CS760

Case-Based Reasoning 1

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Definitions

- A case-based reasoner solves new problems by adapting solutions that were used to solve old problems (Reisbeck & Schank 1986)
- CBR is both the ways people use cases to solve problems and the ways we can make machines use them. (Kolodner, 1993)
- CBR is a recent approach to problem solving and learning (Aamodt & Plaza 1994)
- CBR is reasoning by remembering (Leake, 1996)

CBR is both…

- A methodology to model human reasoning and thinking, and
- A methodology for building intelligent computer systems

A Methodology is…

- an organised set of principles which guide action in trying to "manage" (in the broad sense) real-world problem situations. (Peter Checkland)

- CBR as a methodology for problem solving will become important later…

CBR in a nutshell is…

- store previous experience (cases) in memory
- to solve new problems:
  - retrieve similar experience about similar situations from the memory
  - reuse the experience in the context of the new situation: complete or partial reuse, or adapt according to differences
  - store new experience in memory (learning)

History in the US

- Roger Schank, Yale University: Cognitive Science Research
- 1977: Scripts for knowledge representation (Schank, Abelson)
- 1983: Dynamic Memory Theory, Memory Organization Packets
- 1984: CYRUS, First implemented CBR-System (Kolodner)
- 1984-1988: Other systems, e.g. : JUDGE, SWALE, CHEF, JULIA

Scripts

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- For example - a visit to the doctor

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- Script:
  - introduce yourself to receptionist
  - receptionist says "take a seat the doctor will be with you shortly"
  - sit down read a magazine for 15 mins
  - go into doctor's room
  - get examined by doctor
  - leave with a drug prescription

Scripts

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- most of it also applies when you visit other medical professionals (e.g. the dentist & the vet)
- interestingly much of it still applies when you take your car to a service while u-wait garage

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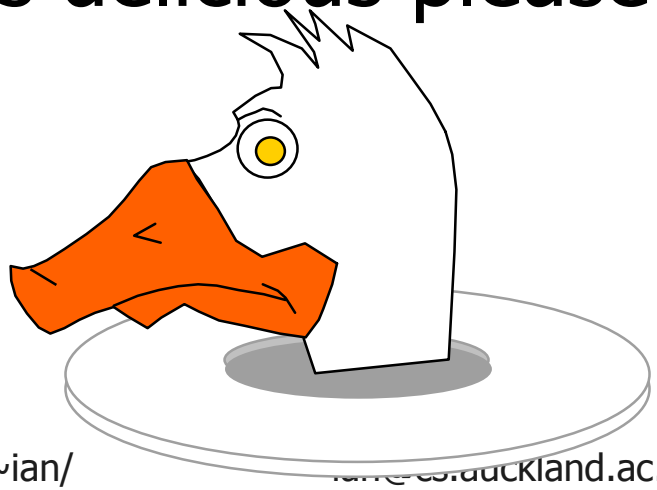
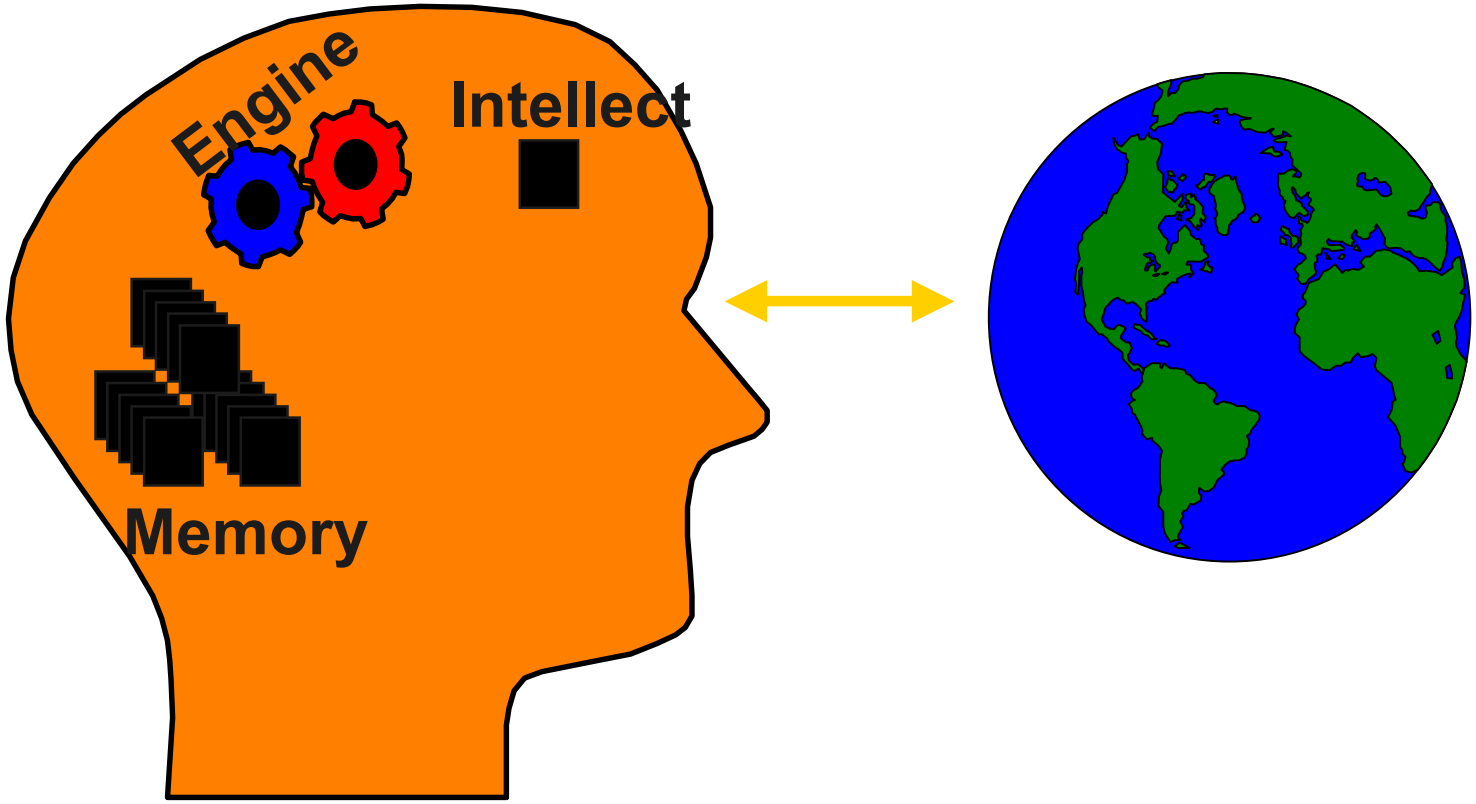


