

Case-Based Reasoning

gentle intro

Dr. Ian Watson

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- Precedent
- Decision Support
- What is Case-Based Reasoning?
 - intuitive
 - simple
 - how does CBR work?
 - transparent
 - learning



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- The Case for CBR
- CBR Tools
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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

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- you expect a product to cost the same today as it did yesterday
- companies make thousands of decisions a day
- successful decisions can be used as precedents

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

Decision Support

Decision Support

- system developers have problems
 - the knowledge elicitation bottleneck
 - decision support is dynamic
 - systems require constant maintenance
 - systems must be accepted
 - advice must be justified

Decision Support

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 - decision support is dynamic
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 - systems must be accepted
 - advice must be justified
- CBR addresses each of these problems

What is CBR?

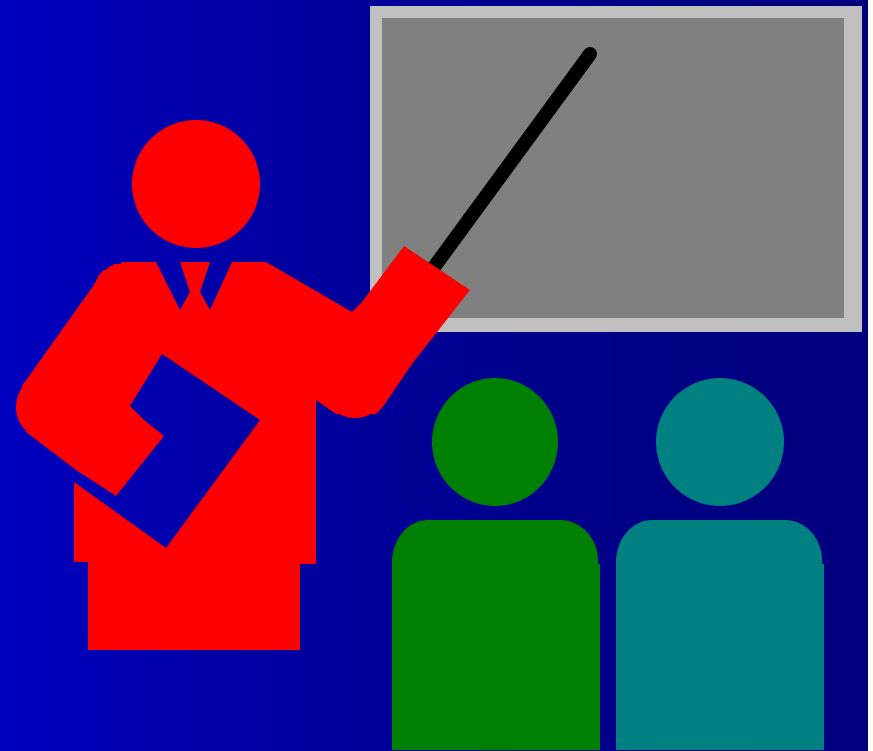
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- A case-based reasoner solves new problems by using or adapting solutions that were used to solve old problems

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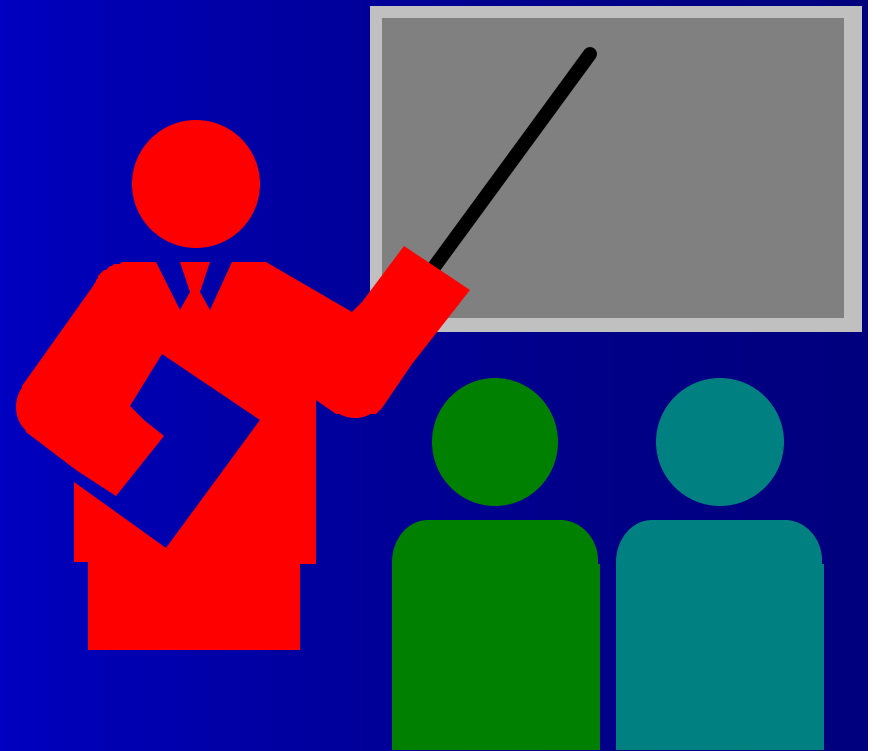
- A case-based reasoner solves new problems by using or adapting solutions that were used to solve old problems
- offers a reasoning paradigm that is similar to the way many people routinely solve problems

What Is CBR?



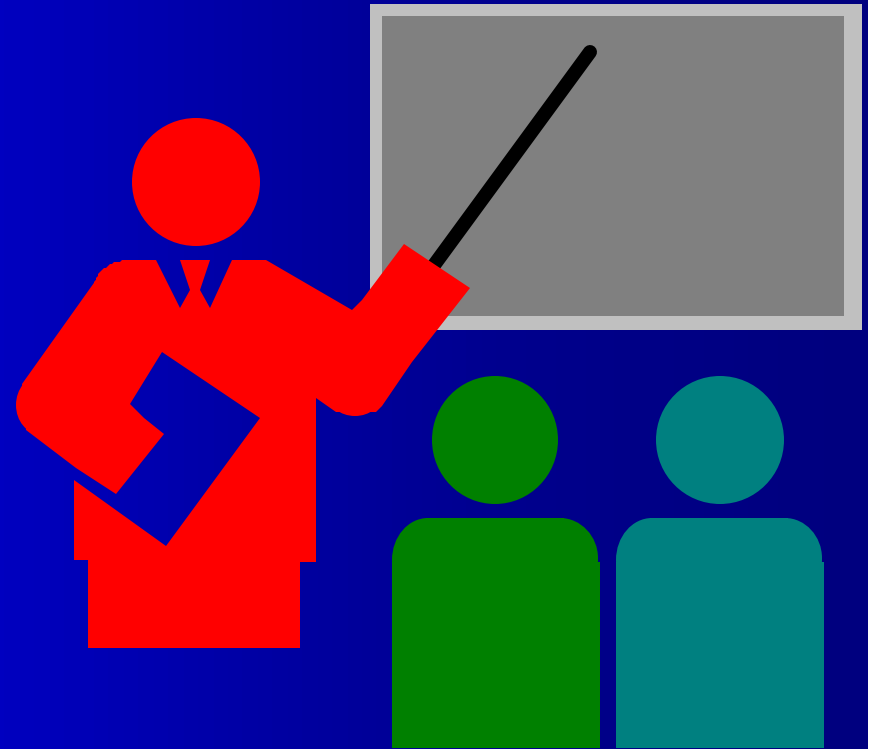
What Is CBR?

- What is 12 x 12 ?



