

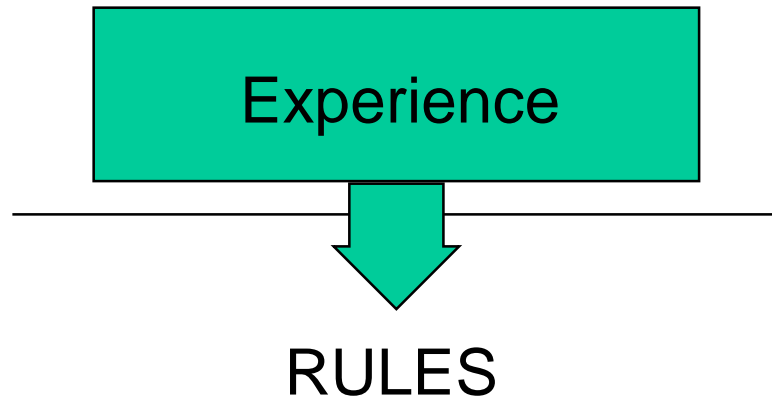
# **Case-Based Reasoning**

**10/23/02**

# Why CBR ?

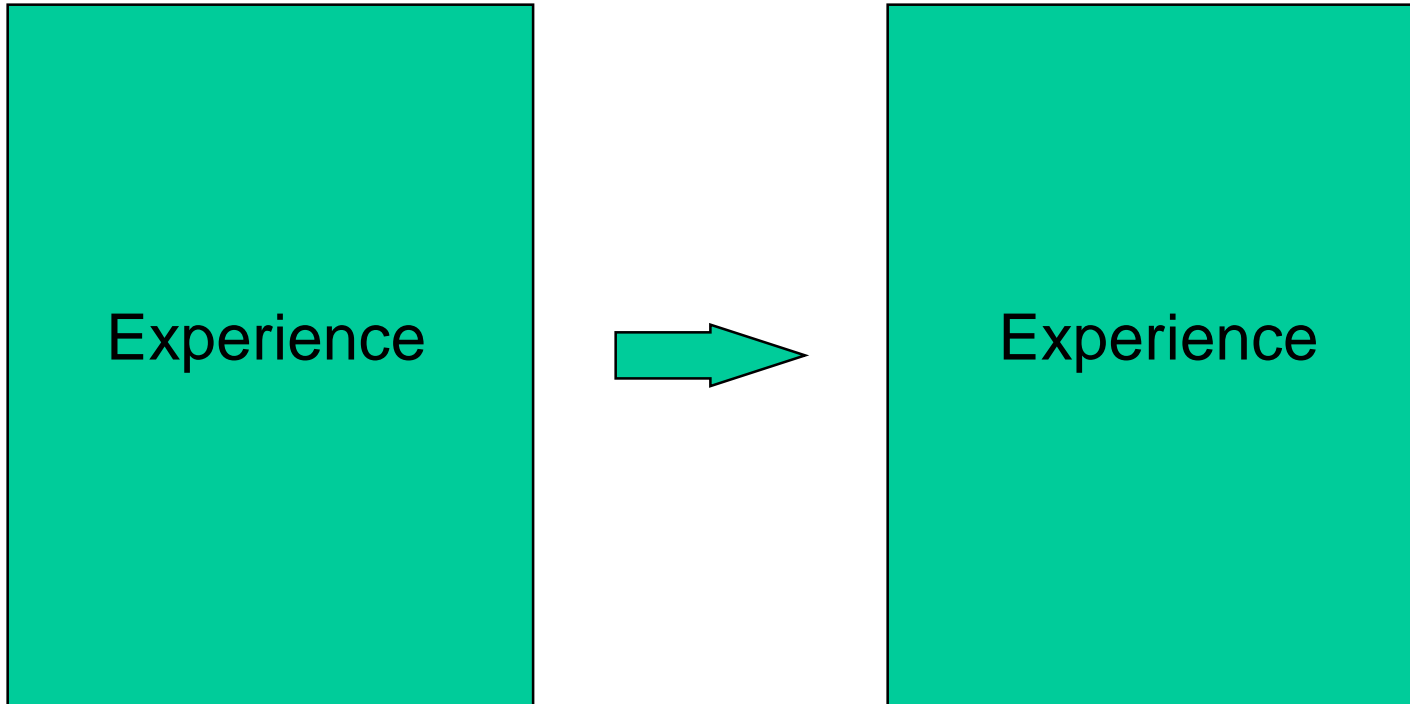
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- Problem: Most of the time the trouble in Building Expert Systems comes from trying to fit experience into rules.

