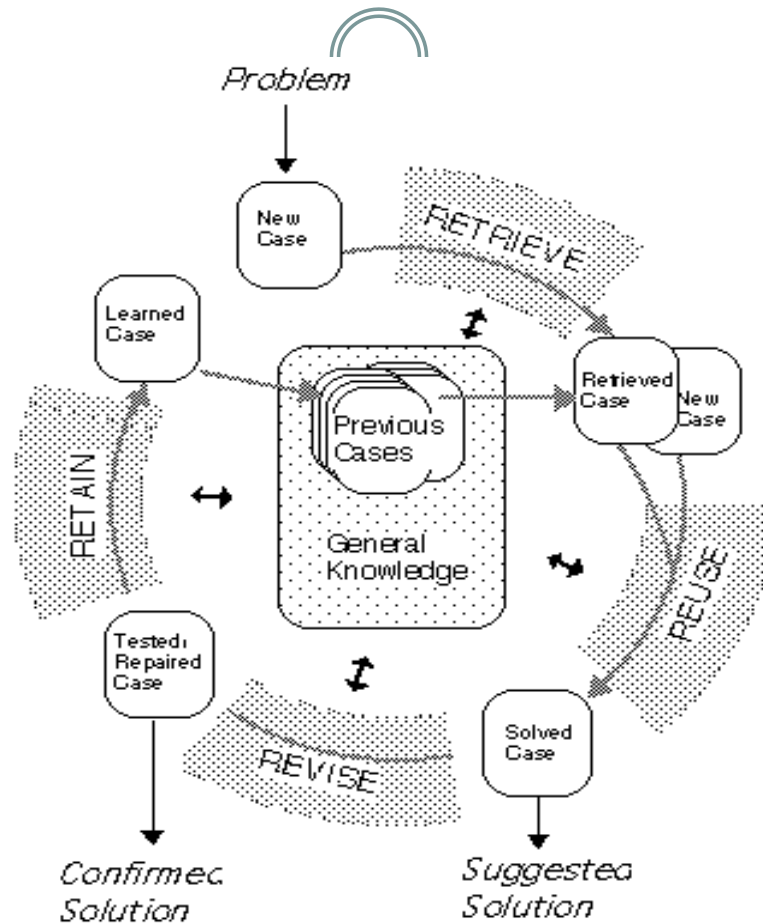


Foundations of Artificial Intelligence



Case Based Reasoning

Case Based Reasoning



An Example

<i>Tid</i>	Refund	Marital Status	Taxable Income	Cheat
1	Yes	Single	125K	No
2	No	Married	100K	No
3	No	Single	70K	No
4	Yes	Married	120K	No
5	No	Divorced	95K	Yes
6	No	Married	60K	No
7	Yes	Divorced	220K	No
8	No	Single	85K	Yes
9	No	Married	75K	No
10	No	Single	90K	Yes

class

Refund	Marital Status	Taxable Income	Cheat
No	Single	75K	?
Yes	Married	50K	?
No	Married	150K	?
Yes	Divorced	90K	?
No	Single	40K	?
No	Married	80K	?

Experts:
- Rules: data mining
- Cases: CBR

Case Based Reasoning



Objectives

Show how CBR works.

To introduce the basic components of CBR systems.

Demonstrate some examples of CBR.