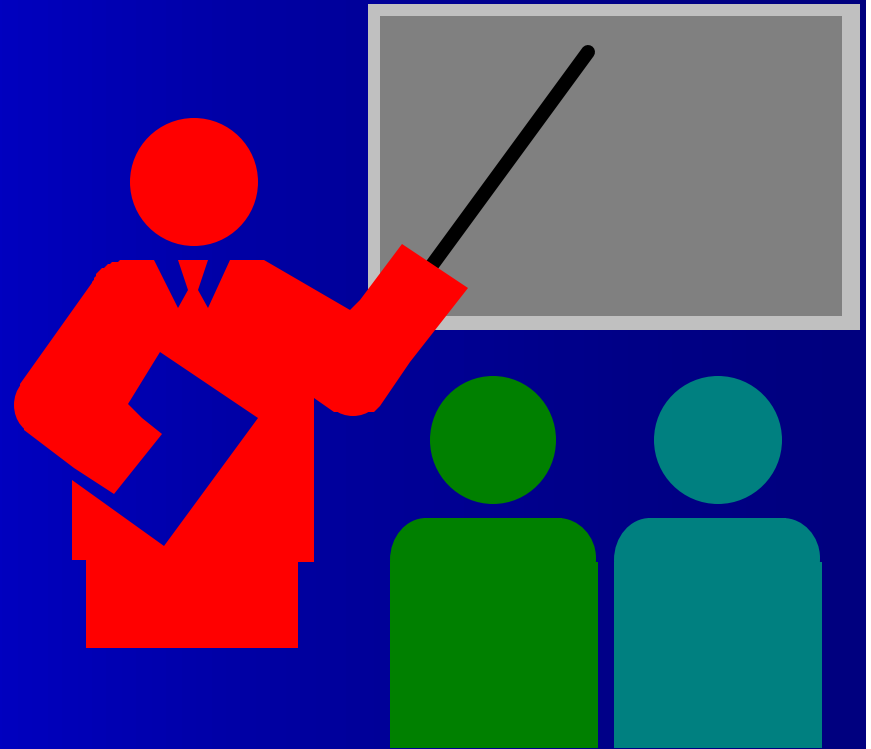
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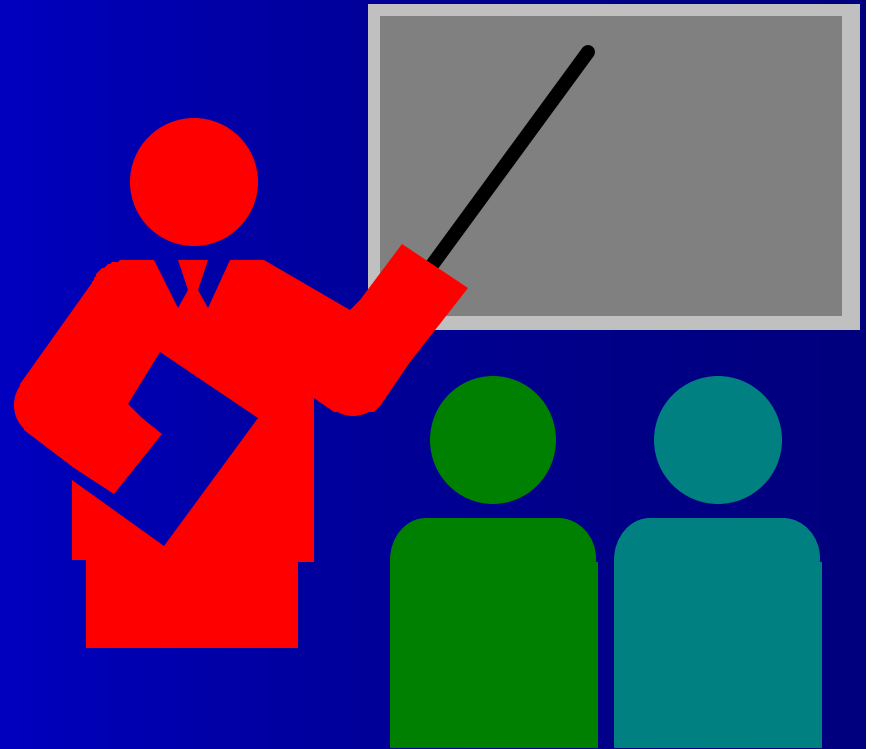
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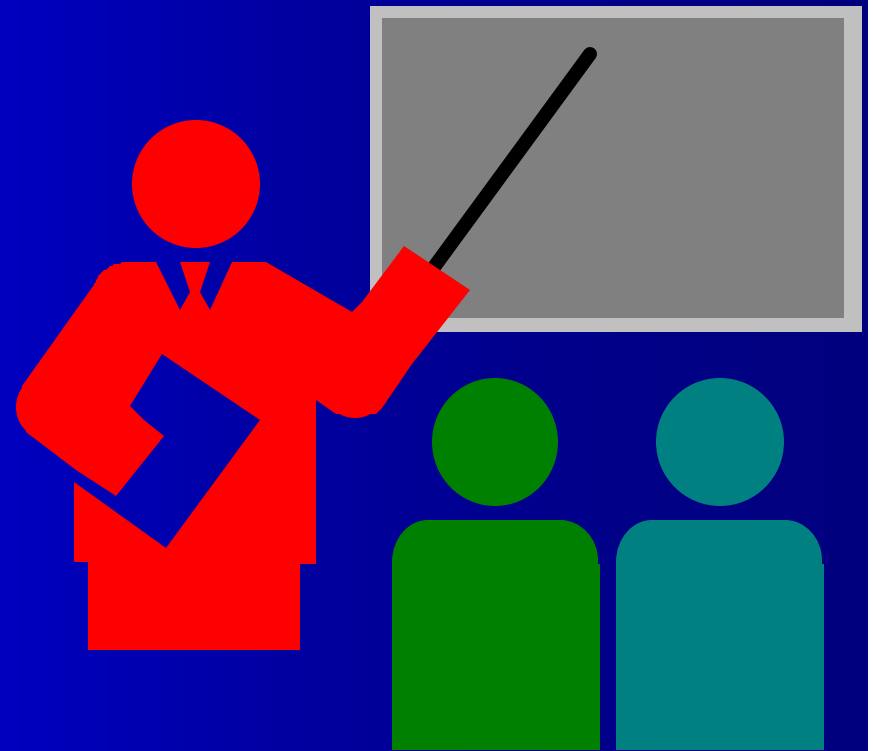
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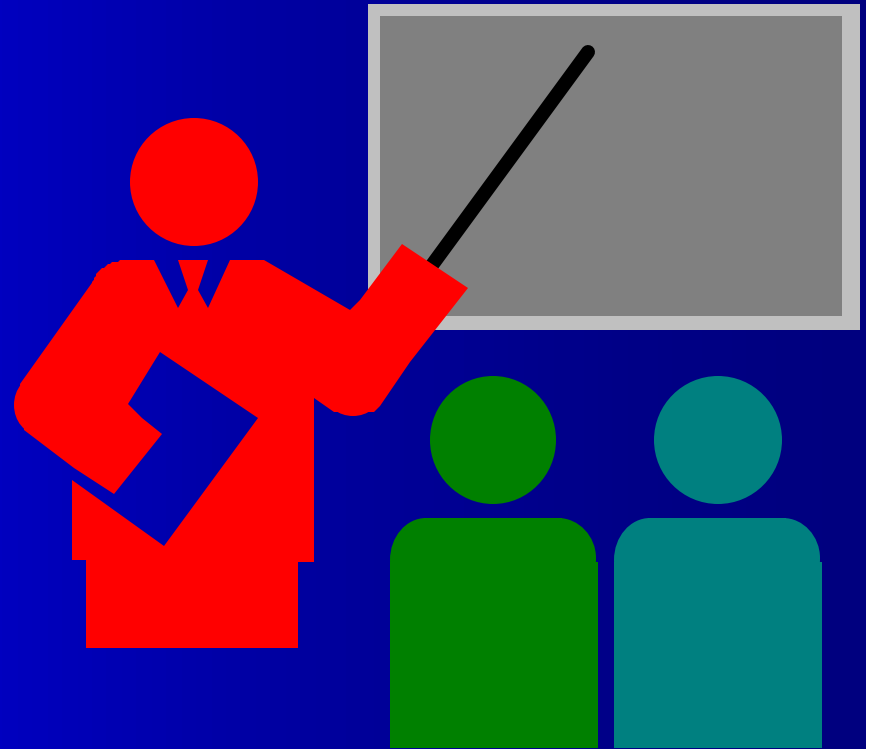
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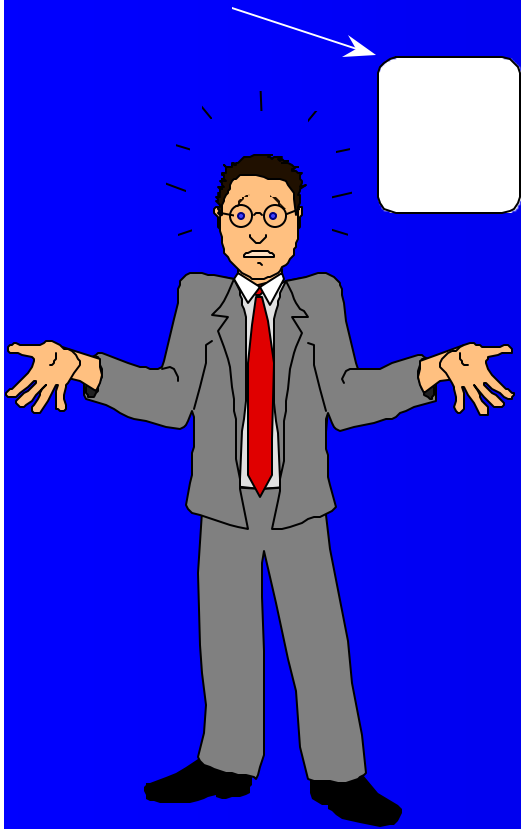
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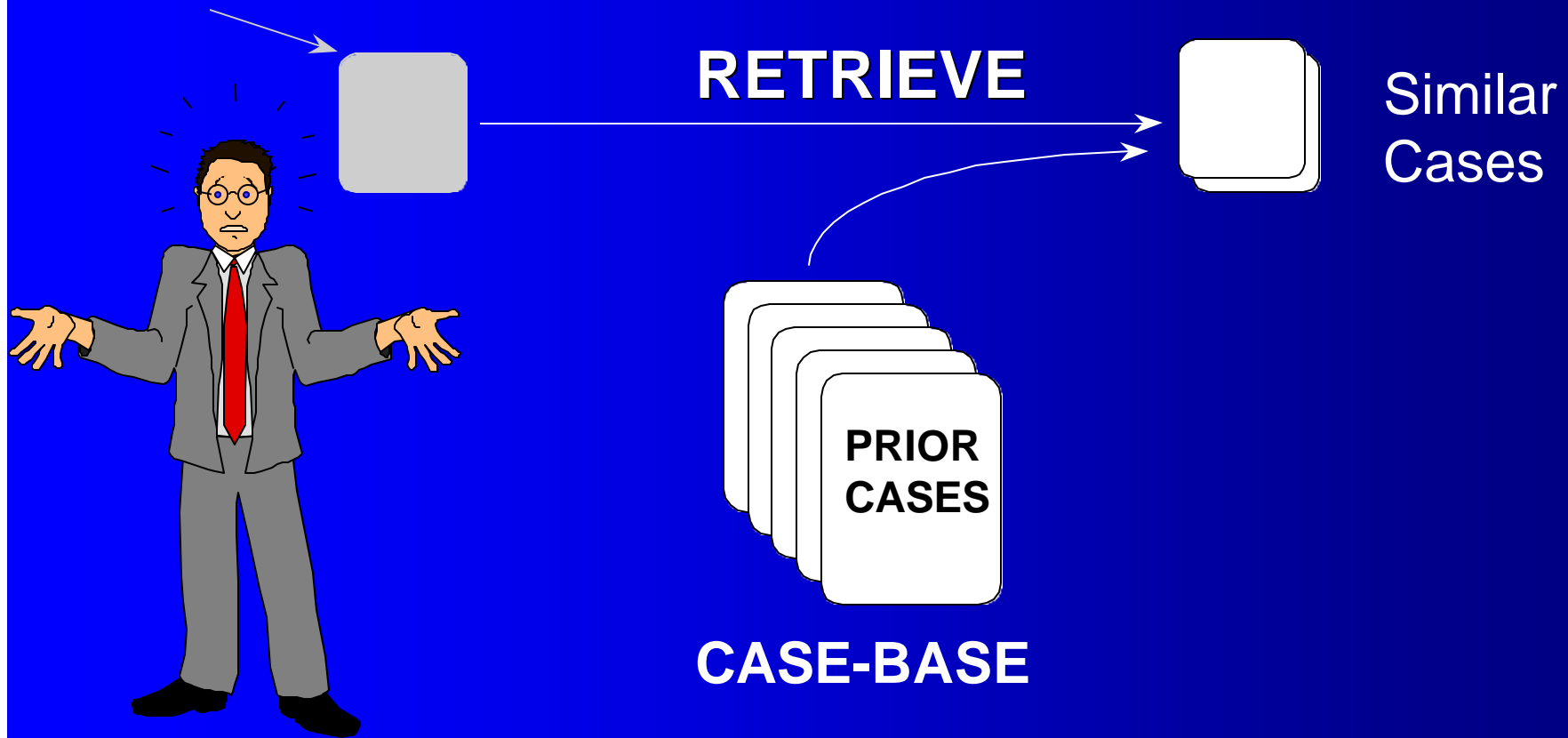
- several features describing a problem
- plus an outcome or a solution
- cases can be very rich
 - text, numbers, symbols, plans, multimedia,
- cases are not distilled knowledge
- cases are records of real events
- and are excellent for justifying decisions