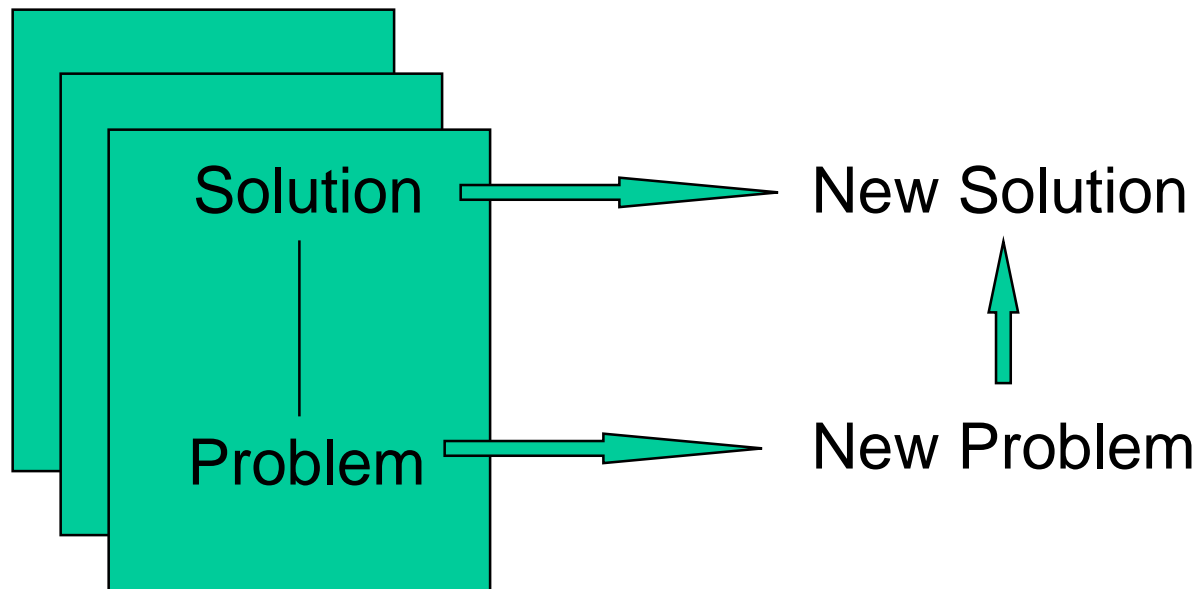


# The CBR Solution

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# CBR: A methodology of solving new problems by adapting the solutions of previous similar problems



# What is Case-Based Reasoning?

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- A kind of ‘table look-up’
- CBR system looks up in case base (indexed store of cases) past cases that bear on current problem
- Indexing and case representation facilitate retrieving relevant cases and comparing them with current problem
- CBR system applies information in retrieved cases to analyzing or solving problem

