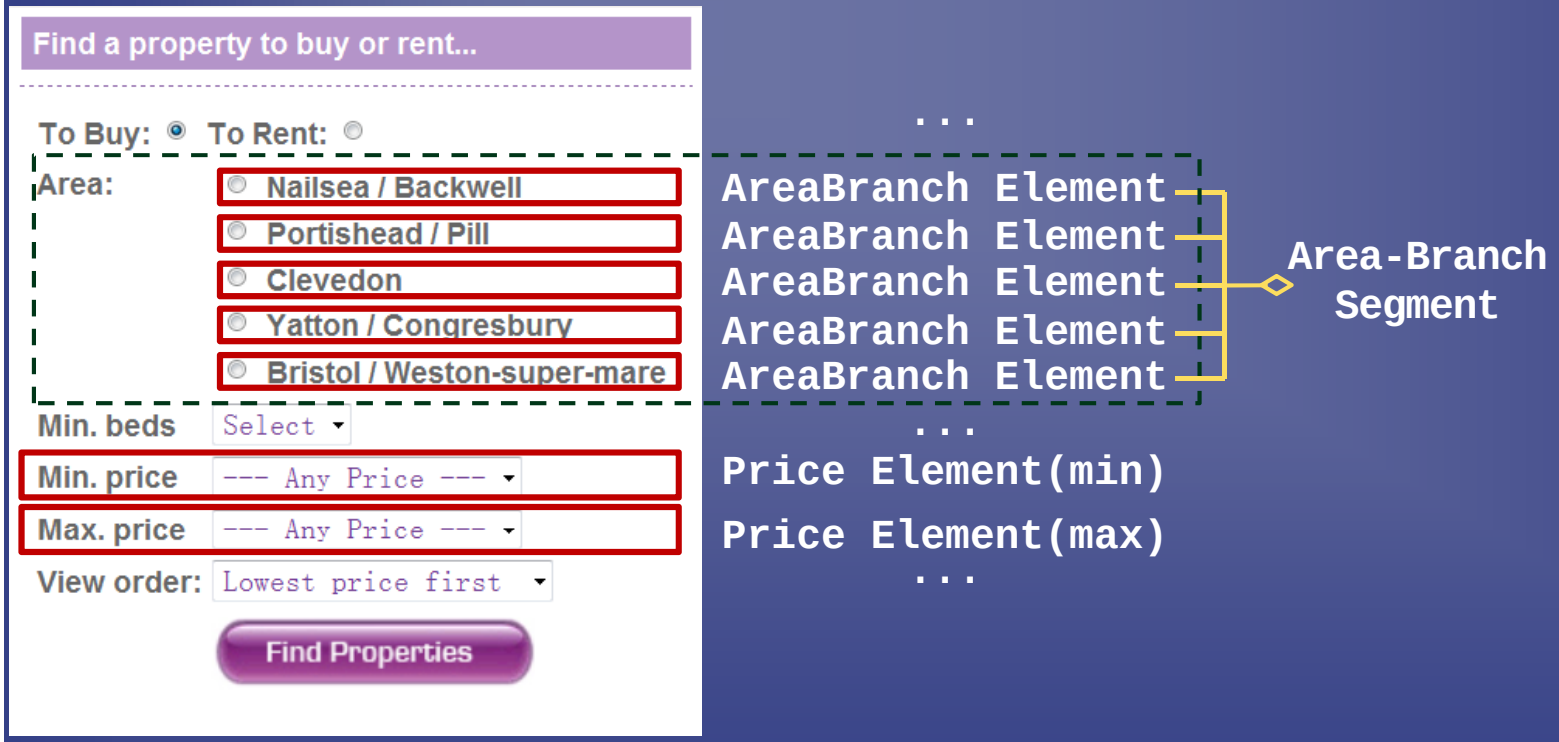
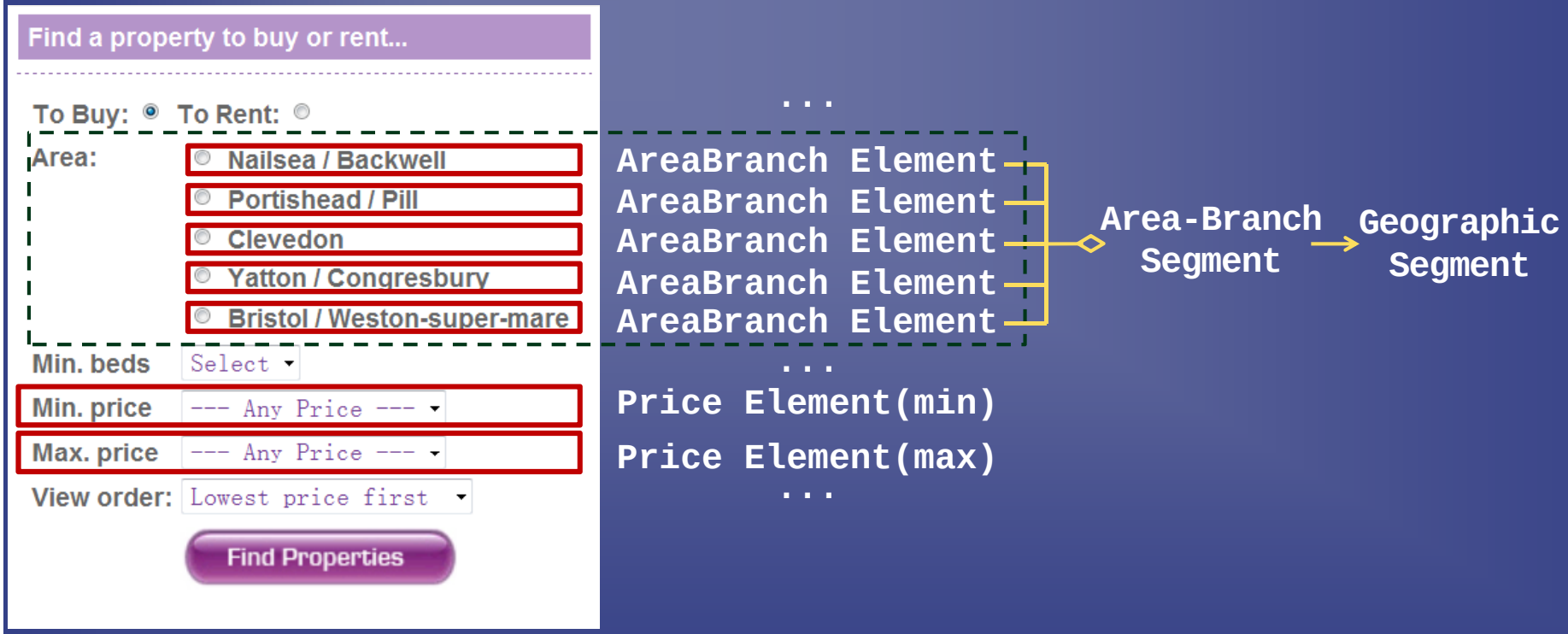
Domain Model


```
...
AreaBranch Element
AreaBranch Element
AreaBranch Element
AreaBranch Element
AreaBranch Element
...
Price Element(min)
Price Element(max)
...
```