Case Based Reasoning

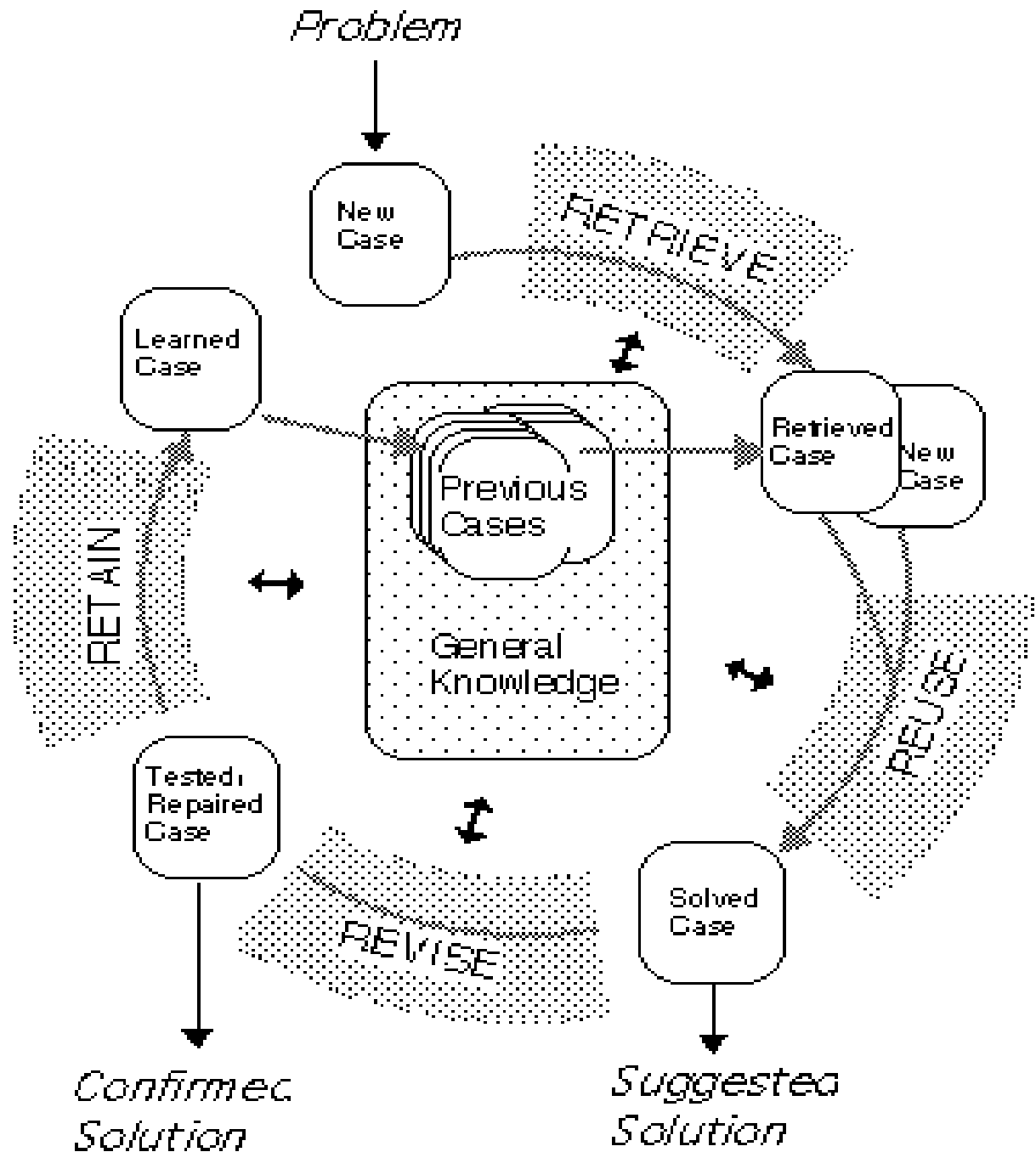
What is CBR?

- Reasoning that adapts previous solutions for similar problem in solving new problem in hand
 - Many problem decision makers encountered are similar to old cases
 - Often more efficient to start with the previous solution to a similar problem than to generate the entire solution again from scratch
 - Experts solve problem based on previous cases
 - Court legal cases, etc