# Case-Based Reasoning

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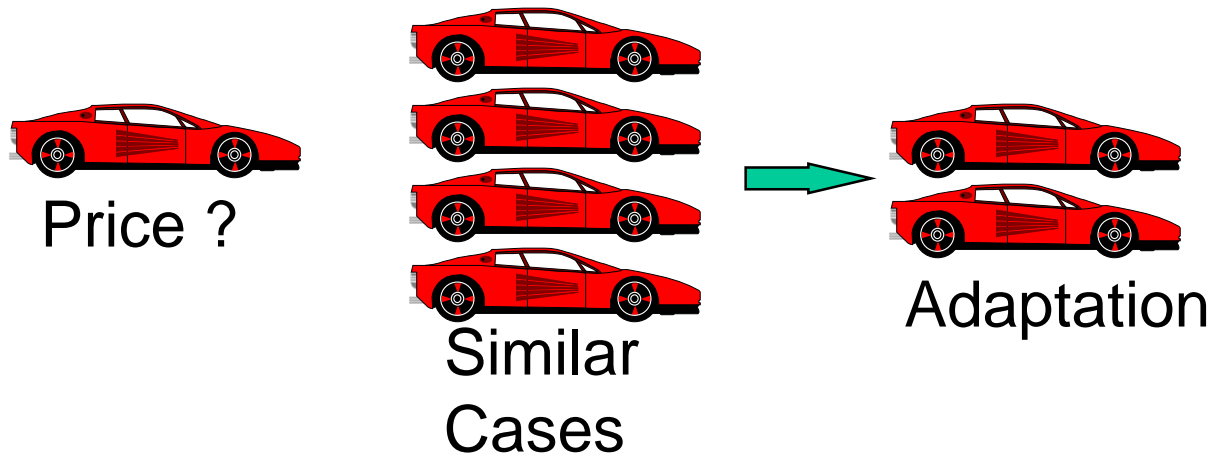
The use of previous experience in new situations

**“I have but one lamp by which my feet are guided, and that is the lamp of experience. I know no way of judging the future but by the past.”** Patrick Henry  
(Speech in Virginia Convention, Richmond. March 23, 1775)

# Processing takes place in 3 stages

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- Current Situation
- Retrieve similar cases from the library
- Adapt



# Case-Based Reasoning

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**“... transferring knowledge from past problem solving episodes to new problems that share significant aspects with corresponding past experience and using the transferred knowledge to construct solutions to new problems.” (Carbonell, 1986)**

# Introductory Examples of CBR

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- **Classification:** “The patient’s ear problems are like this prototypical case of otitis media”
- **Compiling solutions:** “Patient N’s heart symptoms can be explained in the same way as previous patient D’s”
- **Assessing values:** My house is like the one that sold down the street for \$250,000 but has a better view”
- **Justifying with precedents:** “This Missouri case should be decided just like Roe v. Wade where the court held that a state’s limitations on abortion are illegal”
- **Evaluating options:** “If we attack Cuban/Russian missile installations, it would be just like Pearl Harbor”

# Building An Application

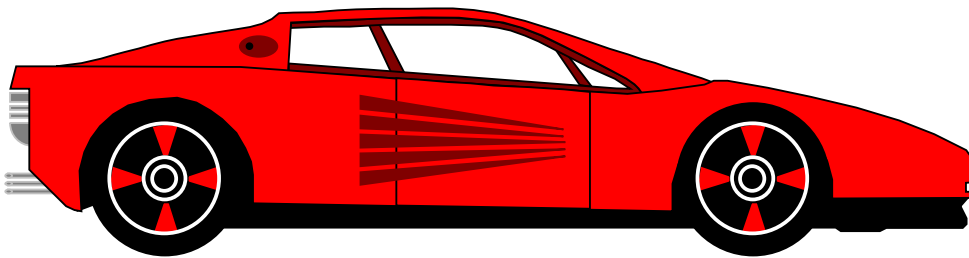
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- Steps
  - Case Representation
  - Case Input
  - Case Indexing
  - Case Retrieval
  - Evaluation and Comparison
  - Case Adaptation

# Case Representation

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- This is the first step in building an application
- Examples are made up of key features



Year  
Model  
Make  
Options  
Condition  
Mileage

# Case Indexing

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- Indexing gives the system knowledge on how to make matches
- What features are important and how much they contribute to the match
  - LoKI (Dattani and Bramer 1995) implements mathematical models to derive an appropriate function:
    - $Y = f(X_1, X_2, X_7)$  using Multivariate techniques

# Sample CBR Applications

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- Machine Tool Fault Diagnosis
- Computer Network Diagnosis
- Credit Analysis
- Geological Deposit Prediction
- Battle Planning
- Bank Telex Classification
- Natural Language Understanding

# Other CBR Applications

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- Network Management
- Legal Reasoning
- Claims Settlement
- Medical Diagnosis
- Weather Prediction
- Fraud Detection
- Planning and Scheduling

**Professor Edwina Rissland  
(Harvard Law School) speaking  
at AAAI-92 on 'Recent  
Progress in AI and Legal  
Reasoning'**

# Reasoning with Precedent Cases

## The Term Papers Example

| Days Late | Medical Certificate? | Accepted? |
|-----------|----------------------|-----------|
| 7         | NO                   | NO        |
| 5         | YES                  | YES       |
| 3         | NO                   | YES       |
| 6         | NO                   | NO        |
| 4         | YES                  | YES       |
| 6         | YES                  | NO        |
| 4         | NO                   | ???       |

# Contents of Cases

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- **Minimum Representation**

  - Problem description

  - Problem solution

- **Extensions**

  - Context (justification etc.)