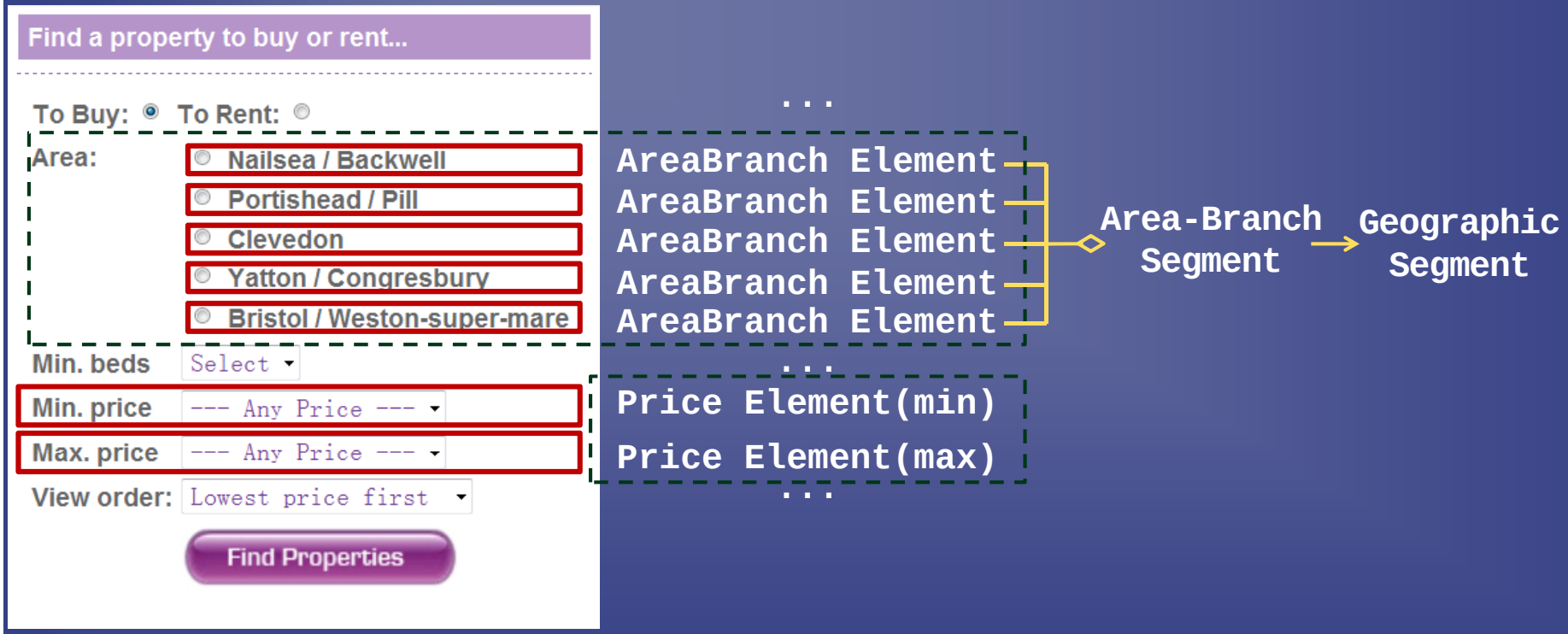
Domain Model



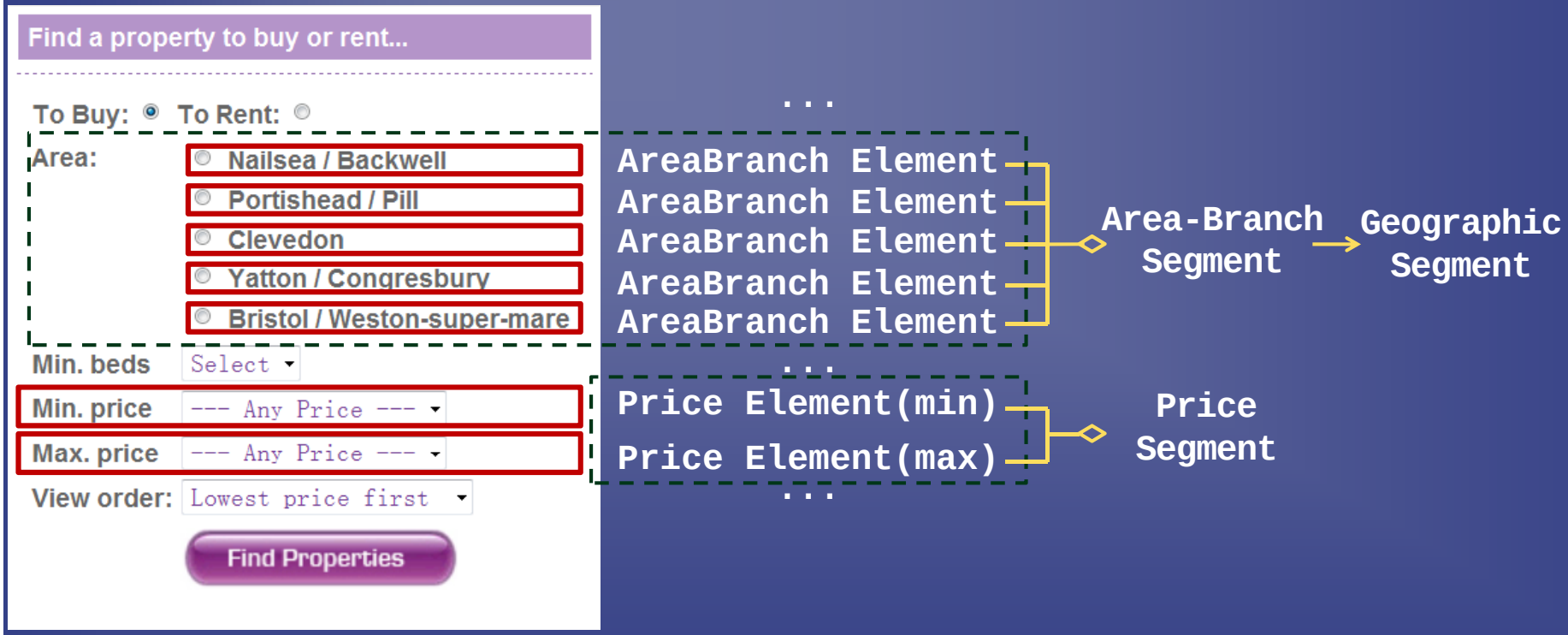
Domain Model



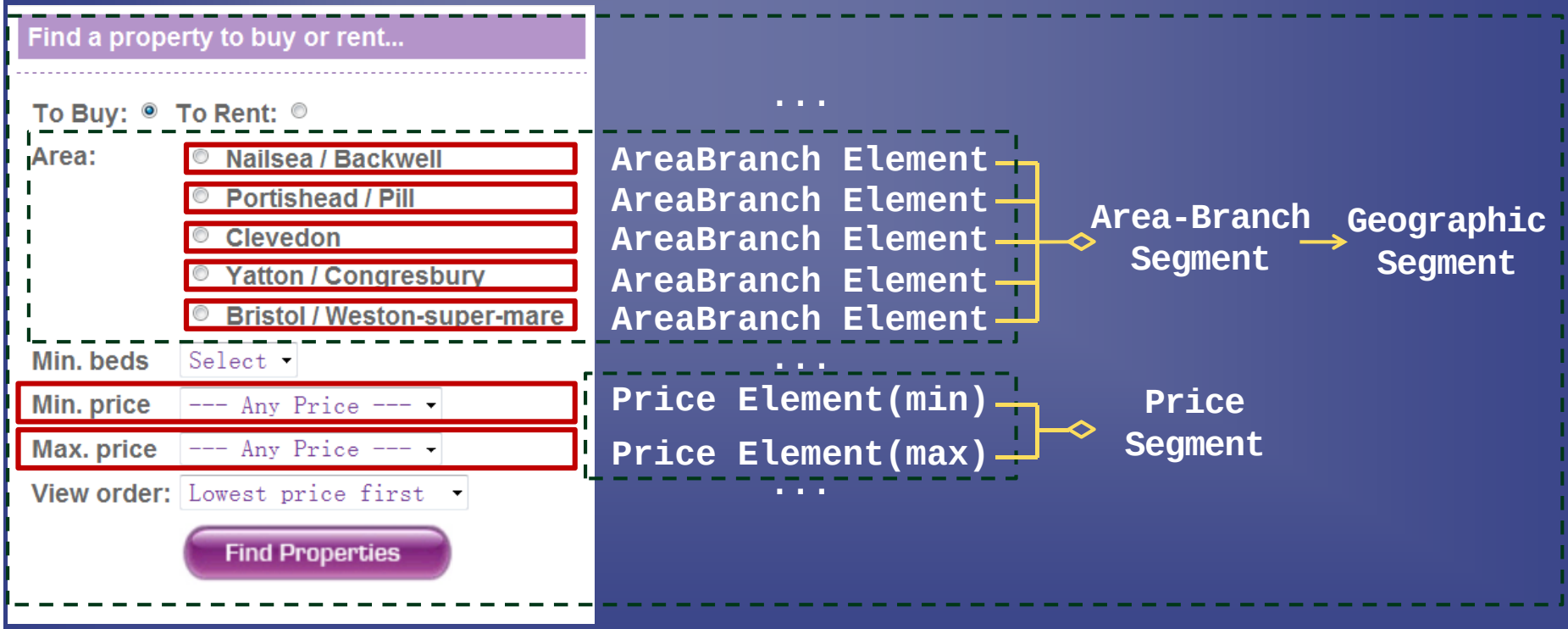
Domain Model



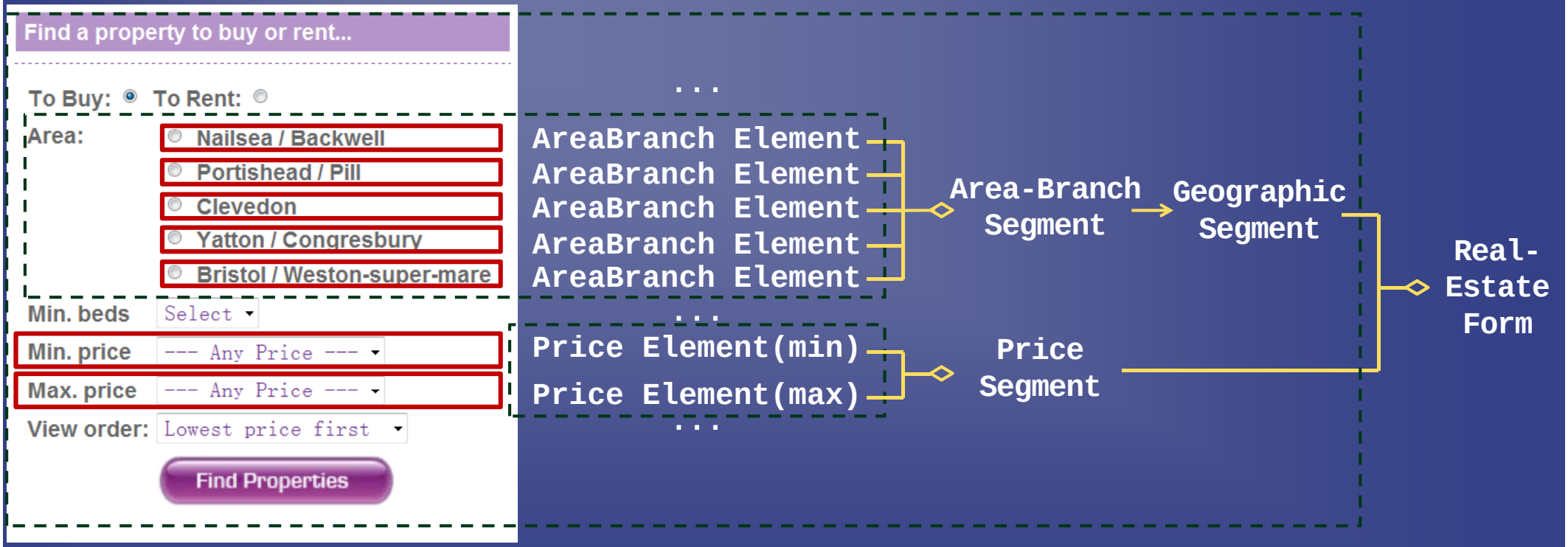
Domain Model



Domain Model



Domain Model



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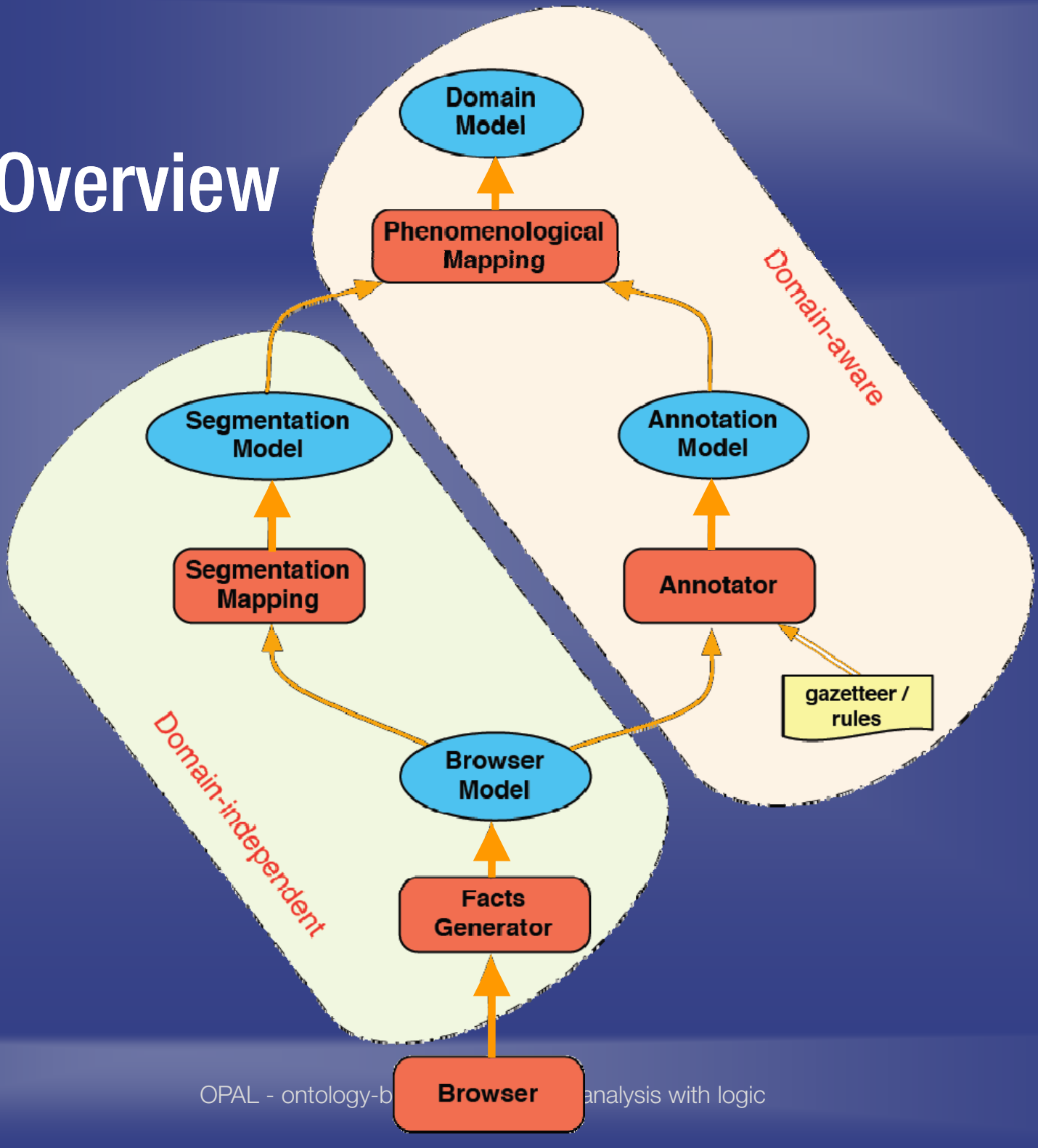
Overview



Analysis and Evaluation

- UK Real Estate Domain
  - 50 domain web forms (sampled from over 2800)
  - Tested Domain-independent and Domain-aware

DIADEM

- Real-Estate

url	form elements total	form elements found(%)	form elements labeled(%)	form segments total	form segments found