Reminding



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Reminding

- How do we remember scripts?
- We must have an index
- it is more efficient to index the differences between cases
- and only store cases that are significantly different

MOPs

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- a *dynamic* memory model that can
  - organise scripts
  - identify scripts that differ
  - and reorganise the structure
- thus allowing us to remember & to learn

The Dynamic Memory Model

Ordering in a Restaurant

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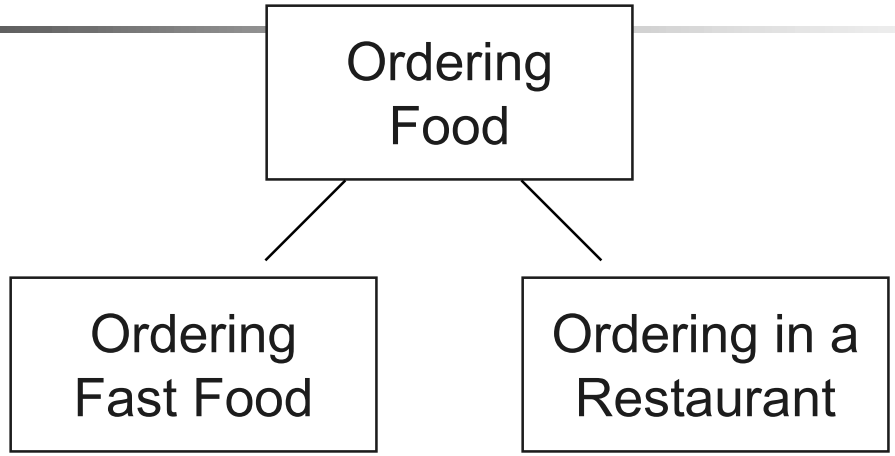
The Dynamic Memory Model