  - Links to other cases

  - Failures encountered

# Some Case-Based Systems

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| <b>Name</b>     | <b>Application</b>             | <b>Year</b> |
|-----------------|--------------------------------|-------------|
| <b>CYRUS</b>    | <b>Episodic Memory</b>         | <b>1980</b> |
| <b>MEDIATOR</b> | <b>Dispute Resolution</b>      | <b>1985</b> |
| <b>PLEXUS</b>   | <b>Adaptive Planning</b>       | <b>1986</b> |
| <b>JUDGE</b>    | <b>Criminal Sentencing</b>     | <b>1986</b> |
| <b>SWALE</b>    | <b>Case-Based Explanation</b>  | <b>1986</b> |
| <b>CHEF</b>     | <b>Chinese Cooking</b>         | <b>1986</b> |
| <b>MBRTalk</b>  | <b>Pronunciation of Words</b>  | <b>1986</b> |
| <b>JULIA</b>    | <b>Catering</b>                | <b>1987</b> |
| <b>HYP0</b>     | <b>Patent Law</b>              | <b>1987</b> |
| <b>COACH</b>    | <b>Football Coach</b>          | <b>1988</b> |
| <b>CASEY</b>    | <b>Heart Failure Diagnosis</b> | <b>1988</b> |
| <b>JOHNNY</b>   | <b>Reading</b>                 | <b>1988</b> |
| <b>REFINER</b>  | <b>Knowledge Refinement</b>    | <b>1988</b> |

