CS.760

Case-Based Reasoning 5

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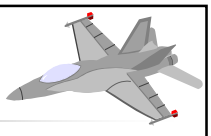
Lockheed



- 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

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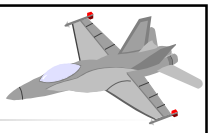
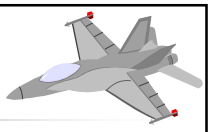
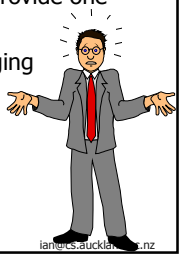


- 2 experienced operators relied on plans of previously successful layouts
- New layouts were adapted from old
- If successful they were added to a library
- they wanted to develop a decision support tool to assist experts and to retain expertise as a corporate asset

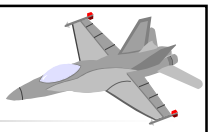
Lockheed



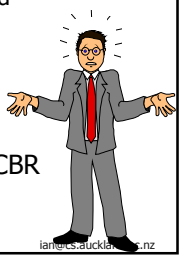
- Lockheed had NO model of the autoclave
- the manufacturers could not provide one
- layouts rarely repeat exactly
- materials are constantly changing
- designs constantly change
- elements interact



Lockheed



- 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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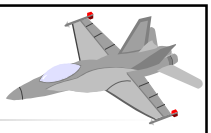
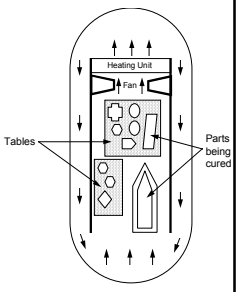


- their CBR system was implemented in 1990
  - In LISP on a Mac
  - A case is a record of:
    - part #'s
    - approx. shape
    - position in autoclave
    - autoclave settings



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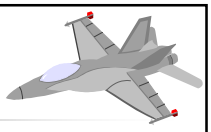

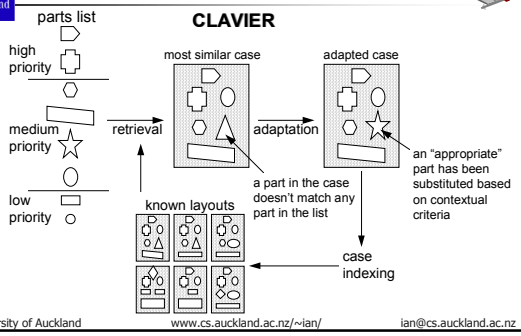

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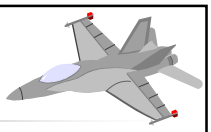
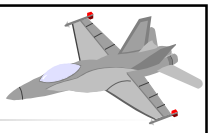


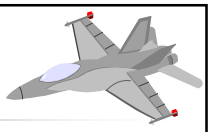
- CLAVIER could automatically adapt retrieved layouts by substituting similar parts in layouts
- But, engineers didn't like this…
- CLAVIER II presents the closest matching layout to the engineers
- Engineers make substitutions
- CLAVIER II checks the new layout is not similar to a know unsuccessful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

Lockheed



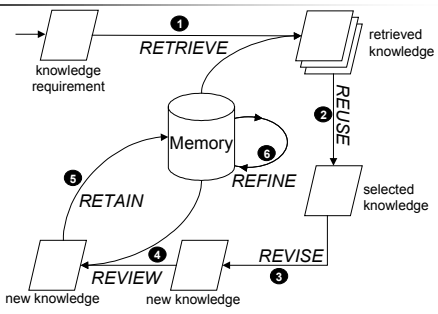
- CLAVIER started with just 20 successful layouts
- CLAVIER now has hundreds of successful layouts
- Its use results in successful layouts over 90% of the time
- acts as a corporate memory

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

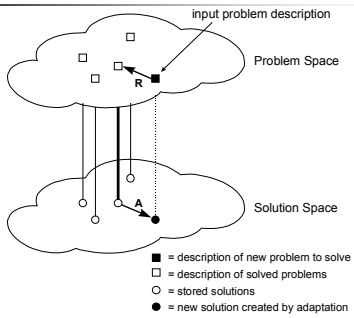
The CBR-cycle



Adaptation (revision)

- Assumptions
  - Similar problems have similar solutions
  - The effort required to adapt a solution will be less the more similar it is to the required solution

Adaptation



Adaptation methods

- Null Adaptation
  - No modification of the solution: just use the solution of the closest matching problem – used by CBR-Lite systems
- Manual/interactive adaptation
  - The user takes the solution of the closest matching problem using it as a basis of a new solution

Adaptation methods

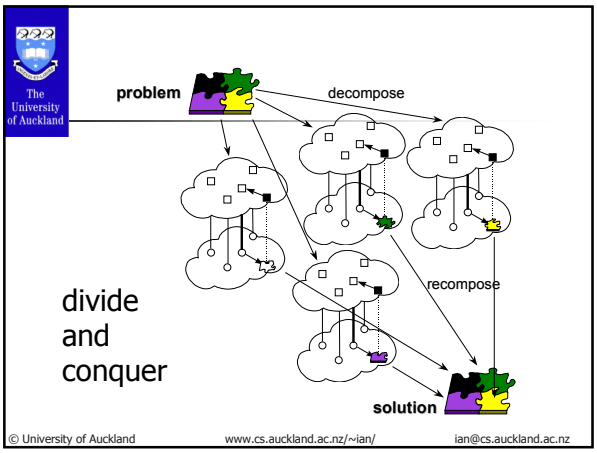
- Automatic solution adaptation
- Transformational Analogy:
  - Rules or operators adjust solution w.r.t. similarities and differences in the problems
  - Knowledge is required about the impact of differences
  - CHEF
    - snow peas and broccoli are both green crispy vegetables
    - spinach and bok choy are both green leafy vegetables

Adaptation methods

- Automatic solution adaptation
- Derivational Analogy
  - replay the problem solving method from the retrieved problem
  - Knowledge required about how to solve the problem in principle
  - Useful when a significant part of the solution involves choosing the correct problem solving method

Adaptation methods

- Automatic solution adaptation
- Compositional adaptation
  - combine parts several cases to form a single solution
  - Useful for large structural cases
  - When similarity varies across the case
  - Constraints between components may be required
- Analogous to divide and conquer



divide & conquer

- critical assumptions
  - that sub-problems can be solved independently
  - that constraints between sub-solutions will not be violated
- else solutions may not just be inaccurate but dangerously incorrect

Adaptation in CBR-Works

- Provides adaptation rules
  - IF *a* THEN *b*
  - classic production rules
- Note: CBR-Works also uses *completion rules*
  - Used to complete a query
  - or fill-in missing case data

Adaptation in CBR-Works

- Vacation domain
  - If number of people wanting to travel is less than the number of vacancies
  - Then the holiday is OK
  - And price calculated on price per person

Adaptation in CBR-Works

- Demonstration…

2 Schools in CBR

- Adaptation is the most contentious issue in CBR
  - One group believe adaptation is not important to CBR since it cannot be solved using CBR (ie similarity based retrieval)
  - Others believe it is vital, without adaptation and generation of new solutions there is no reasoning in CBR (CBR = case-based retrieval)