The Case-Based Cycle

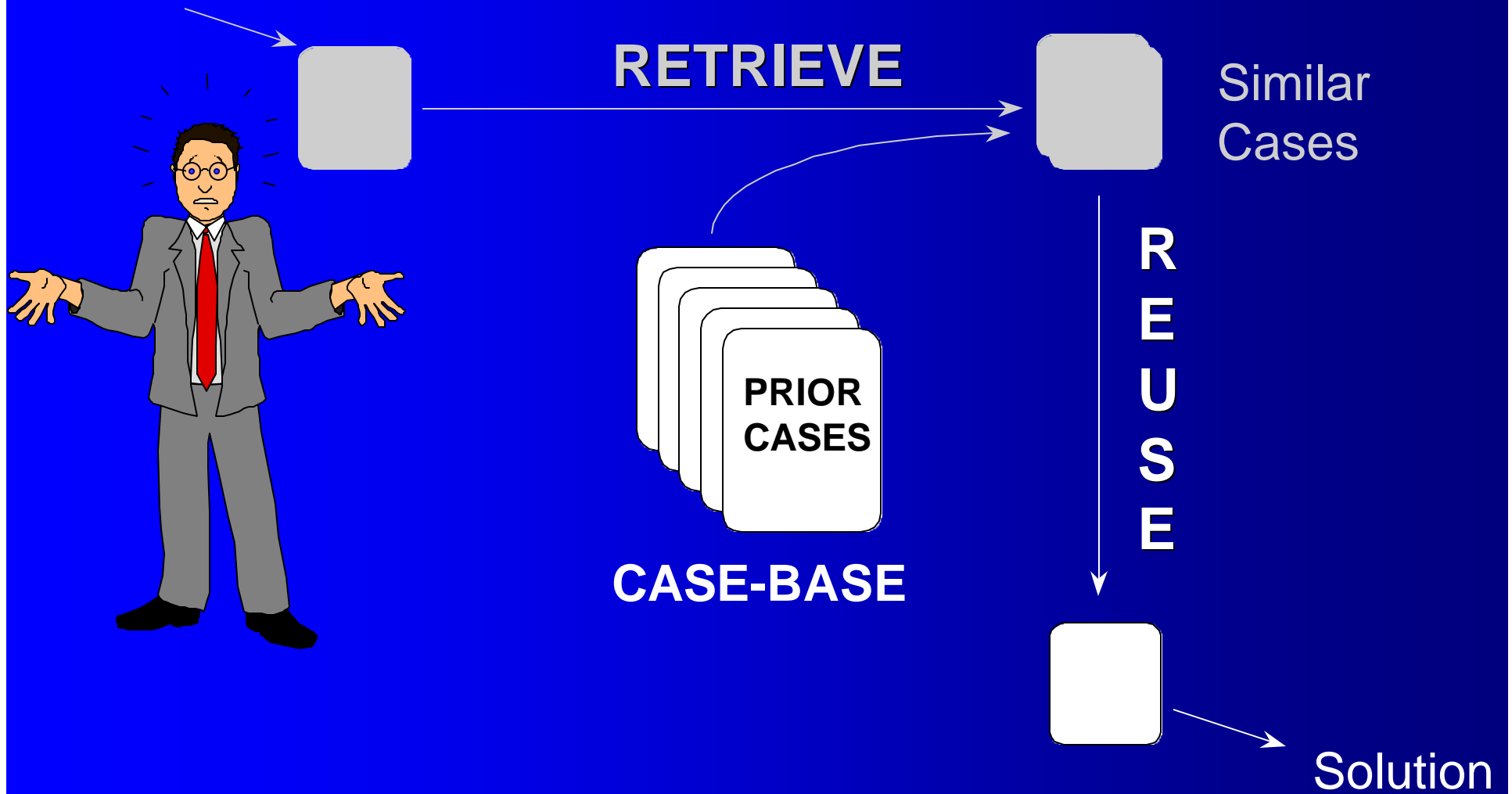
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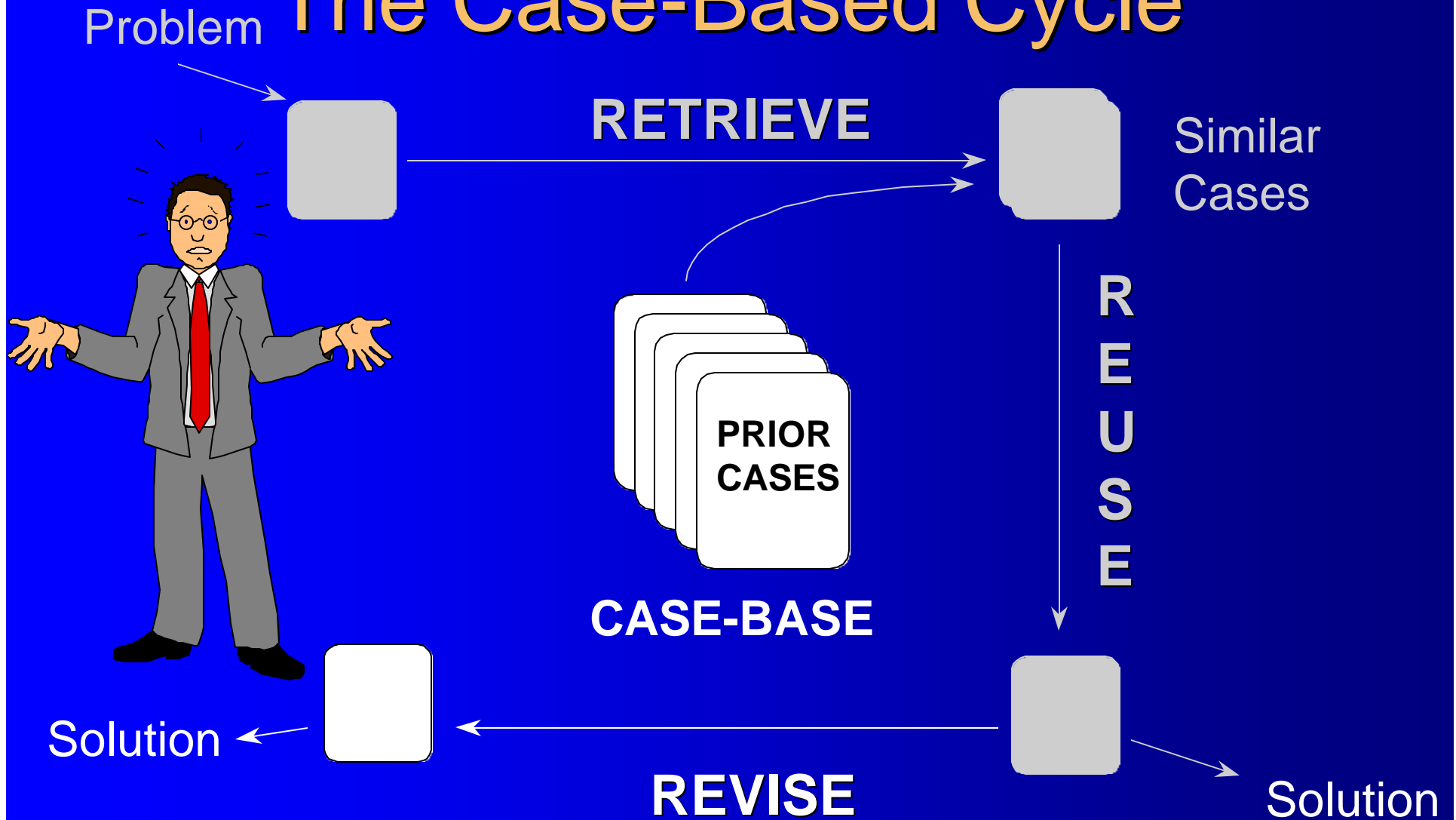
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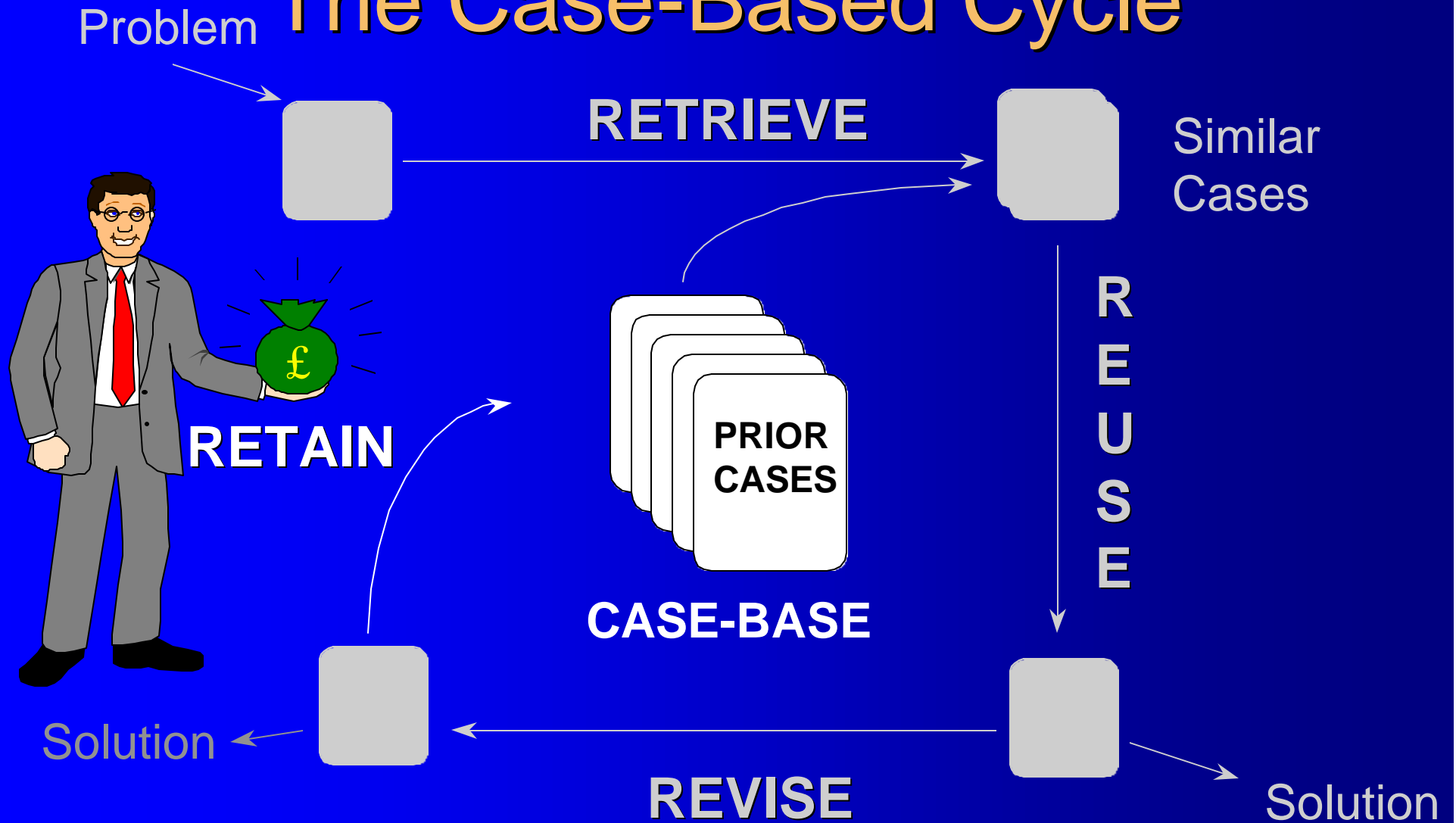
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The Case-Based Cycle



CBR is Intuitive

- this is how we routinely make decisions
- experts rely on their experience
- novices use rules and first principles
- consequently CBR is
 - easy to sell to management
 - easy to sell to users

CBR is Simple

- simple to implement
- you don't need a Ph.D. in maths, cs, logic or astro-physics
- all you need are precedents
- and simple software

How Does CBR Work?



How Does CBR Work?