Case

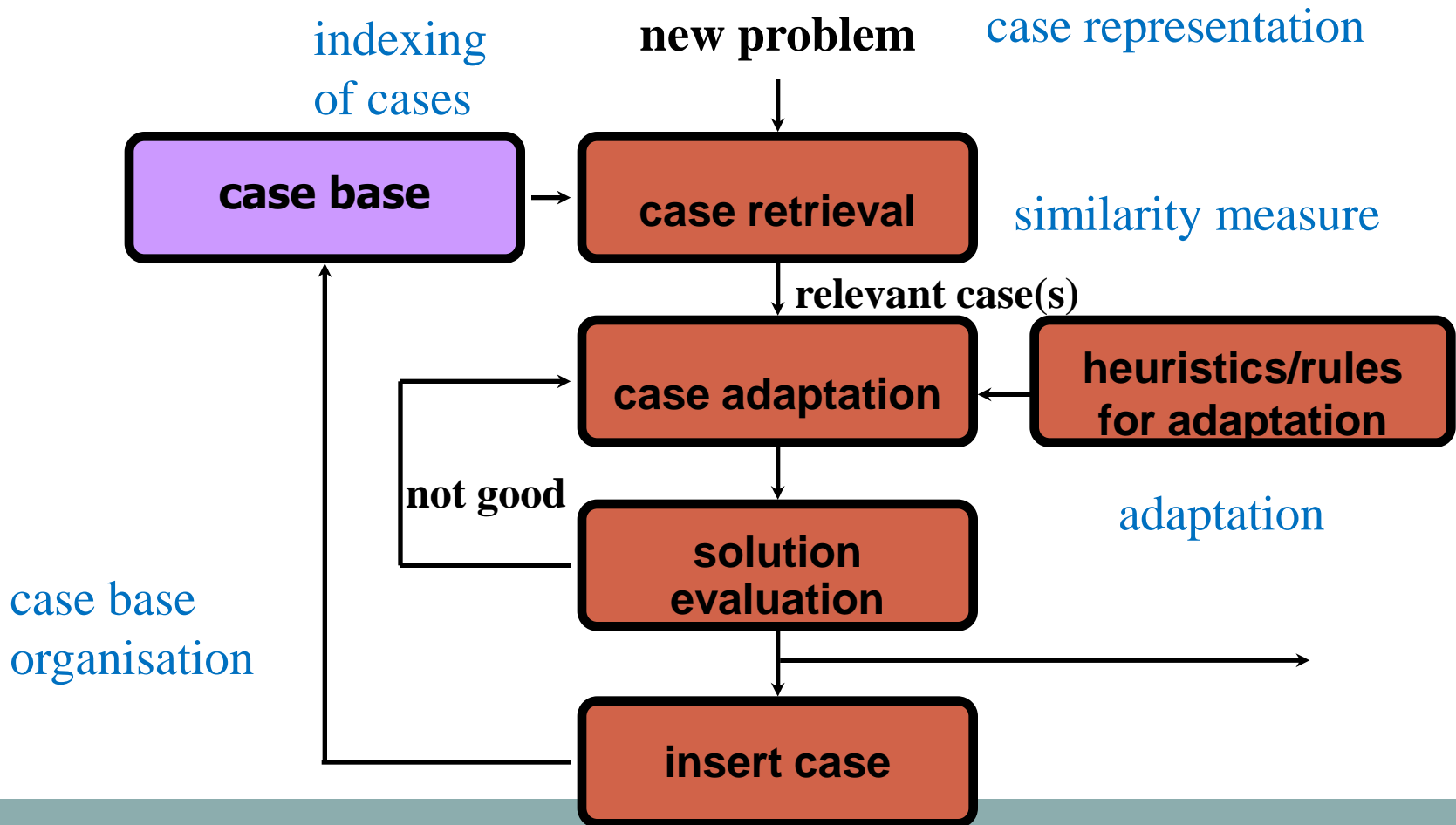
- 4 Re's
 - Retrieve
 - Reuse
 - Revise
 - Retain

Aamodt and Plaza, 1994



Case Based Reasoning

What is CBR?



Case Based Reasoning

Components of CBR

- Case representation
 - the **problem**: describes the state of the world when the case occurred
 - the **solution**: states the derived solution to that problem, and/or
 - the **outcome**: the state of the world after the case occurred
 - text, numbers, symbols, plans, multimedia
 - usually (attribute, value) pairs

Case Based Reasoning

Components of CBR

- Case representation
 - What to store in a case
 - Appropriate ***structure*** to describe case contents
 - How to organise and index for effective retrieval and reuse
 - Functionality and ease of acquisition