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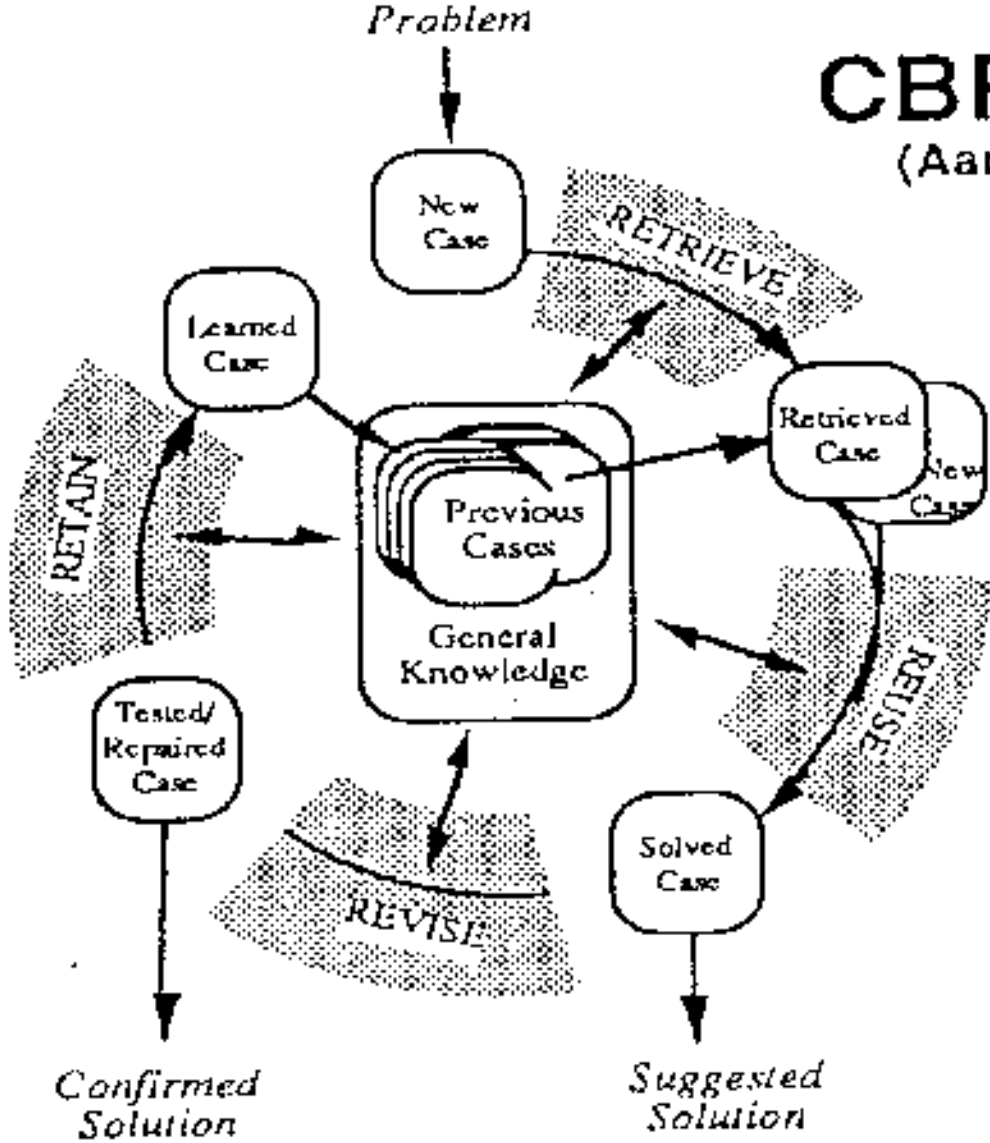
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| <b>Name</b>        | <b>Application</b>           | <b>Year</b> |
|--------------------|------------------------------|-------------|
| <b>PROTOS</b>      | <b>Knowledge Acquisition</b> | <b>1988</b> |
| <b>PRODIGY</b>     | <b>Planning</b>              | <b>1988</b> |
| <b>PATDEX</b>      | <b>Diagnosis</b>             | <b>1989</b> |
| <b>CREEK</b>       | <b>Diagnosis</b>             | <b>1989</b> |
| <b>KATE-CBR</b>    | <b>CBR-Shell</b>             | <b>1990</b> |
| <b>CCC+</b>        | <b>Diagnosis</b>             | <b>1991</b> |
| <b>ESTEEM</b>      | <b>CBR-Shell</b>             | <b>1991</b> |
| <b>ReMind</b>      | <b>CBR-Shell</b>             | <b>1991</b> |
| <b>CBR-Express</b> | <b>CBR-Shell</b>             | <b>1991</b> |
| <b>INRECA</b>      | <b>CBR-Shell</b>             | <b>1993</b> |

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# CBR Cycle

(Aamodt, 1993)



# When should CBR be used?

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## Where ....

- **A large volume of historical data already exists**
- **Experts talk about their domain by giving examples**
- **Experience is as valuable as textbook knowledge**
- **Problems are not fully understood (weak models, little domain knowledge available)**
- **There are a lot of exceptions to rules**
- **There is a need to build a corporate memory and transfer expertise among personnel**

# CBR versus Rule-Based Systems

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- CBR offers a cost-effective solution to the ‘knowledge acquisition bottleneck’ problem
- CBR systems can learn from experience and so can be self-maintaining
- Rule-based systems are better when it is hard to gather case data

# A Sample Example

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- Technical Diagnosis of Car Faults
  - Symptoms are observed (e.g., engine does not start) and values are measured (e.g., battery voltage = 6.3V)
  - Goal: Find the cause for the failure (e.g., battery empty) and a repair strategy (e.g., charge battery)
- Case-based Diagnosis:
  - A case describes a diagnostic situation and contains:
    - Description of the symptoms
    - Description of the failure and cause
    - Description of a repair strategy
  - Store a collection of cases in a case base
  - Find case similar to current problem & reuse repair strategy

