CompSci 367
Case-Based Reasoning

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- What is Case-Based Reasoning?
  - intuitive
  - simple
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  - transparent
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Definition

- precedent *[pres-e-d(a)nt] n.* previous case or occurrence taken as guidance. *Collins Dictionary*

Precedents

- we are all comfortable with the concept of precedent
- precedents inform many of our daily decisions
- they are the basis of our legal system

Precedents

- would you rather bet on Brazil or England in the soccer?
- you expect a product to cost much the same today as it did yesterday
- companies make thousands of decisions a day
- successful decisions can be used as precedents

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Precedents - CBR

- Case-Based Reasoning (CBR)
- uses precedents (prior decisions or actions) to inform current decisions
- CBR is
  - intuitive
  - relatively simple to implement
  - transparent
  - and it learns

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Decision Support

- ES system developers have problems
  - the knowledge elicitation bottleneck
  - decision support is dynamic
  - systems require constant maintenance
  - systems must be accepted
  - advice must be justified
- CBR addresses each of these problems

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What is CBR?

- A case-based reasoner solves new problems by using or adapting solutions that were used to solve old problems
- offers a reasoning paradigm that is similar to the way many people routinely solve problems

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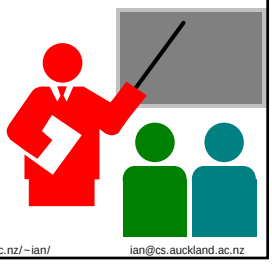
What Is CBR?

- What is 12 x 12 ?
- 144
- What is 12 x 13 ?
- *near* 12 x 12
- (12 x 12) + 12
- 156



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What is a Case?

- several features describing a problem
- plus an outcome or a solution
- cases can be rich
  - text, numbers, symbols, plans, multimedia,
- cases are not distilled knowledge
- cases are records of real events
- and are excellent for justifying decisions

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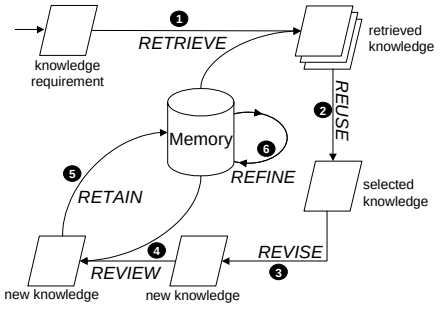
The CBR-cycle



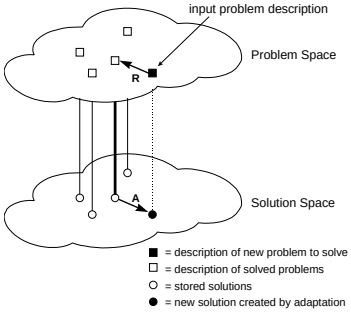
The CBR-cycle

1. Retrieve a set of similar cases from the case-base (these cases are usually ranked by similarity)
2. Attempt to reuse the solution suggested by the most similar case (or solution components from the similar cases)
3. If needed revise the solution to generate a new better solution

The CBR-cycle

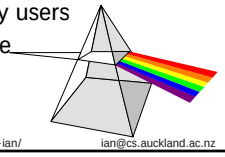
4. Review the new solution – was it better?
5. Retain the new solution (and the original problem description) in the case-base
6. Periodically maintain the case-base and refine it by editing & deleting cases, fine tuning similarity metrics and feature weightings etc....

Conceptualising CBR



CBR is Transparent

- precedent is an accepted method for justifying a decision
- *k*-nearest neighbour retrieves the best matching past *k* cases
- the process is transparent
- i.e., easily understood by users
- this increases acceptance



CBR is Transparent

- rule-based systems justify decisions by showing a rule trace
- decision grant loan because

  rule 24 -> rule 61 -> rule 43 -> rule 202
- rule traces can be confusing to users

CBR is Transparent

- Induction algorithms & neural nets and cannot justify their decisions

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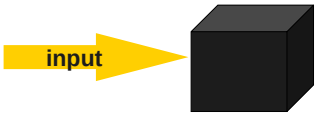
CBR is Transparent

- Induction algorithms & neural nets and cannot justify their decisions
- inputs disappear into a black box



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CBR is Transparent

- Induction algorithms & neural nets and cannot justify their decisions
- and reappear without justification

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CBR is Transparent

- Induction algorithms & neural nets and cannot justify their decisions
- users have to *trust* the computer is always correct

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CBR Systems Learn

- decision making is dynamic
- CBR systems learn by acquiring new cases
  - no addition of new rules
  - no retraining of neural networks
  - no re-induction of rules from data

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Who Uses CBR?