Case Based Reasoning

Components of CBR

- **Case indexing**
 - Assign indices to cases to facilitate their retrieval
 - Features and dimensions tend to be predictive
 - The system has to retrieve the right case at the right time
 - Predictive, useful, abstract and concrete

- Abstract enough to allow for widening the future use of the case-base;

- Not too abstract to avoid retrieving too many cases

Case Based Reasoning

Components of CBR

- **Case base organisation**
 - Flat memory
 - sequentially in a simple list, array or file
 - Hierarchical organisation
 - large case base
 - only small subset needs to be considered during the retrieval
 - organise specific cases which share similar attributes under a more general structure

Case Based Reasoning

Components of CBR

- **Case base organisation**

- Flat memory
 - Nearest neighbour
 - Weighting: by experts
- Hierarchical organisation
 - Tree search
 - Find the node that best matches the input

$$\sum_{n=1}^N w_n \text{sim}(f_n^I, f_n^R)$$

$$\sum_{n=1}^N w_n$$

Case Based Reasoning

Components of CBR

- **Case adaptation**
 - Structural adaptation
 - adaptation rules are applied directly to the solution stored in cases
 - Derivational adaptation
 - reuses the algorithms, methods or rules that generated the original solution to produce a new solution to the current problem
 - Simple or complex techniques, depend on the problem domain

Case Based Reasoning

Development of CBR

- **Case representation**

- Attributes that identify problems
- Indices for storage and retrieval

- **Similarity measure**

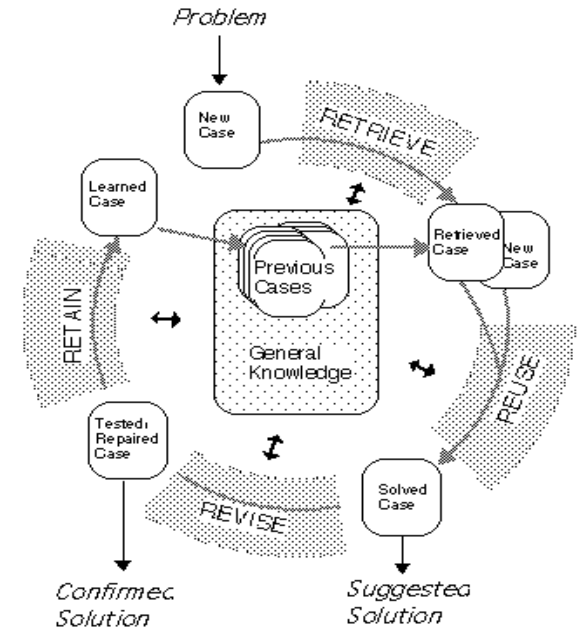
- Features that explain solutions

- **Adaptation**

- Domain theory of impact of attributes on solutions

- **Case base organization**

- A CBR system is heavily dependant on structure and content of case base



Case Based Reasoning



Rule based system

- Rules
- Difficult to convert knowledge to rules, i.e. difficult to explain rules
- Failure reported when no rules are matched
- Difficult to justify the solution
- Easier to validate

Case based reasoning

- Examples, stories
- Easier to tell stories, i.e. handles exceptions/novel cases in weak domains such as law
- Learning from both successes and failures
- Explanation becomes easier and pervasive
- Difficult validation

CBR – A modified example



- Residential property valuation*
 - ✦ To determine an estimated value at a given location and given time
 - ✦ most common methods used by the human appraisers is to find the recent sales that are comparable with the subject property