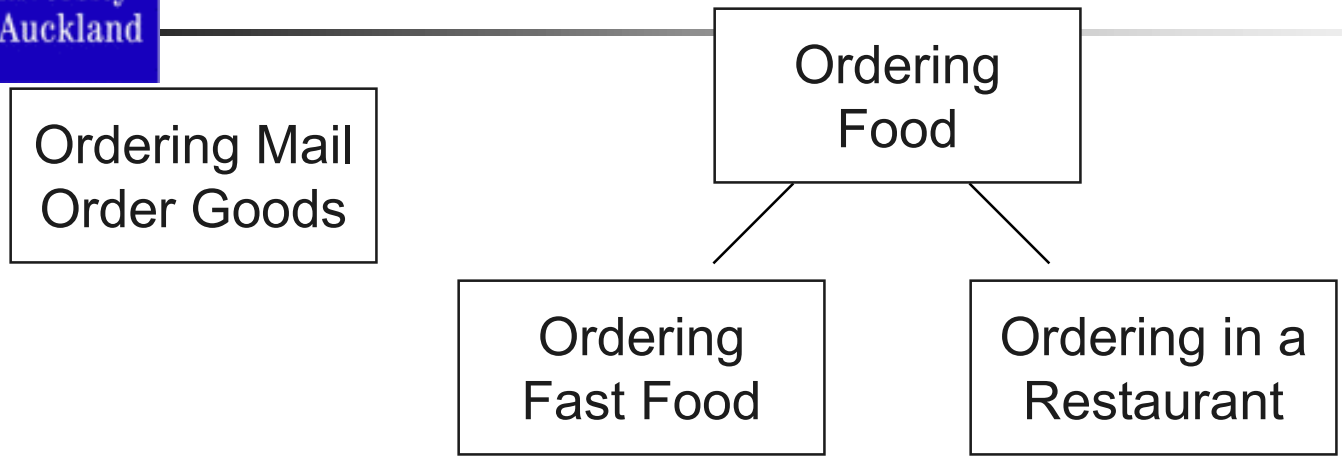
Ordering in a Restaurant

Ordering Fast Food

The Dynamic Memory Model



The Dynamic Memory Model



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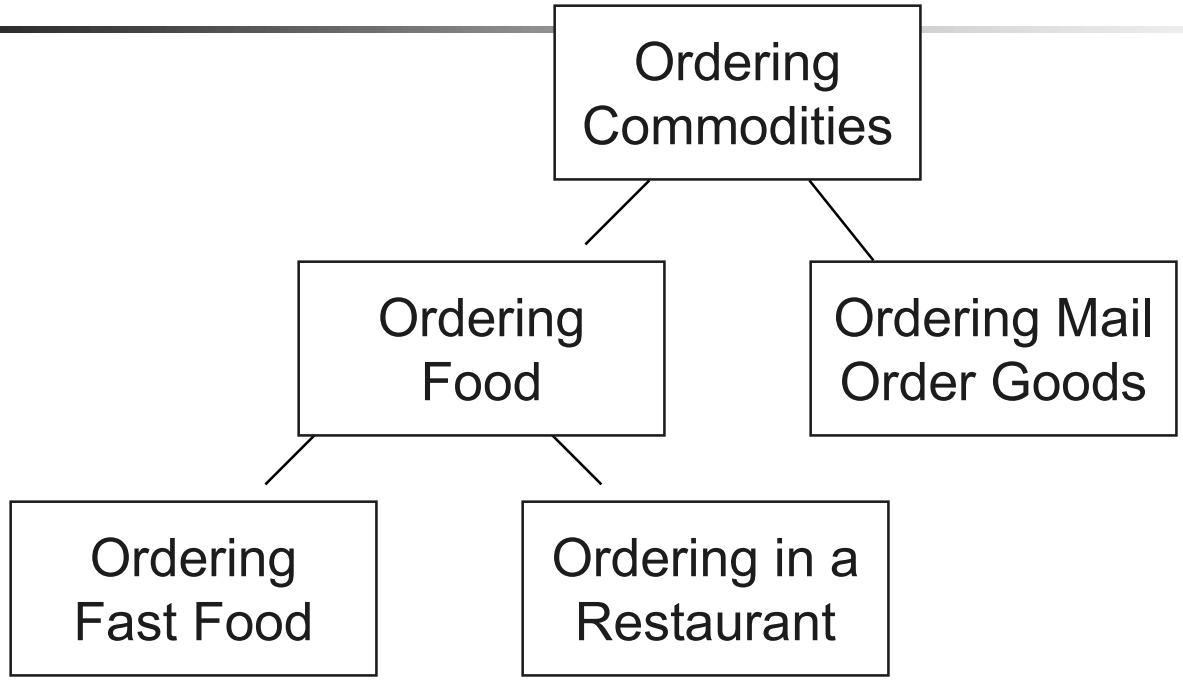

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- early CBR work was
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  - not with inferencing
- Computationally inefficient

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- CYRUS dynamically stored and retrieved events in the life of Cyrus Vance, the US secretary of state under Jimmy Carter

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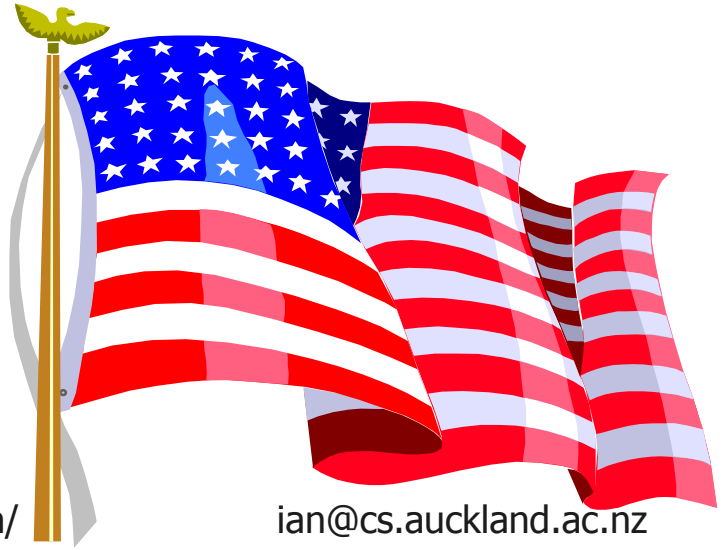
- could remember, retrieve and *adapt* Chinese recipes
- given a list of ingredients (eg beef and broccoli) it could retrieve *stir-fried beef and snow peas* and substitute the snow peas with the broccoli to make a new recipe *stir-fried beef and broccoli*

DARPA



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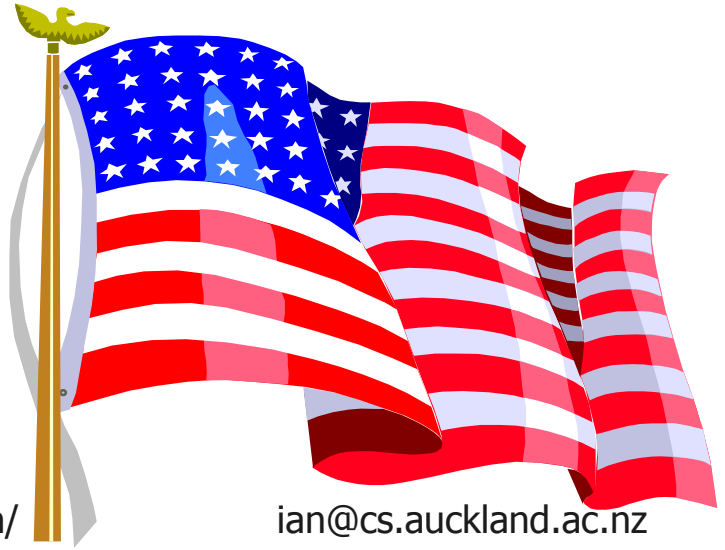
DARPA