- imagine a decision with two factors that influence it



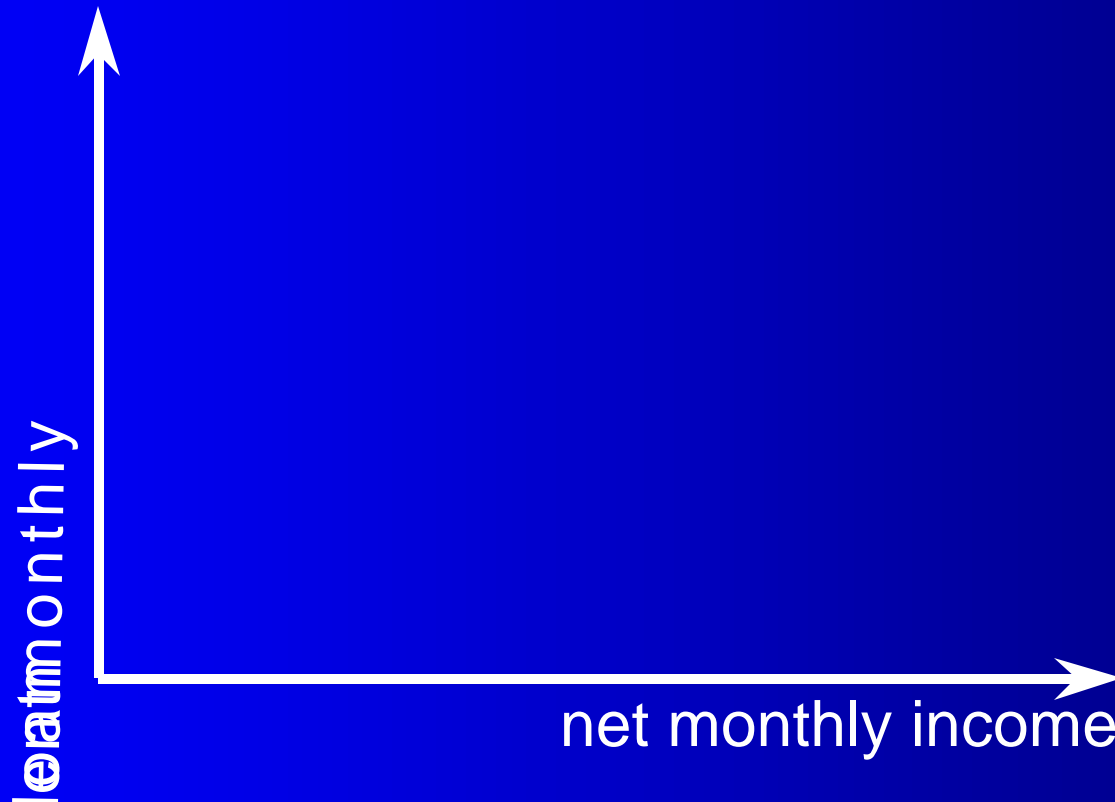
How Does CBR Work?

- imagine a decision with two factors that influence it
- should you grant a person a loan?
 - ① net monthly income
 - ② monthly loan repayment



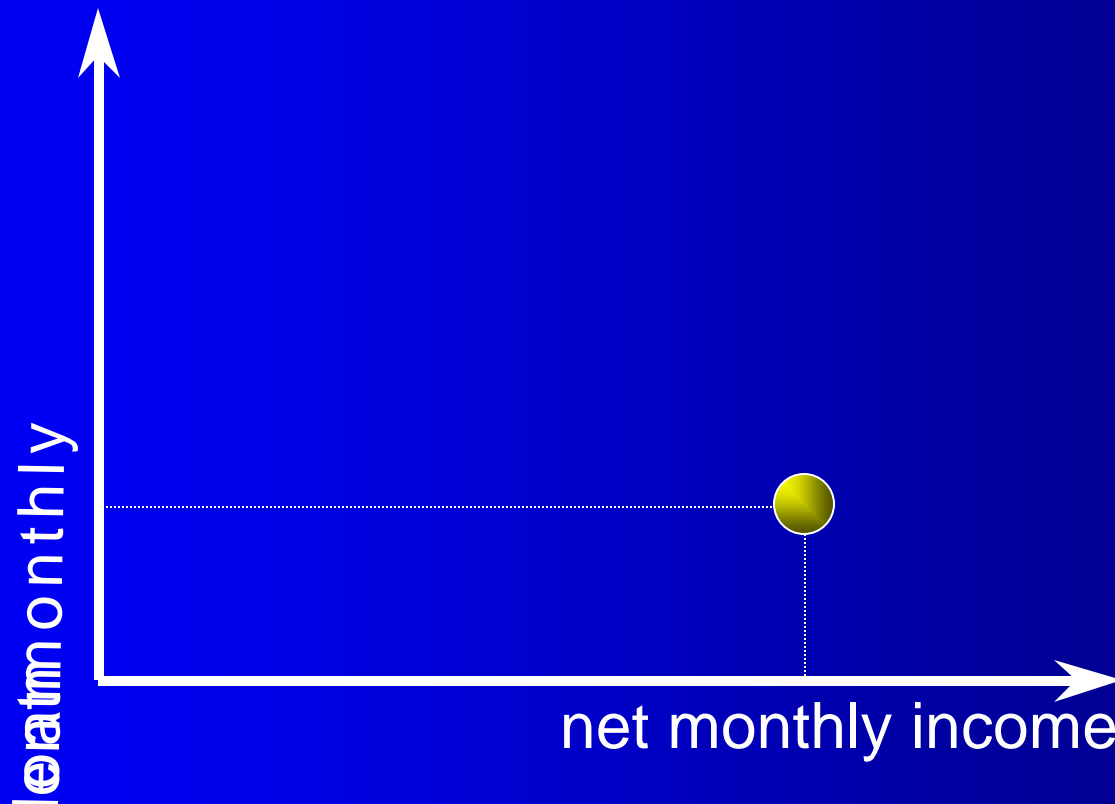
How Does CBR Work?

- these factors can be used as axes for a graph



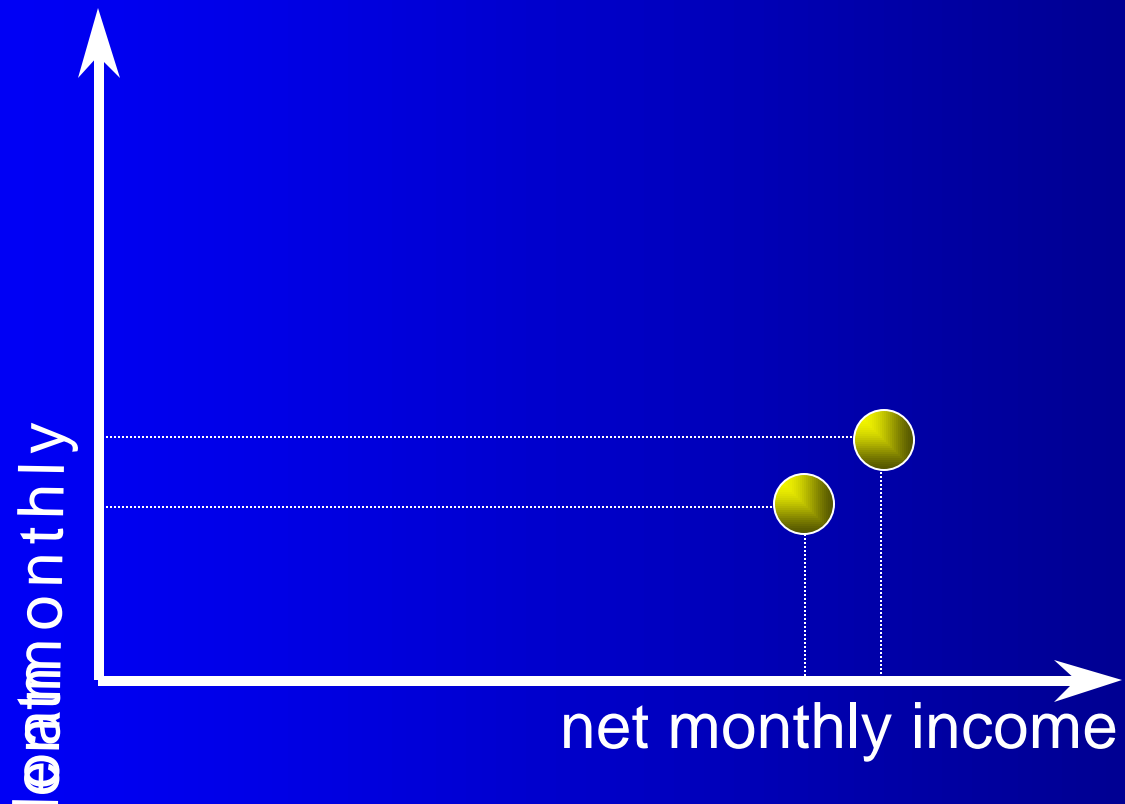
How Does CBR Work?

- a previous loan can be plotted against these axes



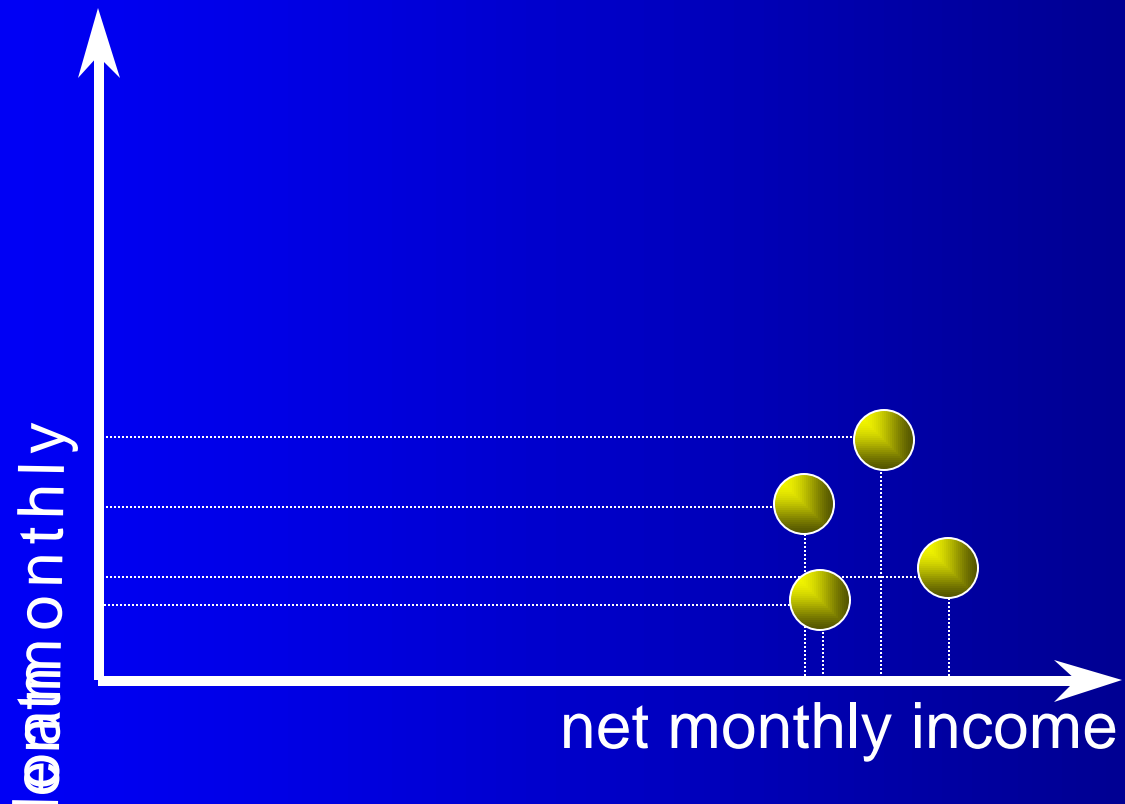
How Does CBR Work?