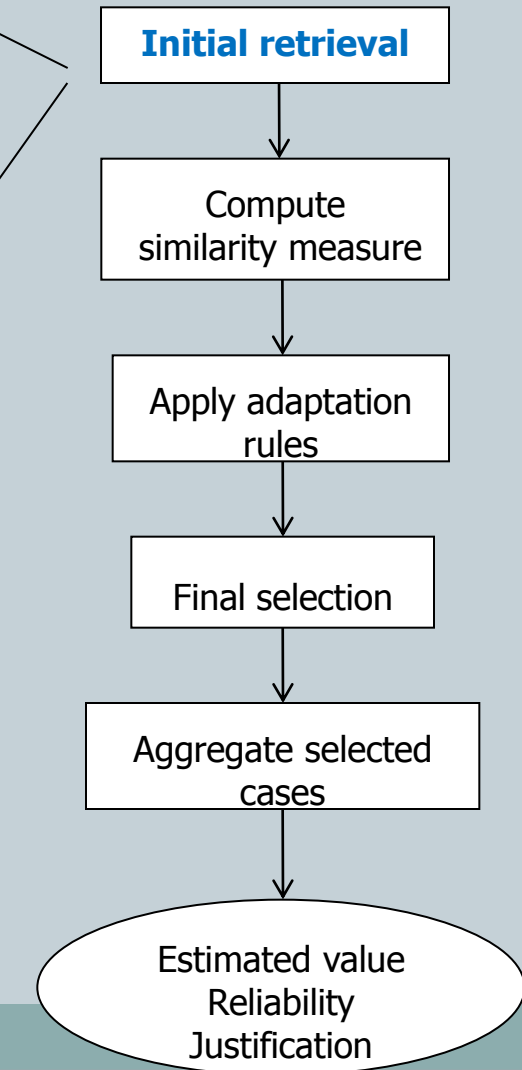
- Case: (attribute, value) pairs
 - ✦ Sale Price £185,000
 - ✦ Address Wollaton Road, Nottingham
 - ✦ Living Area 2000 sq. ft
 - ✦ Lot size 20000 sq. ft
 - ✦ Bedrooms 3
 - ✦ Bathrooms 2.5
 - ✦ ...

* Adapted from (Cheetham et al. 2004)

CBR – A modified example

- **Initial retrieval**
 - A standard SQL query against a DB uses the following attributes:
 - ✦ Date of sale (within 24 months)
 - ✦ Distance (within 10 miles)
 - ✦ Living area (+ / - 25%)
 - ✦ Lot size (+ / - 50%)
 - ✦ Number of bedrooms (+/- 3)
 - ✦ Number of bathrooms (+/- 3)

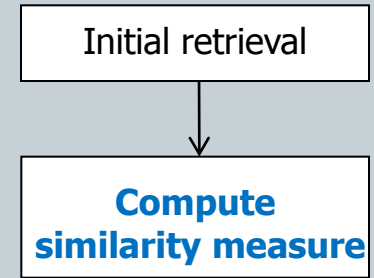
Location
Date of Sale
Living Area
Lot Size
Bedrooms
Bathrooms



CBR – A modified example

- **Similarity measure**
 - Weighted sum of attributes
 - Retrieved cases are ranked

Location
Date of Sale
Living Area
Lot Size
Bedrooms
Bathrooms



attribute	new case	retrieved case	comparison	weight	weighted sum
Months	X	6 months	75%	0.222	0.1665
Distance	X	0.2 miles	80%	0.222	0.1776
Area	2000	1800	90%	0.333	0.2997
Lot size	20000	35000	75%	0.111	0.8325
#Bedrooms	3	3	100%	0.056	0.056
#Bathrooms	2.5	2	80%	0.056	0.0448