- in the mid 80s the US DARPA programme invested heavily in CBR



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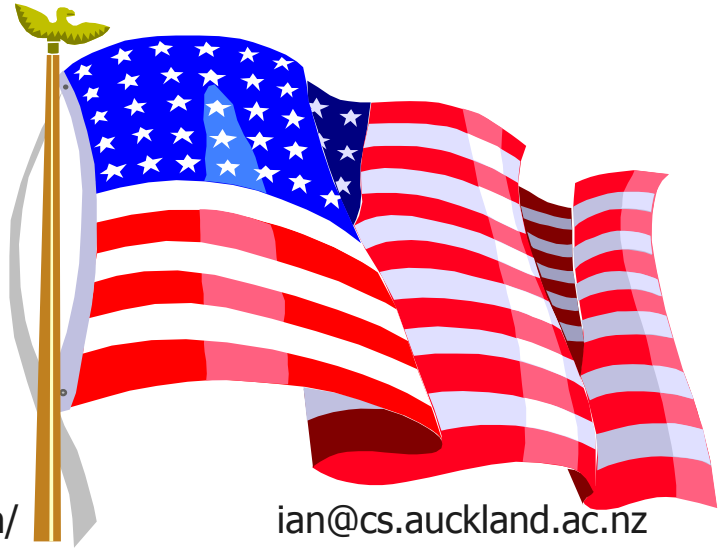

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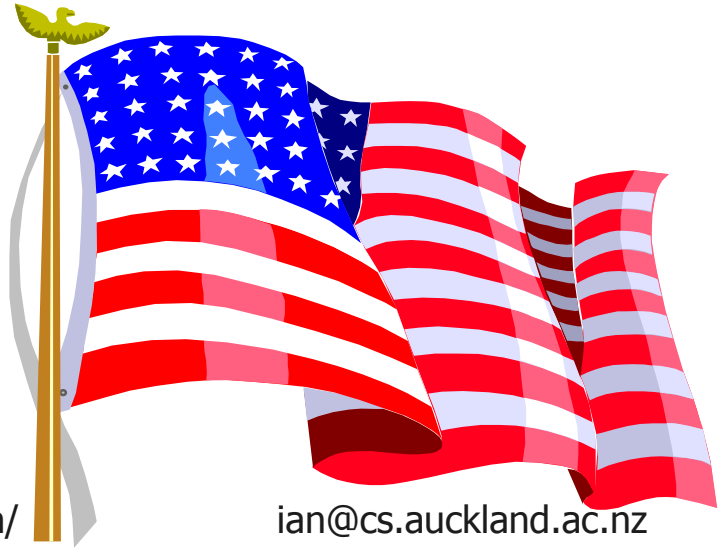
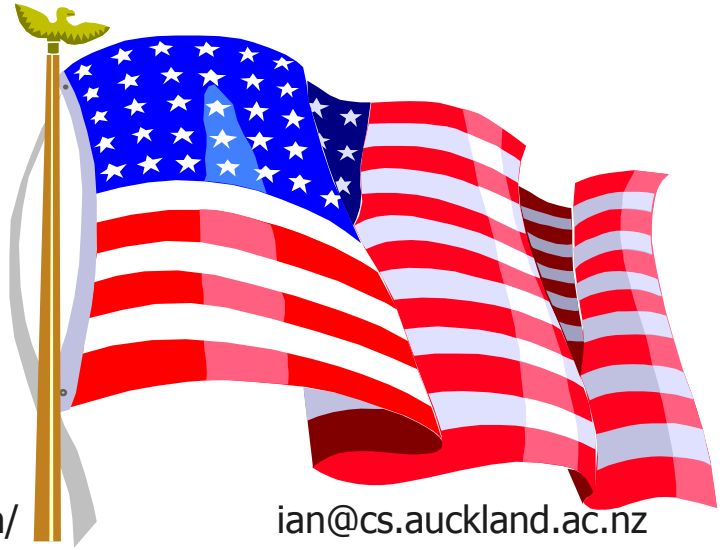
- the first commercial applications



DARPA

- in the mid 80s the US DARPA programme invested heavily in CBR
- resulted in software tools
- the first commercial applications
- A strong US research community



History in the US

- Bruce Porter, Austin Texas: Concept Learning
  - 1986-89: System PROTOS (Exemplar-based concept representation)
- Edwina Rissland, U. of Massachusetts: Cases in Law (since 1983)
  - 1990-92: Systems HYPO (Ashley) and CABARET (Skalak)
- Jaime Carbonell & Manuela Veloso, Carnegie Mellon U.: Analogy
  - since 1990 Prodigy/Analogy: Case-based Planning using analogy

History in Europe

- Michael M. Richter, U. Kaiserslautern, Germany: CBR for Expert Systems
  - 1988-1991 Systems MOLTKE and PATDEX (technical diagnosis)
  - since 1991 Case-Based Planning: Systems Caplan/CbC, PARIS
  - since 1992 European Projects INRECA, INRECA-II
- Company TECINNO formed

History in Europe

- Ramon Mantaras, Enric Plaza, IIIA Blanes, Spain: CBR and ML
  - 1990 Case-Based Learning for medical diagnosis
- Agnar Aamodt, U. Trondheim, Norway: CBR and Knowledge Acquisition
  - 1991 System CREEK: Integration of Cases and general knowledge
- Mark Keane, Trinity College, Dublin: Cognitive Science
  - since 1988 Theory of analogical reasoning

History in Europe

- Ian Watson, University of Salford
  - Since 1994: CBRefurb, NIRMANI, case-based estimating & design
  - AI-CBR: CBR web-portal
- Padraig Cunningham & Barry Smyth, Trinity College & University College Dublin
  - Since 1995: case-coverage, maintenance, CBR for e-commerce
  - Company ChangingWorlds.com