Feature

Value

|                                       |   |
|---------------------------------------|---|
| <b>C<br/>A<br/>S<br/>E<br/><br/>1</b> | <b>Problem (Symptoms)</b> <ul style="list-style-type: none"><li>• <i>Problem:</i> Front light doesn't work</li><li>• <i>Car:</i> VW Golf II, 1.6 L</li><li>• <i>Year:</i> 1993</li><li>• <i>Battery voltage:</i> 13,6 V</li><li>• <i>State of lights:</i> OK</li><li>• <i>State of light switch:</i> OK</li></ul> |
|                                       | <b>Solution</b> <ul style="list-style-type: none"><li>• <i>Diagnosis:</i> Front light fuse defect</li><li>• <i>Repair:</i> Replace front light fuse</li></ul>   |

Existing Cases

|                                       |   |
|---------------------------------------|---|
| <b>C<br/>A<br/>S<br/>E<br/><br/>2</b> | <b>Problem (Symptoms)</b> <ul style="list-style-type: none"><li>• <i>Problem:</i> Front light doesn't work</li><li>• <i>Car:</i> Audi A6</li><li>• <i>Year:</i> 1995</li><li>• <i>Battery voltage :</i> 12,9 V</li><li>• <i>State of lights:</i> surface damaged</li><li>• <i>State of light switch:</i> OK</li></ul> |
|                                       | <b>Solution</b> <ul style="list-style-type: none"><li>• <i>Diagnosis:</i> Bulb defect</li><li>• <i>Repair:</i> Replace front light</li></ul>  |

# Case Representation

- Case-based reasoner depends heavily on the structure and content of its collection of cases.
- Since a problem is solved by recalling a previous experience suitable for solving the current problem, the case *search* and *matching* process has to be *effective* and *reasonably time efficient*.

# Case Representation

- Flat feature-value list
- Object Oriented representation
- Graph representation
  
- The choice of representation is
  - Dependent on requirements of domain and task
  - Structure of already available case data

## Problem to be solved

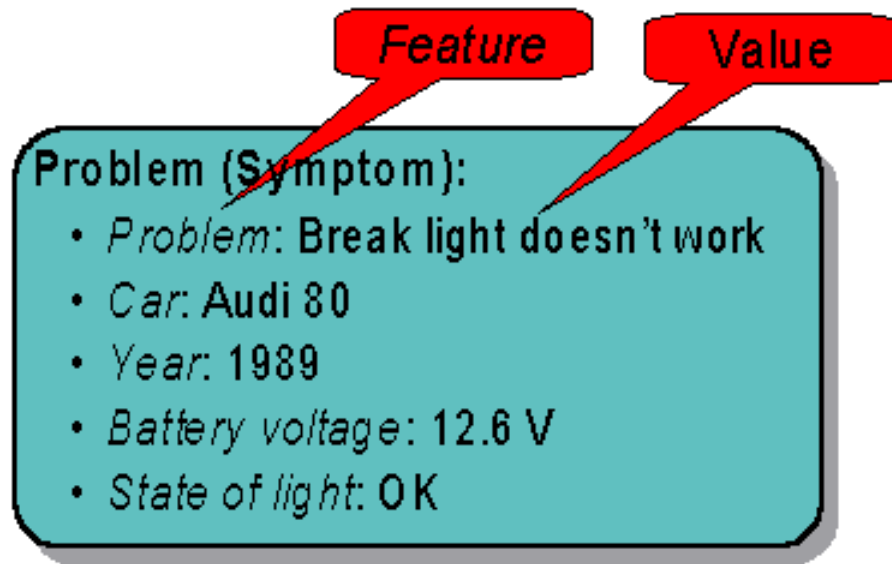


Figure Credit: R. Bergmann, University of Kaiserslautern

# Case Retrieval

- Retrieval starts with a (partial) problem description, and ends when a best matching previous case has been found.

# Similarity Measurement

- Purpose: To select the most relevant case
- Basic Assumption: Similar problems have similar solutions
- Similarity value between 0 and 1 are assigned for feature value pairs
- E.g.: Feature: Problem