Similarity Measure (Sum of Weighted Sum/Sum of Weights) = 0.8279

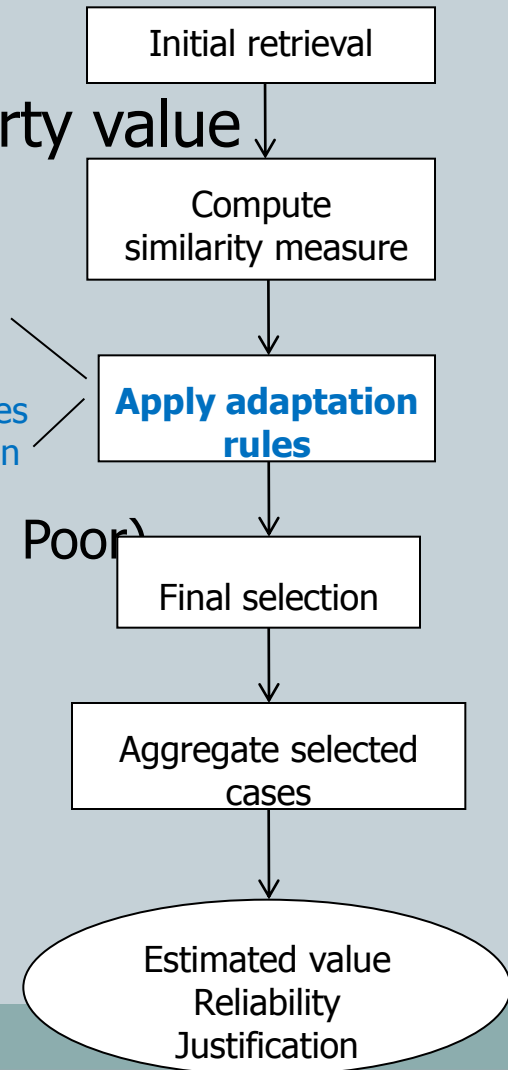
Justification

CBR – A modified example

- **Adaptation rules**

- Adjust sales price to better reflect property value
- Additional features cause the difference between subject and retrieved case
 - ✦ Fireplaces (subject - retrieved) * 2000
 - ✦ Quality (.02*sale price) for each level of difference:
(Luxury > Excellent > Good > Average > Fair > Poor)
 - ✦ Lot Area (subject - retrieved) * 1
 - ✦ ...
- Rules obtained from engineering sessions with expert appraisers

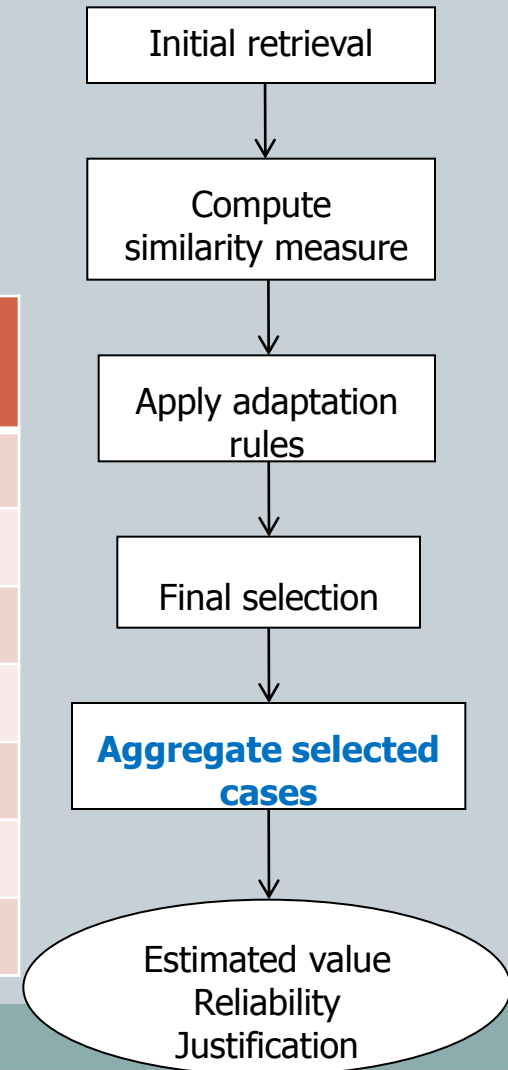
Age
Quality
Fireplaces
Condition



CBR – A modified example

- Aggregate selected cases
 - combined to produce an estimate of the value of the subject

Retrieved cases	Adjusted price	Score	Weighted price
113-012	197000	0.95	187150
306-008	202000	0.88	177760
093-011	196500	0.78	153270
685-046	192000	0.64	122880
847-984	201000	0.58	116580
Total		3.83	757640
Final estimate = $757640 / 3.83 = 199900$			



Case Based Reasoning

CBR Applications

- legal reasoning (examples Hypo, JUDGE)
 - decision making in courts are based on legal precedents
- diagnosis (CASEY, Protos)
 - depends heavily on case histories and the doctor's experience with other patients and their treatments
- design (Clavier)
 - successfully executed artifacts for a new situation
- scheduling (CABINS)
- help-desk support (Cascade, ReMind)
- planning (Chef)