rodgersestates.com	8	100.00	100.00	1	✓
bspokeproperty.com	4	100.00	100.00	0	✓
dreweryandwheeldon.co.uk	5	100.00	100.00	0	✓
nicholasestates.co.uk	6	100.00	100.00	0	✓
wilkie.co.uk/main.htm	7	100.00	100.00	0	✓
harveyrobinson.co.uk	6	83.33	83.33	0	✓
henrygeorgeestates.co.uk	9	100.00	100.00	3	✓
dawsonsproperty.co.uk	23	100.00	100.00	6	✓
knightfrank.com	2	100.00	100.00	0	✓
all about homes.co.uk	5	100.00	100.00	0	✓
carlisleandborder.com	6	100.00	100.00	0	✓
bernadetteharris.co.uk	7	100.00	100.00	2	✓
harmony-homes.co.uk	6	100.00	100.00	0	✓
kippencampbell.co.uk	3	100.00	100.00	0	✓
jimmcmillan.co.uk	10	100.00	100.00	5	✓
huwtudor.co.uk					
tspc.co.uk					
stewartwatson.co.uk					
morganyork.co.uk					
robsoncarter.co.uk					
clearwateruk.net					
johnhoole.co.uk					
hi-m.co.uk	6	100.00	100.00	1	1 missed
qualityhomes.co.uk	13	100.00	100.00	5	✓
bychoice.co.uk	7	100.00	100.00	0	✓
rowelluk.com	9	100.00	77.78	2	1 missed
nicktart.com	17	100.00	100.00	4	✓
lawsonsestateagents.co.uk	5	100.00	100.00	1	✓
christopherbice.co.uk	7	100.00	100.00	1	✓
finders.co.uk	8	100.00	100.00	2	✓
andrewsonline.co.uk	7	100.00	100.00	0	✓
vebra.com	6	100.00	100.00	1	✓
ankerandpartners.co.uk	4	75.00	75.00	0	✓
babingtons.co.uk	5	100.00	100.00	0	✓
bairstoweves.co.uk	2	50.00	50.00	0	✓
cjhole.co.uk	7	100.00	100.00	3	✓
heritage4homes.co.uk	11	100.00	100.00	1	✓
besleyhill.co.uk	5	100.00	100.00	1	✓
countryproperty.co.uk	8	100.00	100.00	0	✓
chestertonhumberts.com	15	100.00	100.00	3	✓
edisonfordproperty.co.uk	5	100.00	100.00	0	✓
edwards-online.co.uk	7	100.00	100.00	1	✓
bruntandfussell.co.uk	5	100.00	100.00	1	✓
geoffreysmith.org	5	80.00	80.00	0	✓
sequencehome.co.uk	7	100.00	100.00	1	✓
hootons.co.uk	14	100.00	100.00	3	✓
lettingzed.co.uk	7	100.00	100.00	0	✓
houseandco.co.uk	13	92.31	84.62	6	✓
		97.61% average precision	96.68%		93.33% correct segmentation