- and a second loan



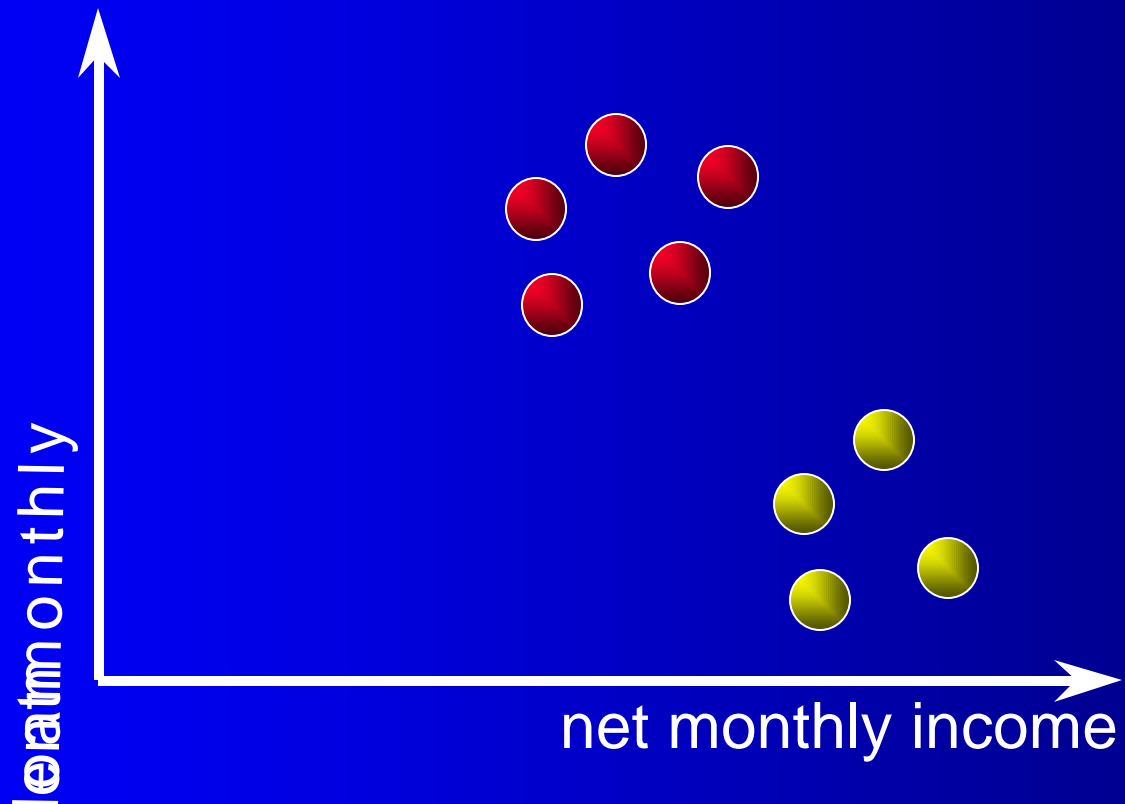
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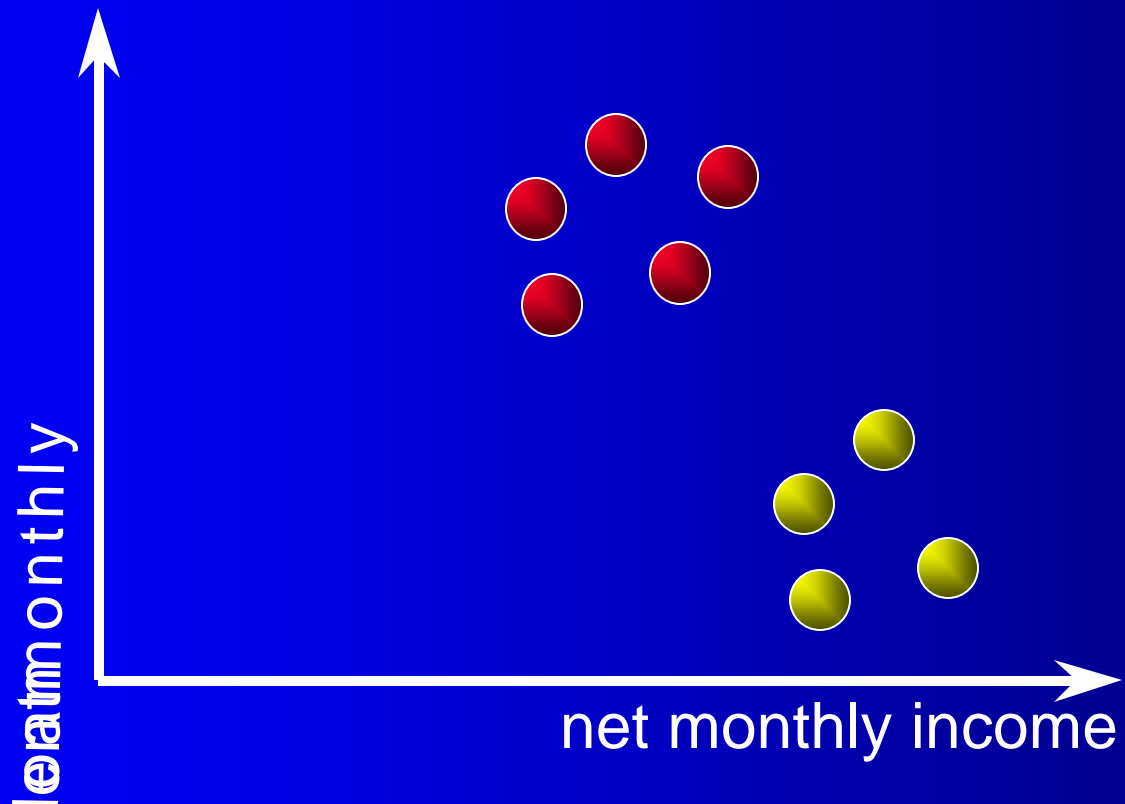
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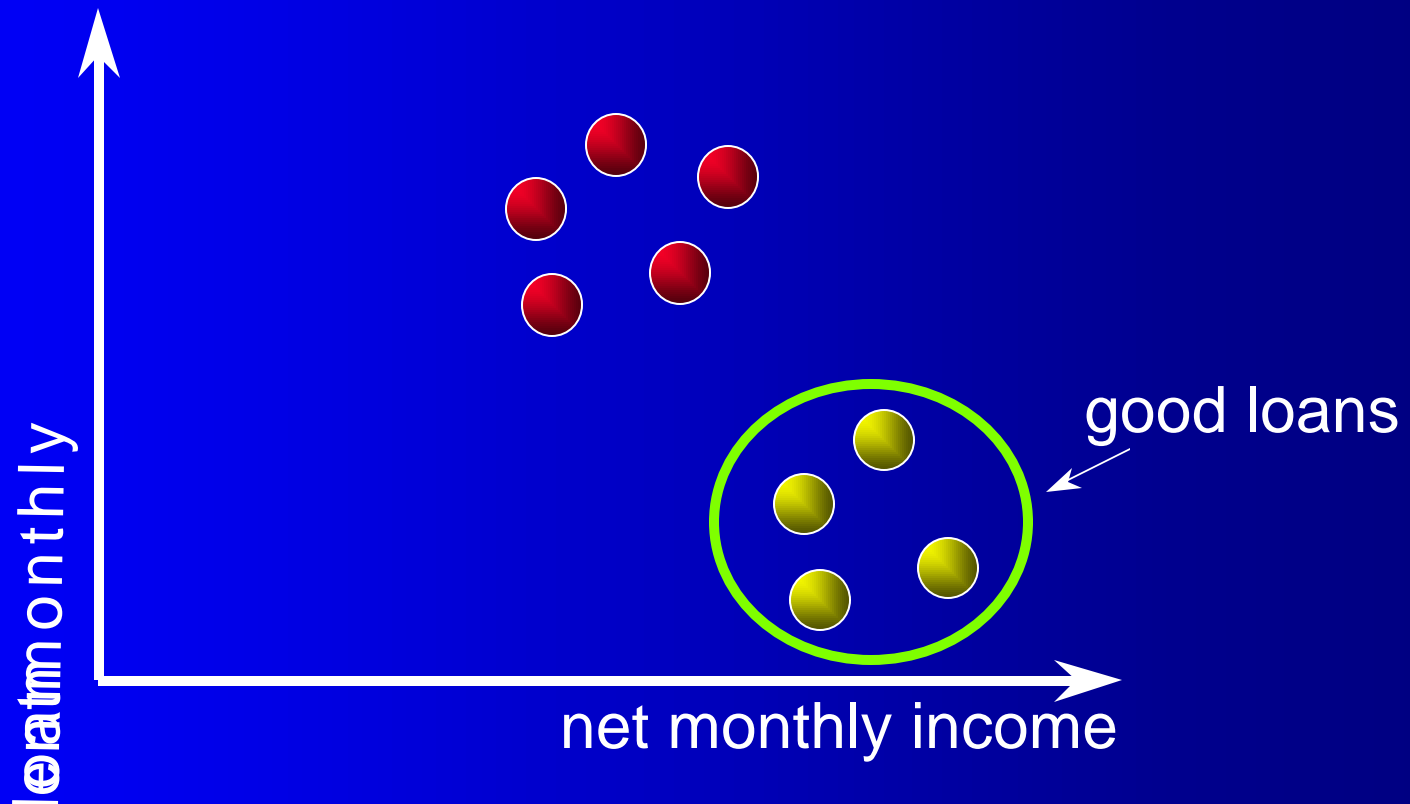
How Does CBR Work?