- American Express - credit card risk assessment
- Microsoft – help desks
- P&O – container ship engine diagnostics
- General Electric – train diagnostics, plastic fabrication
- British Airways – plane maintenance
- Daimler Chrysler – software support & vehicle diagnosis
- Analog – component selection
- NASA – space shuttle support
- Swiss Bank - investment management
- Deloitte Touche - fraud assessment

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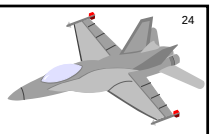
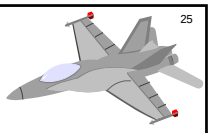
Lockheed



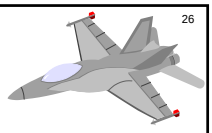
- PROBLEM - how to optimise the loading of an autoclave for curing composite materials
- different materials need different heating & cooling procedures
- materials interact with each other in the autoclave
- mistakes are VERY costly

Lockheed

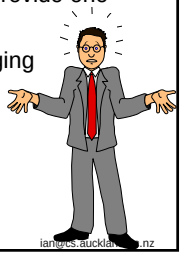


- 2 experienced operators relied on plans of previously successful layouts
- New layouts were adapted from old
- If successful they were added to a library
- they wanted to develop a decision support tool to assist experts and to retain expertise as a corporate asset

Lockheed



- Lockheed had NO model of the autoclave
- the manufacturers could not provide one
- layouts rarely repeat exactly
- materials are constantly changing
- designs constantly change
- elements interact



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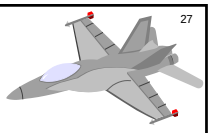
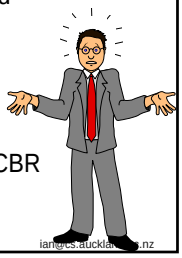


- Tried to develop a mathematical model
  - Finite element analysis failed
- Tried to develop a KBS
  - Engineers could not explain why some layouts succeed
  - Could not elicit rules
- Desperate they turned to CBR



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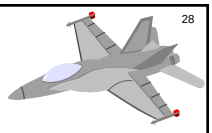
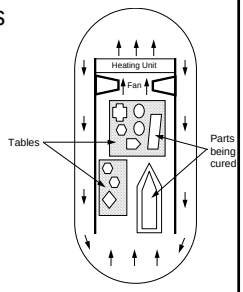


- their CBR system was implemented in 1990
  - In LISP on a Mac
  - A case is a record of:
    - part #'s
    - approx. shape
    - position in autoclave
    - autoclave settings



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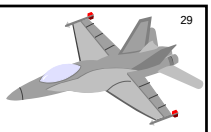

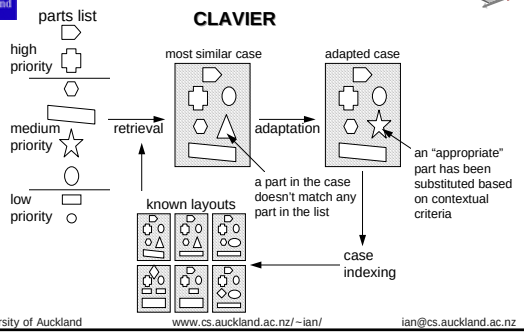

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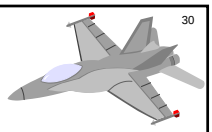

- CLAVIER could automatically adapt retrieved layouts by substituting similar parts in layouts
- But, engineers didn't like this...
- CLAVIER II presents the closest matching layout to the engineers
- Engineers make substitutions
- CLAVIER II checks the new layout is not similar to a know unsuccessful layout

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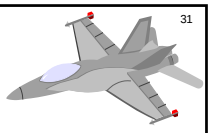
Lockheed



- CLAVIER started with just 20 successful layouts
- CLAVIER now has hundreds of successful layouts
- Its use results in successful layouts over 90% of the time
- acts as a corporate memory

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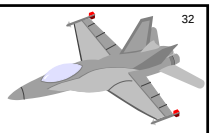
Lockheed



- "Clavier has been in continuous daily use at Lockheed's Composites Fabrication facility in Sunnyvale, California since September 1990. Two or three autoclave loads are cured per day in this facility, all of which are selected through operator consultations with CLAVIER. The system has recently been expanded for use in other Lockheed manufacturing facilities, and negotiations are under way for licensing the software to other aerospace companies...Since CLAVIER came on line, discrepancy reports due to incompatible loads have virtually been eliminated, savings hundreds thousands of dollars each month."
  David Hinkle and Christopher Toomey of the Lockheed AI Centre

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The Case for CBR

- CBR is intuitive - it's how we work
- no knowledge elicitation to create rules or methods
- this makes development easier
- systems *learn* by acquiring new cases through use
- this makes maintenance easy
- justification through precedent

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The Case for CBR

- CBR is easy to understand
- easy to use
- and easy to sell to management and users
- this increases the success of CBR systems

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When to Apply CBR?

- when a domain model is difficult or impossible to elicit (a weak theory domain)
- when the system will require constant maintenance
- when records of previously successful solutions exist
- or when experts can design prototypical cases

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More Info on CBR?

- www.ai-cbr.org
- www.cbr-web.org
- http://home.earthlink.net/~dwaha/