Domain independent

Form Fields		Form Segments
found	labeled	correct segmentation
97.61%	96.68%	93.33%

DIADEM

- Real-Estate

	form fields			form groups	
url	total	found(%)	labeled(%)	total	found(%)
rodgersestates.com	8	100.00	100.00	1	v
bspokeproperty.com	4	100.00	100.00	0	v
dreweryandwheeldon.co.uk	5	100.00	100.00	0	v
nicholasestates.co.uk	6	100.00	100.00	0	v
wilkie.co.uk/main.htm	7	100.00	100.00	0	v
harveyrobinson.co.uk	6	100.00	100.00	0	v
henrygeorgeestates.co.uk	9	100.00	100.00	3	v
dawsonsproperty.co.uk	23	100.00	100.00	6	v
knightfrank.com	2	100.00	100.00	0	v
all-about-homes.co.uk	5	100.00	100.00	0	v
carlisleandborder.com	6	100.00	100.00	0	v
bernadetteharris.co.uk	7	100.00	71.43	2	v
harmony-homes.co.uk	6	100.00	100.00	0	v
kippencampbell.co.uk	3	100.00	100.00	0	v
[illegible]					
huwtudor.co.uk					
tspc.co.uk					
stewartwatson.co.uk					
morganyork.co.uk					
robsoncarter.co.uk					
clearwateruk.net					
johnhoole.co.uk	8	100.00	100.00	1	v
hi-m.co.uk	6	100.00	83.33	1	v
qualityhomes.co.uk	13	100.00	100.00	5	v
bychoice.co.uk	7	100.00	100.00	0	v
rowelluk.com	9	100.00	77.78	4	2 missed
nicktart.com	17	100.00	100.00	4	v
lawsonsestateagents.co.uk	5	100.00	100.00	1	v
christopherbice.co.uk	7	100.00	100.00	1	v
finders.co.uk	8	100.00	100.00	2	v
andrewsonline.co.uk	7	100.00	100.00	0	v
[illegible]					
bairstoweves.co.uk					
cjhole.co.uk					
heritage4homes.co.uk					
besleyhill.co.uk					
countryproperty.co.uk					
chestertonhumberts.com					
edisonfordproperty.co.uk	5	100.00	100.00	0	v
edwards-online.co.uk	7	100.00	100.00	1	v
bruntandfussell.co.uk	5	100.00	100.00	1	v
geoffreysmith.org	5	100.00	100.00	0	v
sequencehome.co.uk	7	100.00	100.00	1	v
hootons.co.uk	14	100.00	100.00	3	v
lettingzed.co.uk	7	100.00	100.00	0	v
houseandco.co.uk	12	100.00	91.67	6	v

Domain independent	Form Fields		Form Segments
	found	labeled	correct segmentation
	97.61%	96.68%	93.33%

Domain aware	Form Fields		Form Segments
	found	labeled	correct segmentation
	100.00%	97.28%	95.31%

100.00	97.28	95.31
average precision		correct segmentation

Conclusion and Future Work

- Improve structural segmentation
  - Visual segmentation and labeling
  - Ontology guided segmentation
- Accelerate domain adaption
  - Calling for machine learning for ontology creation
- Enhance ambiguity resolution
  - Necessitating probabilistic logic in the future
- Interactive form filling / probing

Thank you very much !