Front Light does not work

↓ .8

Break Light does not work

Front Light does not work

↓ .4

Engine doesn't start

# Similarity Measurement

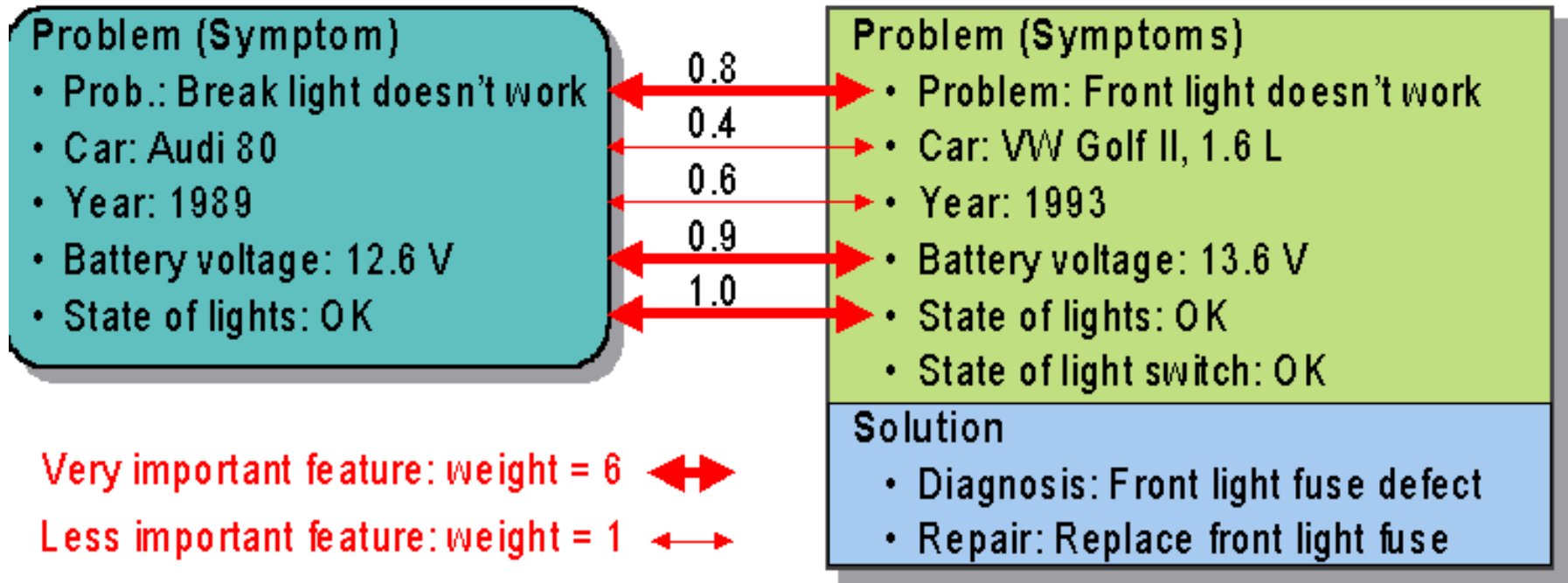
- Feature: Battery Voltage

$$12.6 \overset{.9}{-} 13.6$$

$$12.6 \overset{.1}{-} 6.7$$

- Different features have different importance
- Two kinds of Similarity Measures
  - Local Similarity – similarity on feature level
  - Global Similarity - similarity on case or object level