- past cases (loans) will naturally tend to form clusters



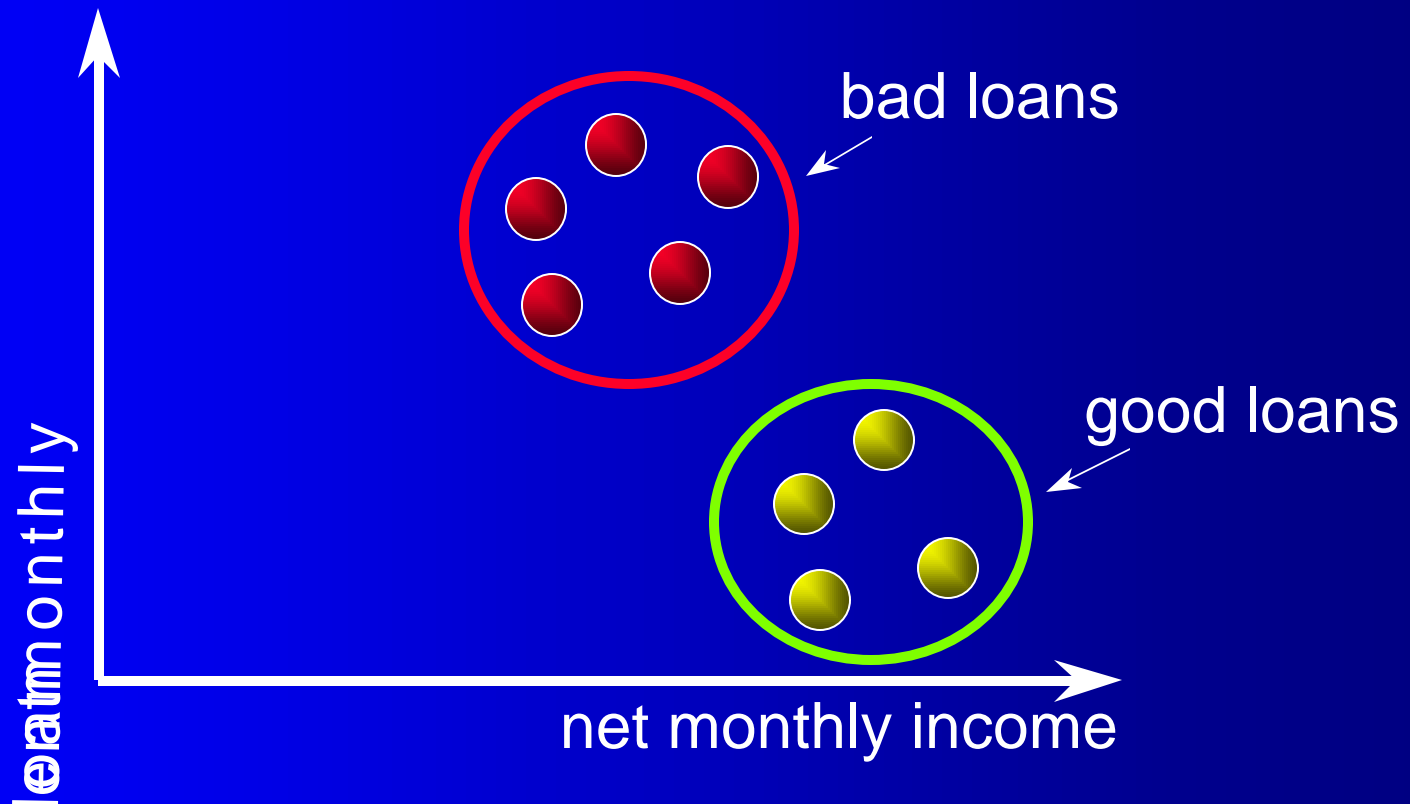
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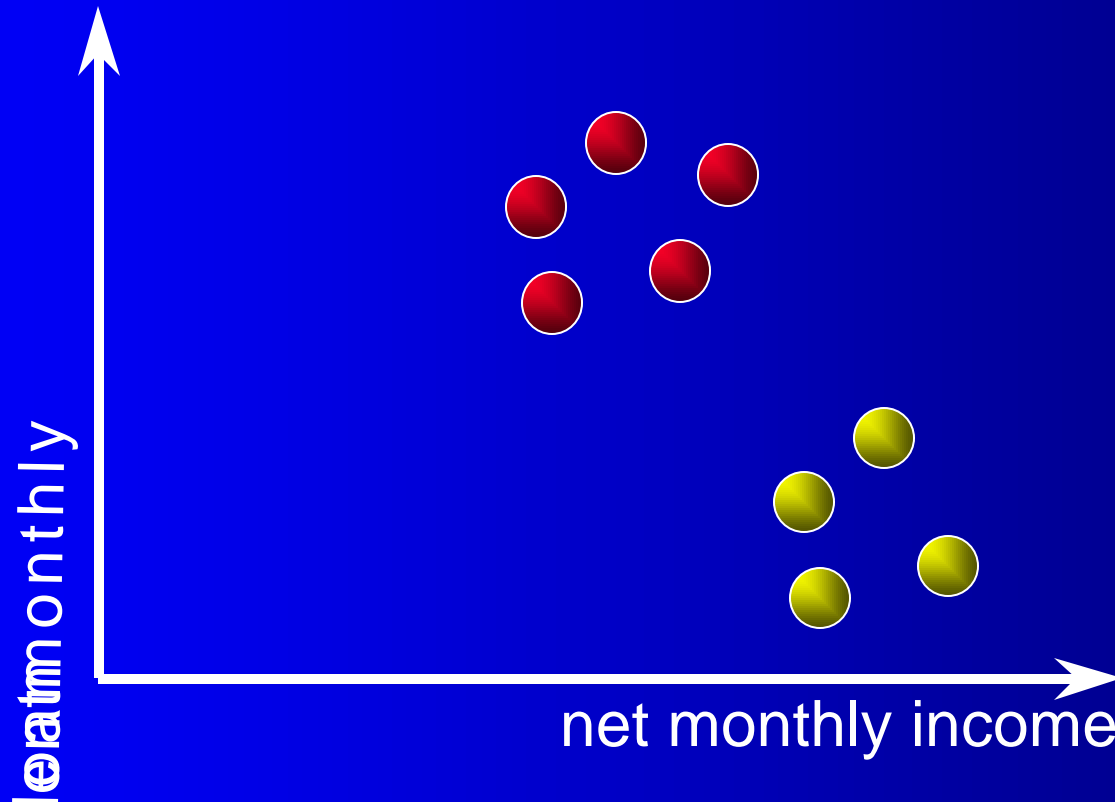
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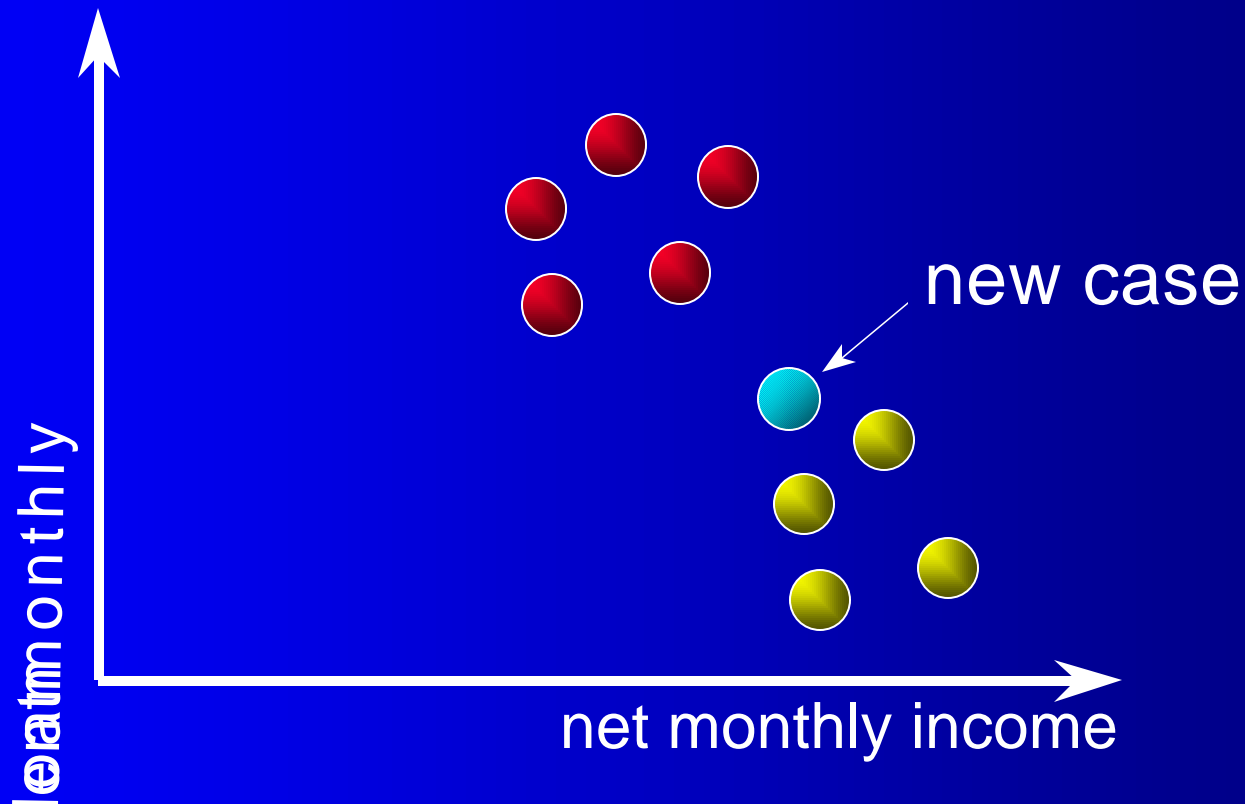
How Does CBR Work?

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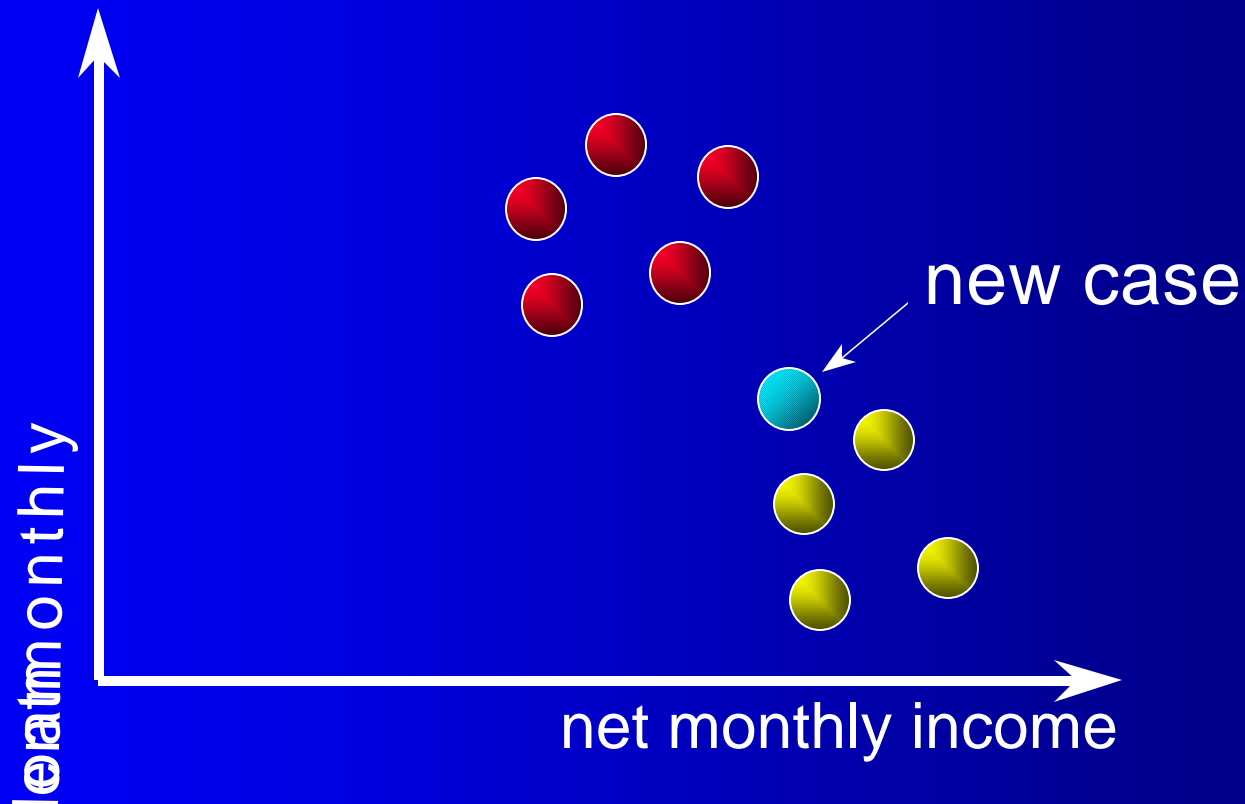
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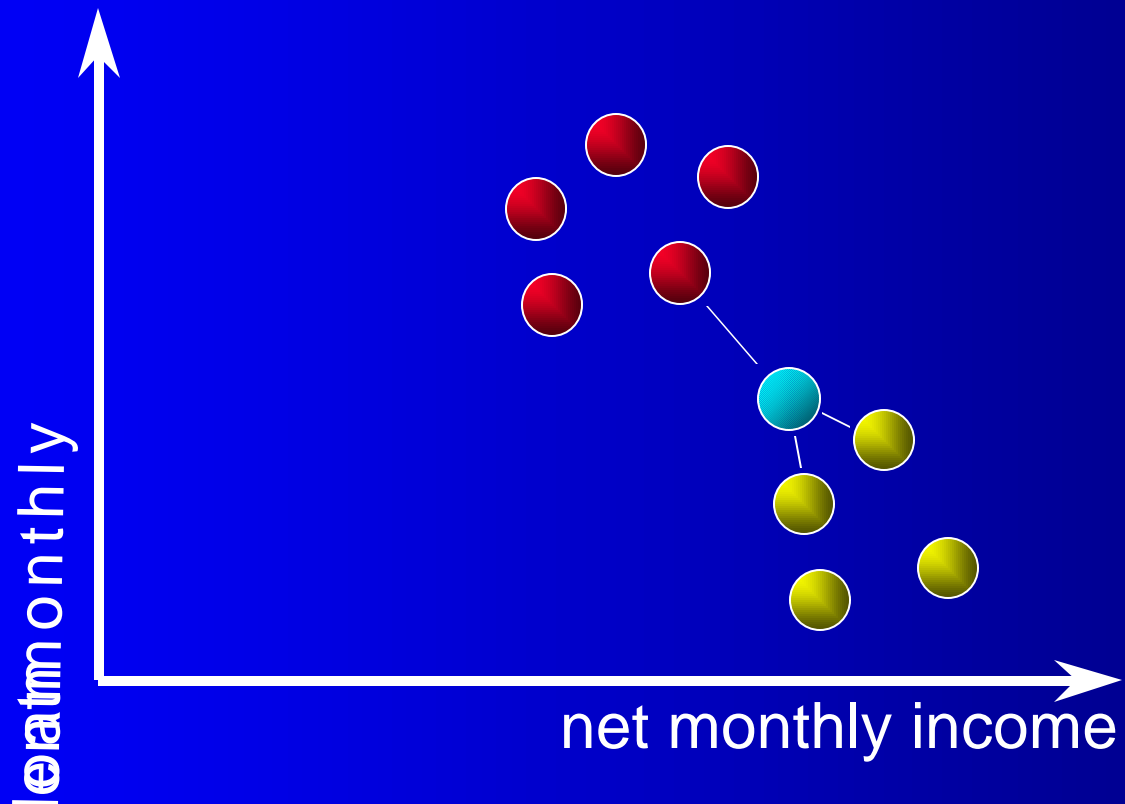
How Does CBR Work?