History in Europe

- European workshops strengthen CBR:
  - German workshops since 1991
  - European workshops since 1993
  - UK Workshops since 1995
  - Italian workshops since 1999
- 1st International CBR conference held in Portugal in 1995 (Roger Schank was keynote speaker)

CBR Tools

- Cognitive Systems – ReMind– went bust 1998
- AcknoSoft – KATE tools (now Kaidara Int.)
- Inference – Art*Enterprise and k-Commerce (now MindBox Inc. eGain Inc.)
- Tecinno – CBR-Works
- Haley Enterprise – Help!CPR, Eclipse…

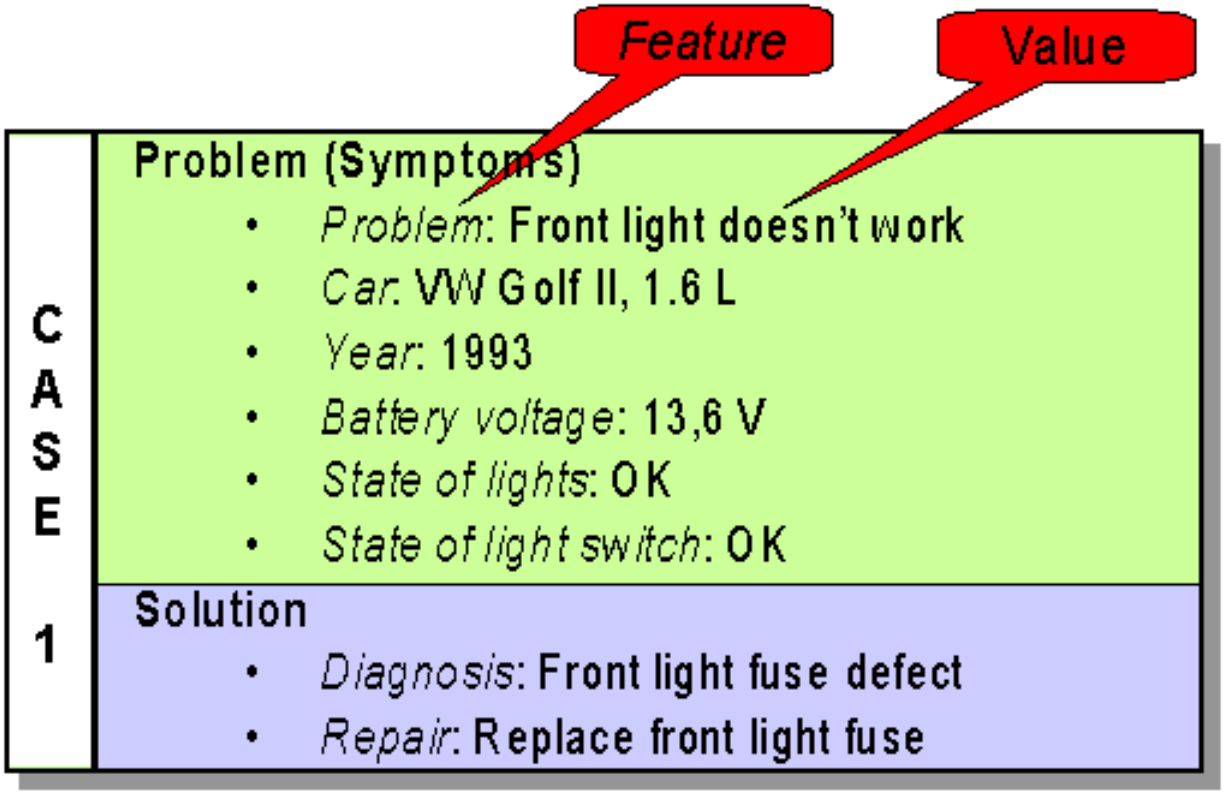
CBR Apps. *Demos…??? <@#*!>*

- The "quick win" was shallow technical diagnosis
- Ideal for help desks and customer support
- http://support.lucasarts.com/yoda/start.htm
- http://pawnt139.external.hp.com/servlet/Setec?product=LaserJet5si
- Product selection
- http://www.hookemacdonald.com/letonthenet/
- http://imsgrp.com/analog/query.htm

Technical diagnosis

- Simple example: Car Faults
  - Symptoms are observed (e.g. engine doesn't start) and values are measured (e.g. battery voltage = 6.3V)
  - Goal: Find the cause for the failure (e.g. battery empty) and 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 the cause
  - description of a repair strategy

Technical diagnosis



CASE 1	Problem (Symptoms) • Problem: Front light doesn't work • Car: VW Golf II, 1.6 L • Year: 1993 • Battery voltage: 13,6 V • State of lights: OK • State of light switch: OK
	Solution • Diagnosis: Front light fuse defect • Repair: Replace front light fuse

CASE 2	Problem (Symptoms) • Problem: Front light doesn't work • Car: Audi A6 • Year: 1995 • Battery voltage : 12,9 V • State of lights: surface damaged • State of light switch: OK
	Solution • Diagnosis: Bulb defect • Repair: Replace front light