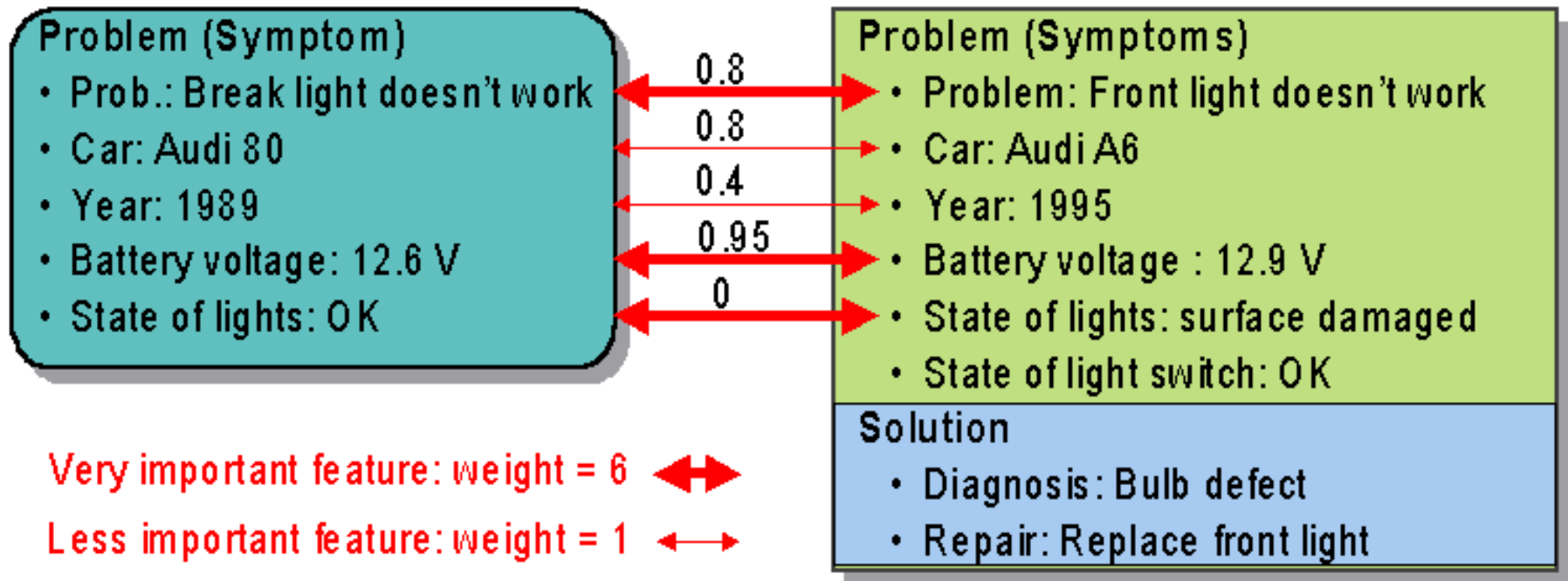
## Similarity Computation for case 1



## Similarity Computation by Weighted Average

$$\text{similarity}(\text{new}, \text{case 1}) = 1/20 * [ 6*0.8 + 1*0.4 + 1*0.6 + 6*0.9 + 6* 1.0 ] = 0.86$$

## Similarity Computation for case 2



## Similarity Computation by Weighted Average

$$\text{similarity}(\text{new}, \text{case 2}) = 1/20 * [ 6*0.8 + 1*0.8 + 1*0.4 + 6*0.95 + 6*0 ] = 0.585$$

Figure Credit: R. Bergmann, University of Kaiserslautern

# CBR on the Web

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## Case

# Based Reasoning *on the Web*

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### • About CBR

- Applying CBR
- CBR Research
- CBR by Fields
- Editorial

@Kaiserslautern:

- Research
- CBR-Works




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This is the Case-Based Reasoning homepage at the [University of Kaiserslautern](http://www.uni-kl.de). It provides up-to-date information on CBR, relevant to both research and commercial topics.

You are currently **not** registered. If you plan to visit this page occasionally, you should consider to [register](#).

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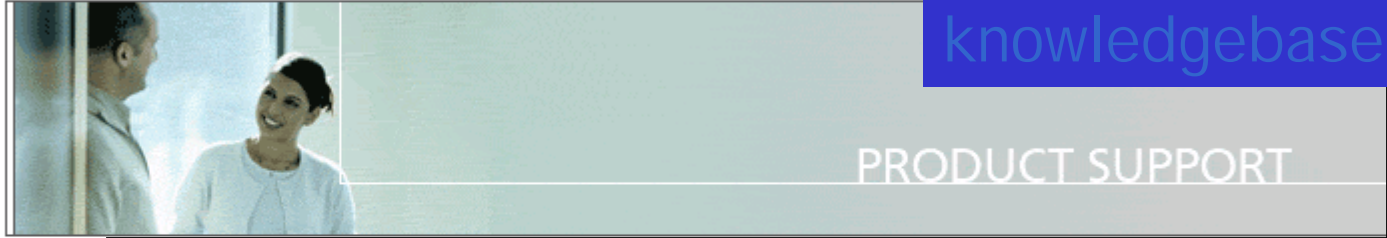
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| <a href="#">Low Frequency Current Noise</a>     | =< <input type="text"/>                            | (p)App      | Priority <input type="checkbox"/> |
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