- and the distance to its nearest neighbours calculated



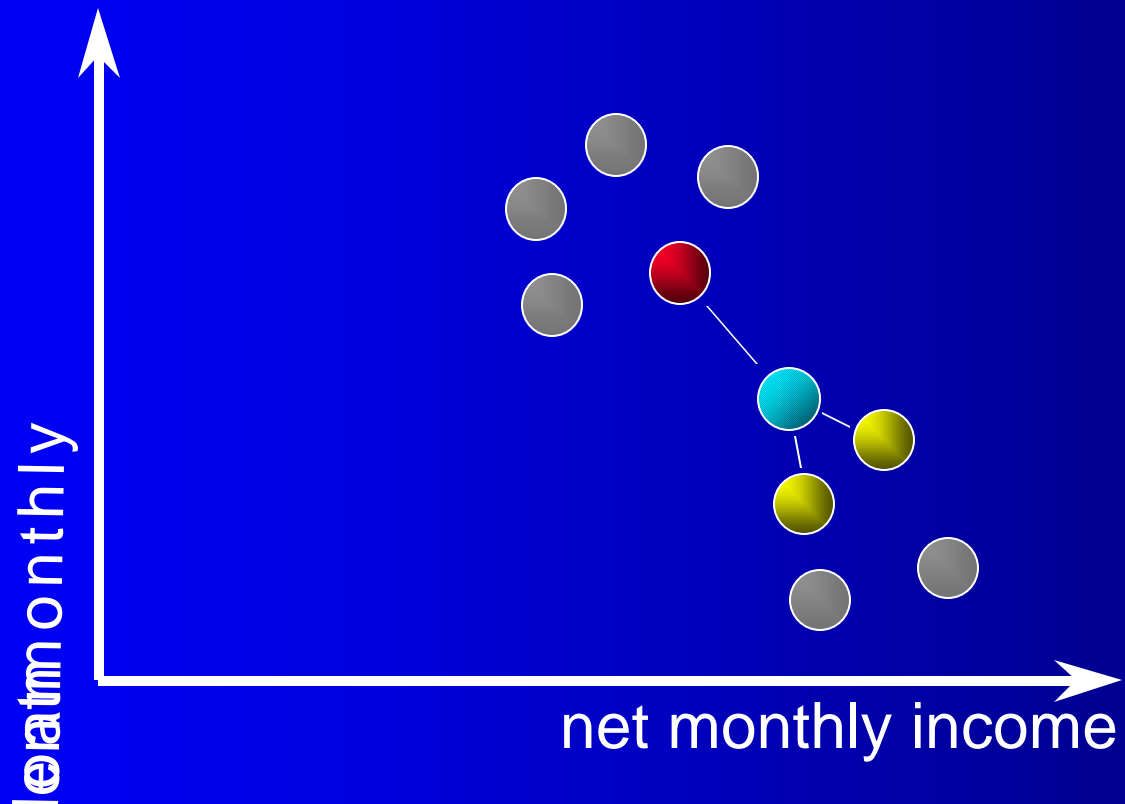
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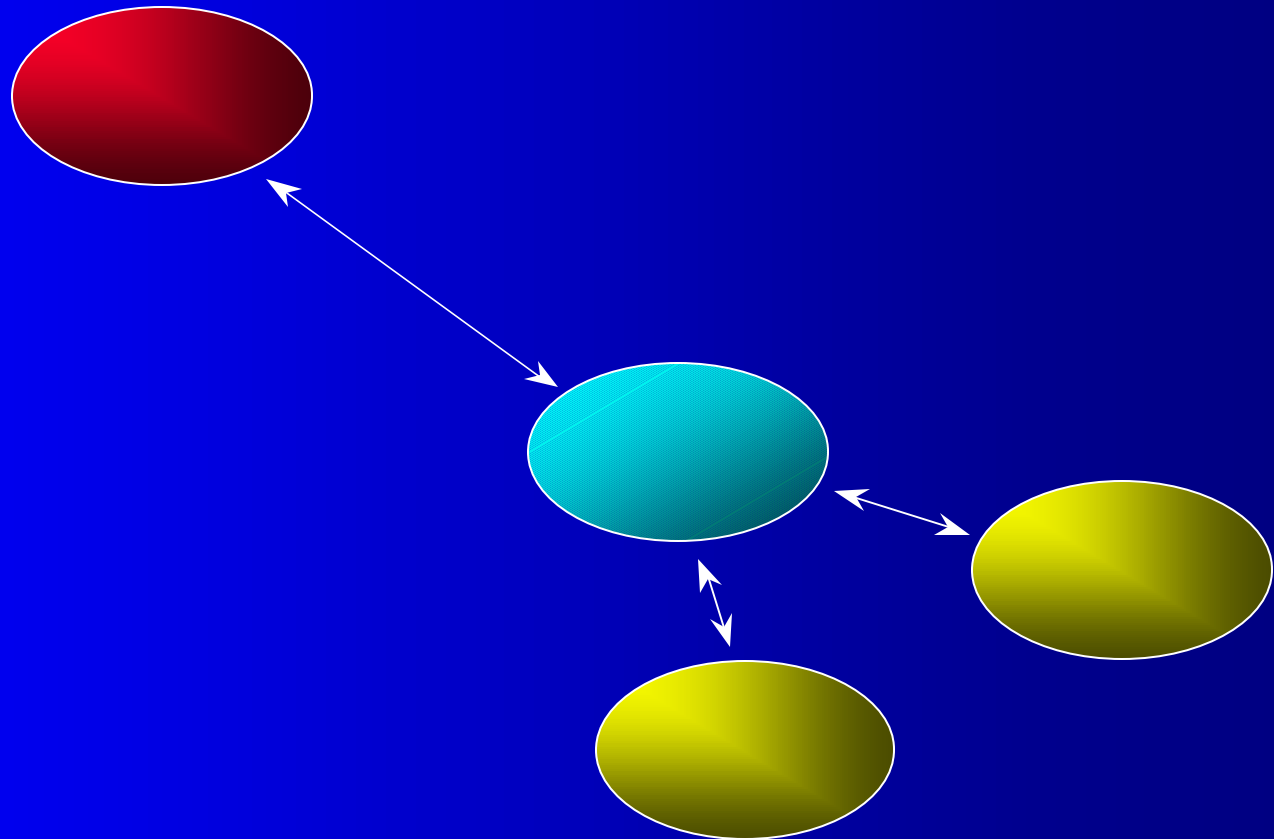
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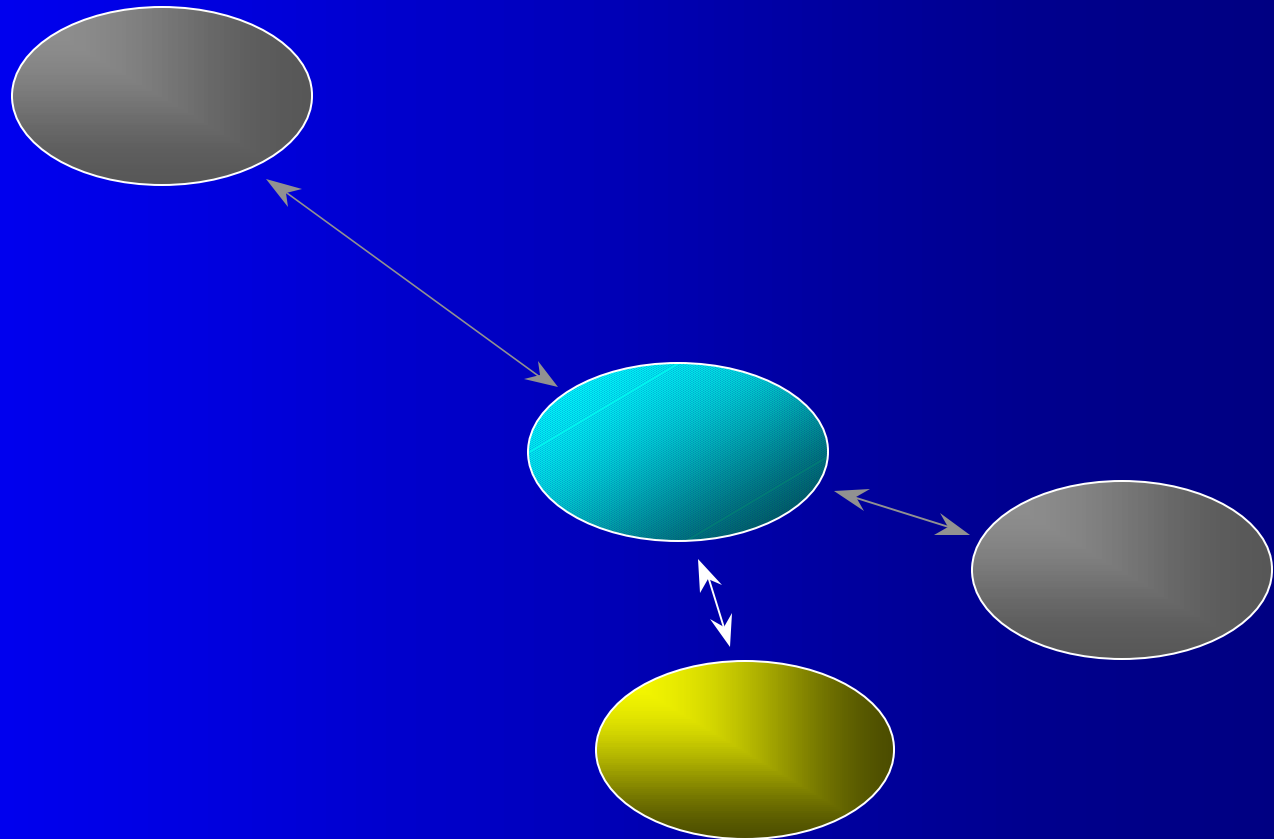
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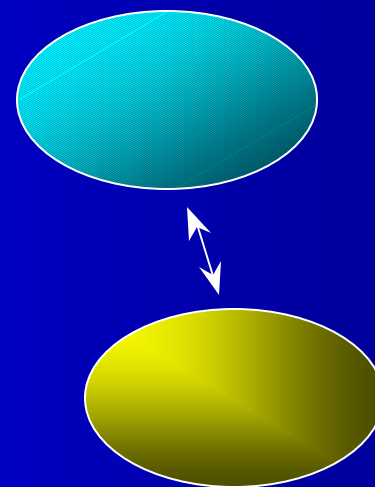
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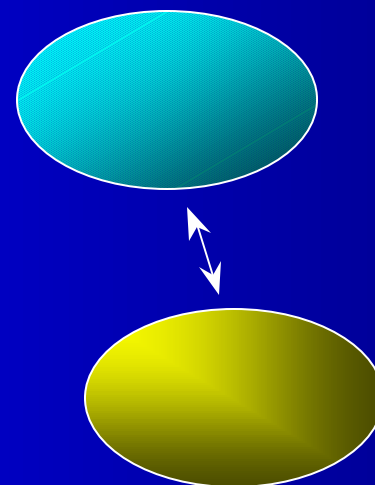
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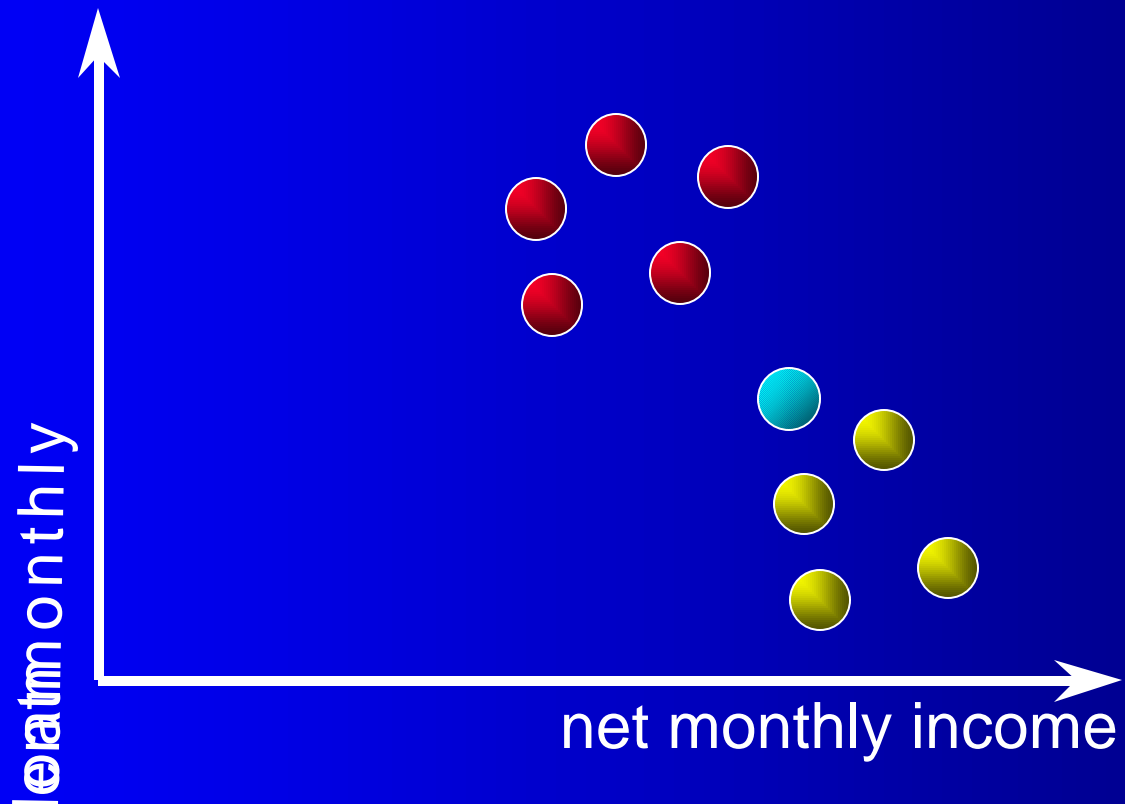
How Does CBR Work?