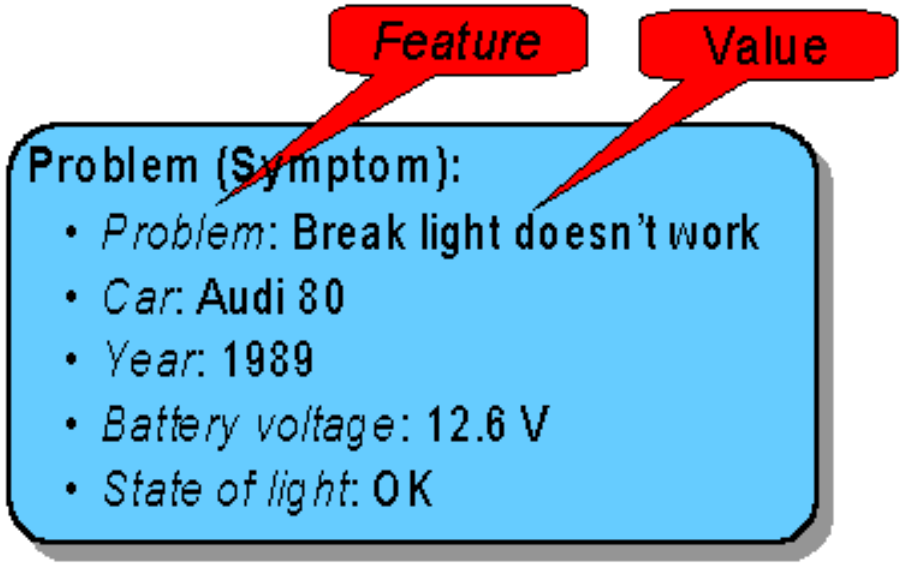
Each case describes one situation

Cases are independent of each other

Case are not rules

Solving a diagnostic problem

- Make several observations about new problem
- Not all features must be known
- The new problem is a case without the solution part



Solving a diagnostic problem

- Compare the new problem with each case & select most similar case
- *Similarity* is the most important concept in CBR

Similarity

- Similarity is assessed for each feature
- Depends on the feature value
- Features can have different weights (importance)

– Feature: *Problem*

Front light doesn't work ←0.8→ Break light doesn't work

Front light doesn't work ←0.4→ Engine doesn't start

– Feature: *Battery voltage* (similarity depends on the difference)

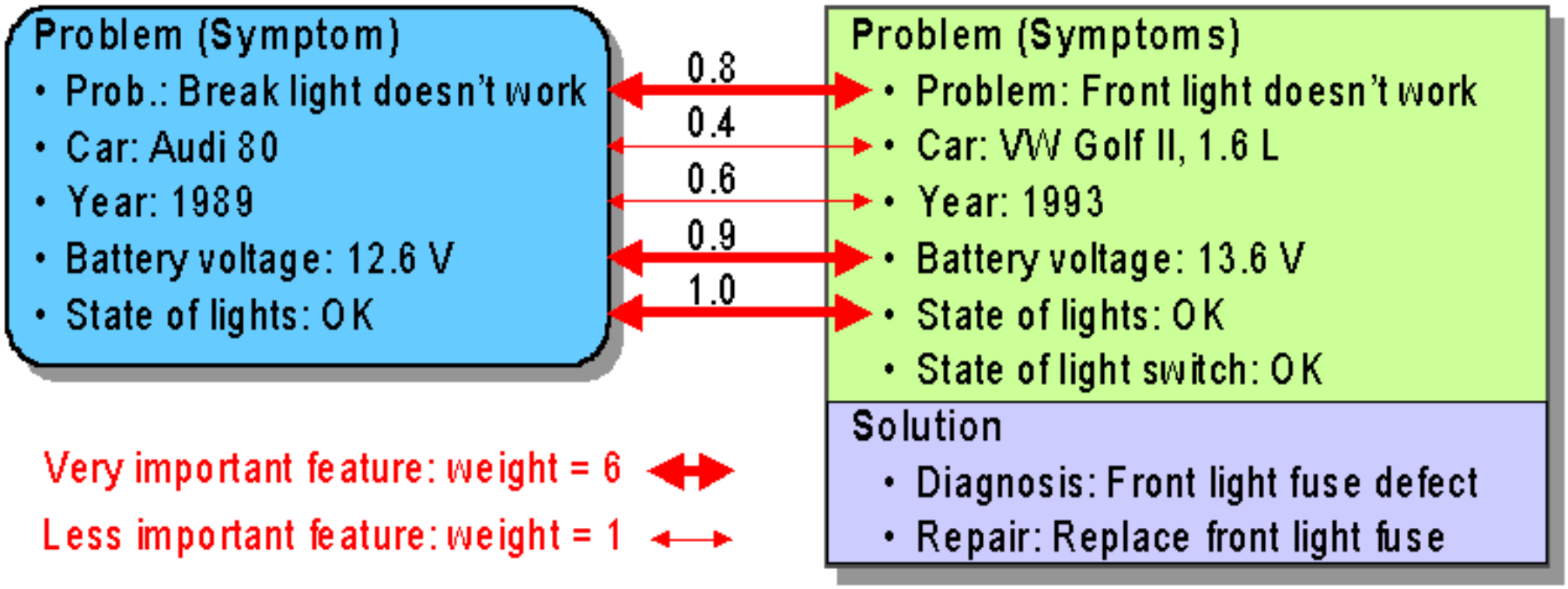
12.6 V ←0.9→ 13.6 V

12.6 V ←0.1→ 6.7 V

Similarity

- Different features have different importance
  - High importance:
    Problem: Battery_voltage: State_of_light:
  - Low importance:
    Make: Model: Year: Colour:

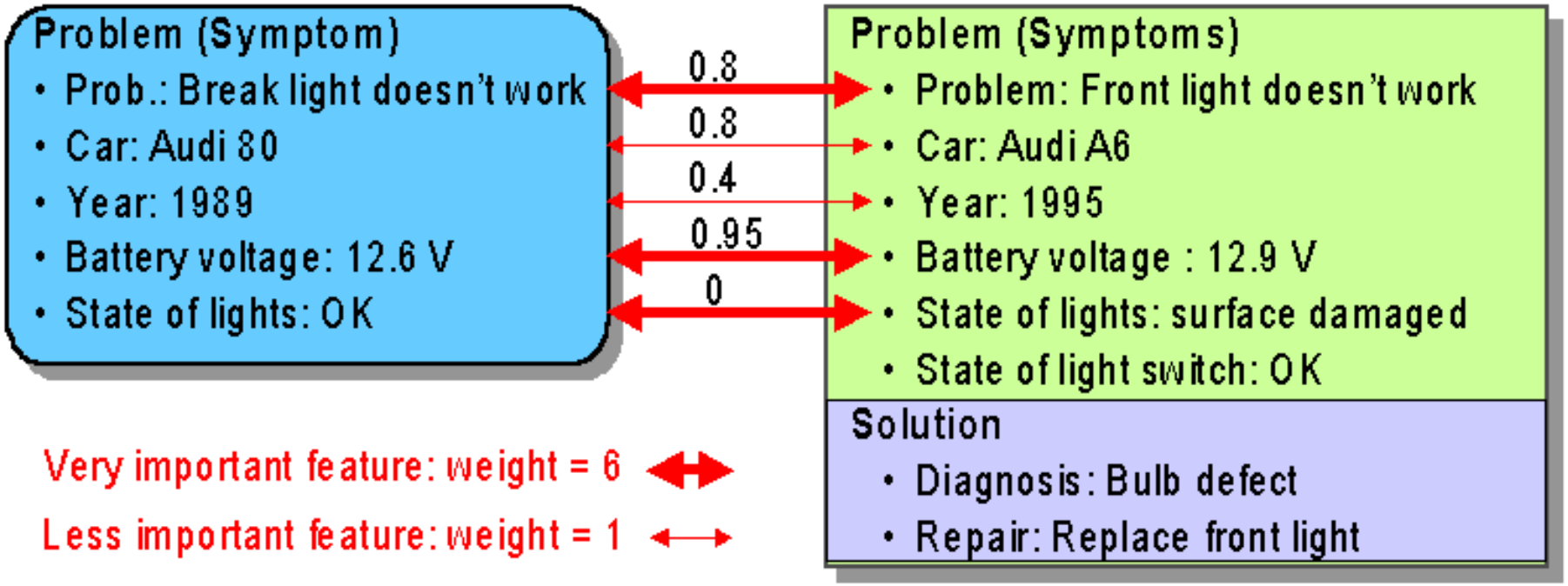
Compare new problem with case 1



Similarity Computation by Weighted Average

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

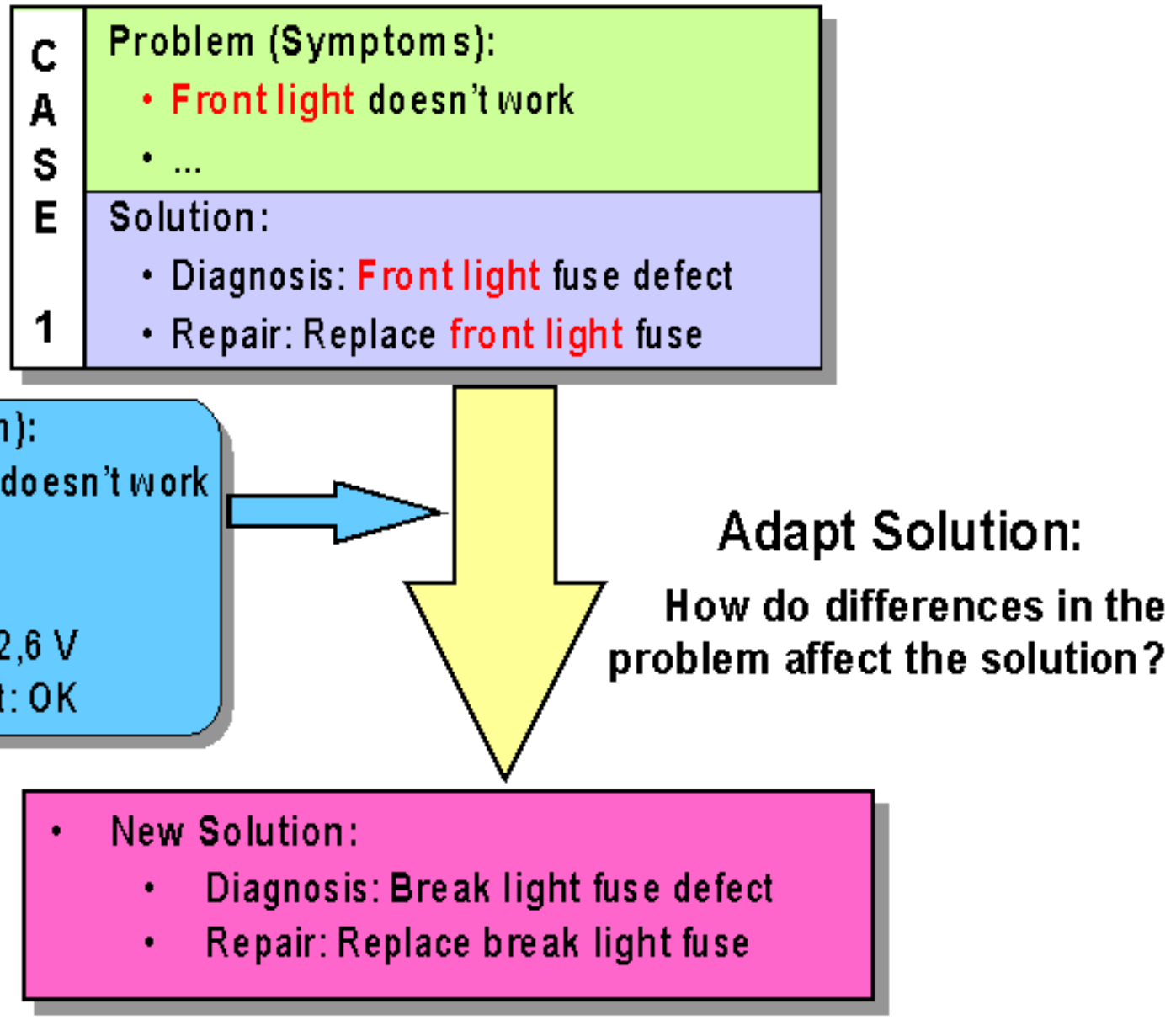
Compare new problem with case 2



Similarity Computation by Weighted Average

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

Reuse the Solution of Case 1



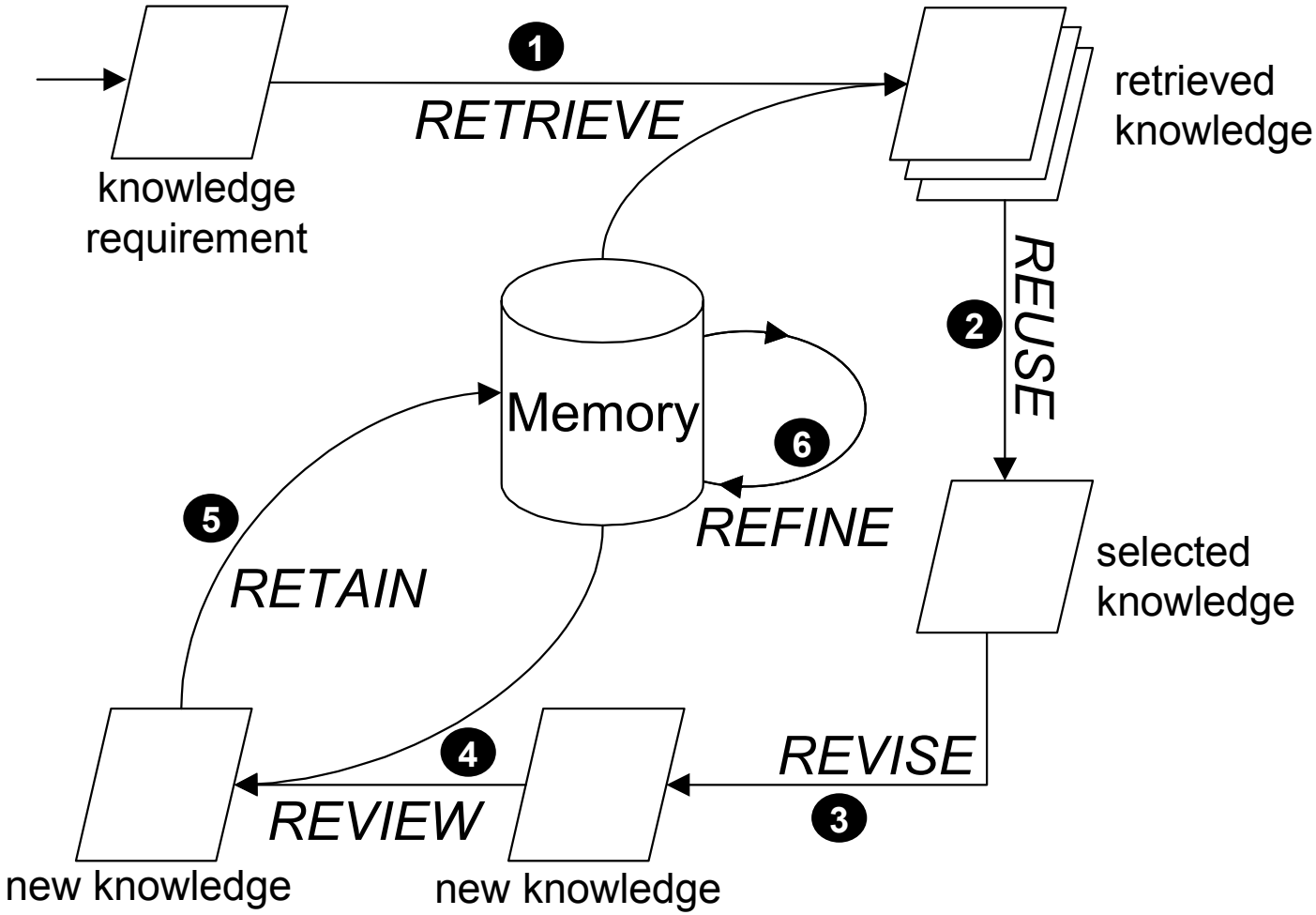
Store the New Experience

If diagnosis is correct:

store new case in the memory.

CASE 3	
	Problem (Symptoms): • Problem: Break light doesn't work • Car: Audi 80 • Year: 1989 • Battery voltage: 12.6 V • State of break lights: OK • light switch clicking: OK
	Solution: • Diagnosis: break light fuse defect • Repair: replace break light fuse

The CBR-cycle



The CBR-cycle

- 6 processes:
  1. Retrieve
  2. Reuse
  3. Revise
  4. Review
  5. Retain
  6. Refine