- this suggests a precedent
- the loan will be successful



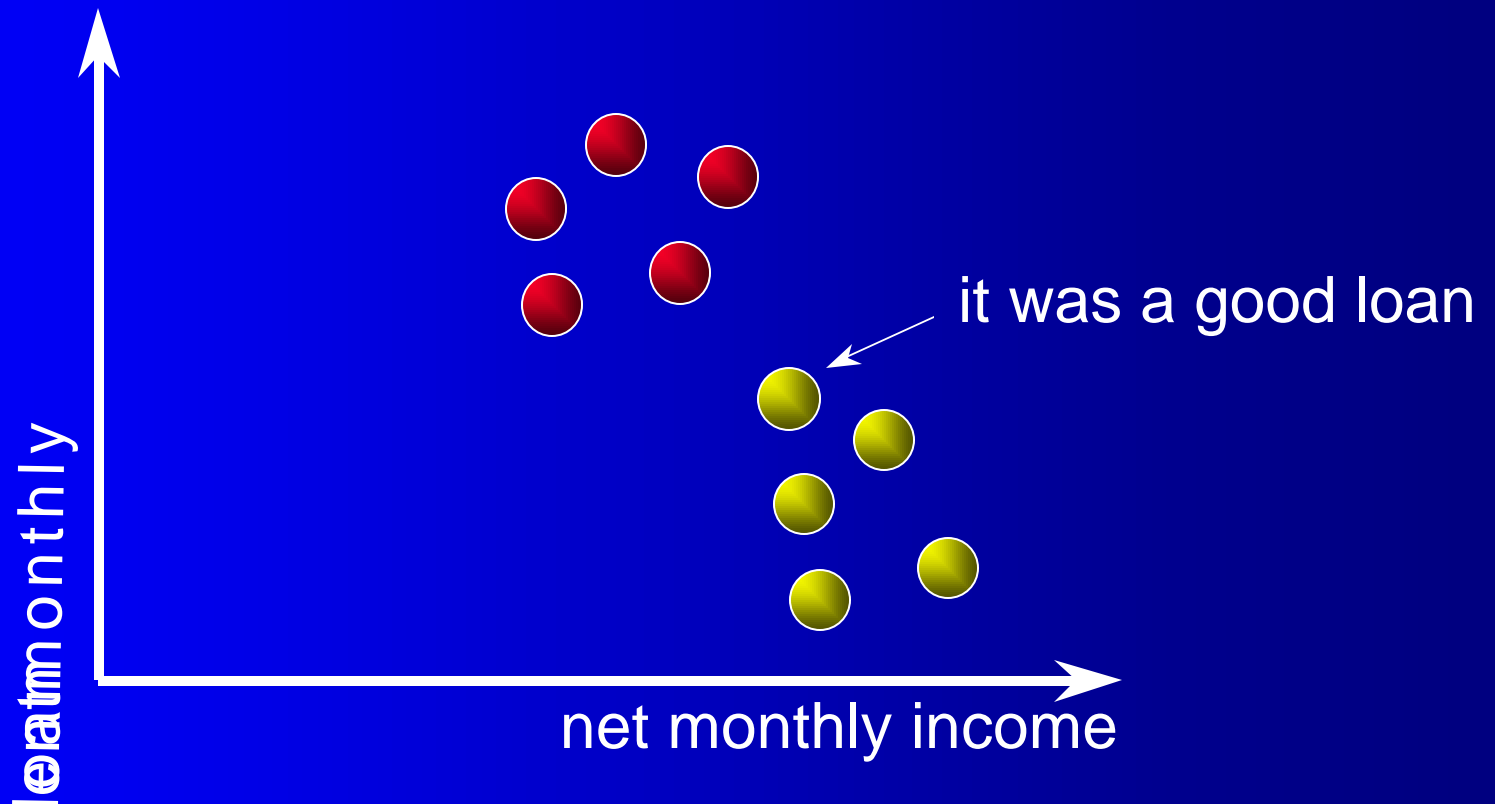
How Does CBR Work?

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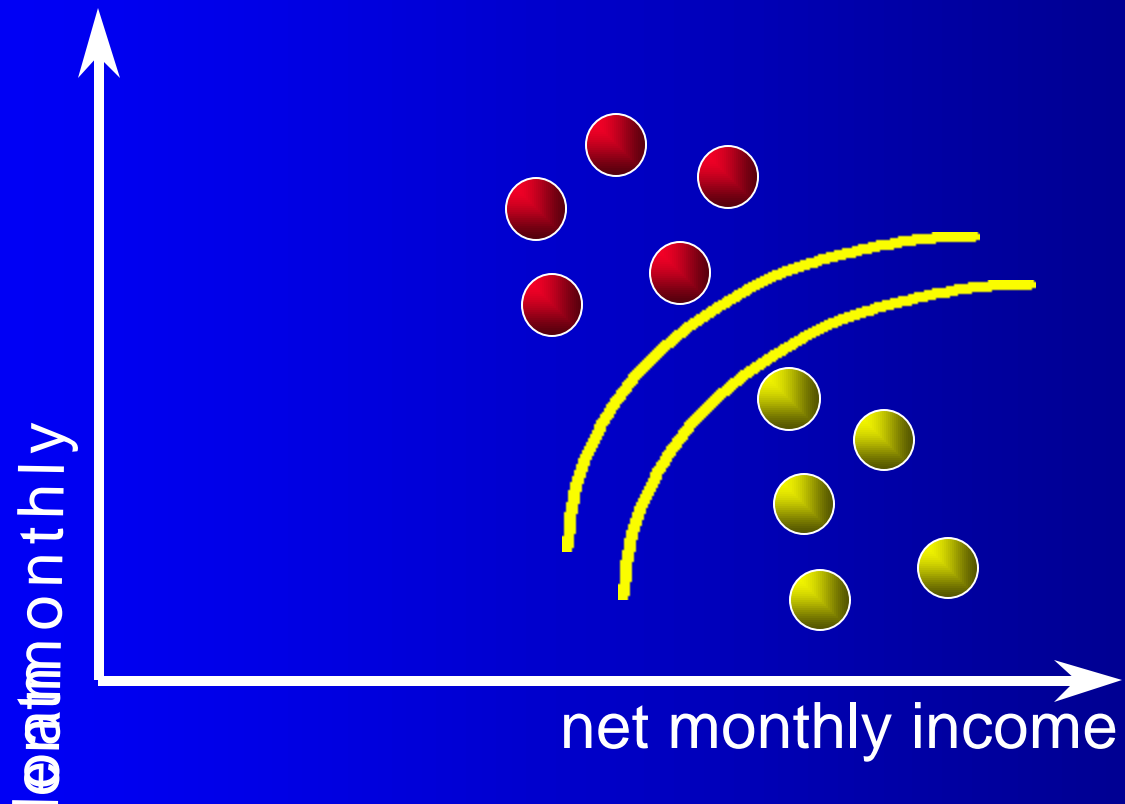
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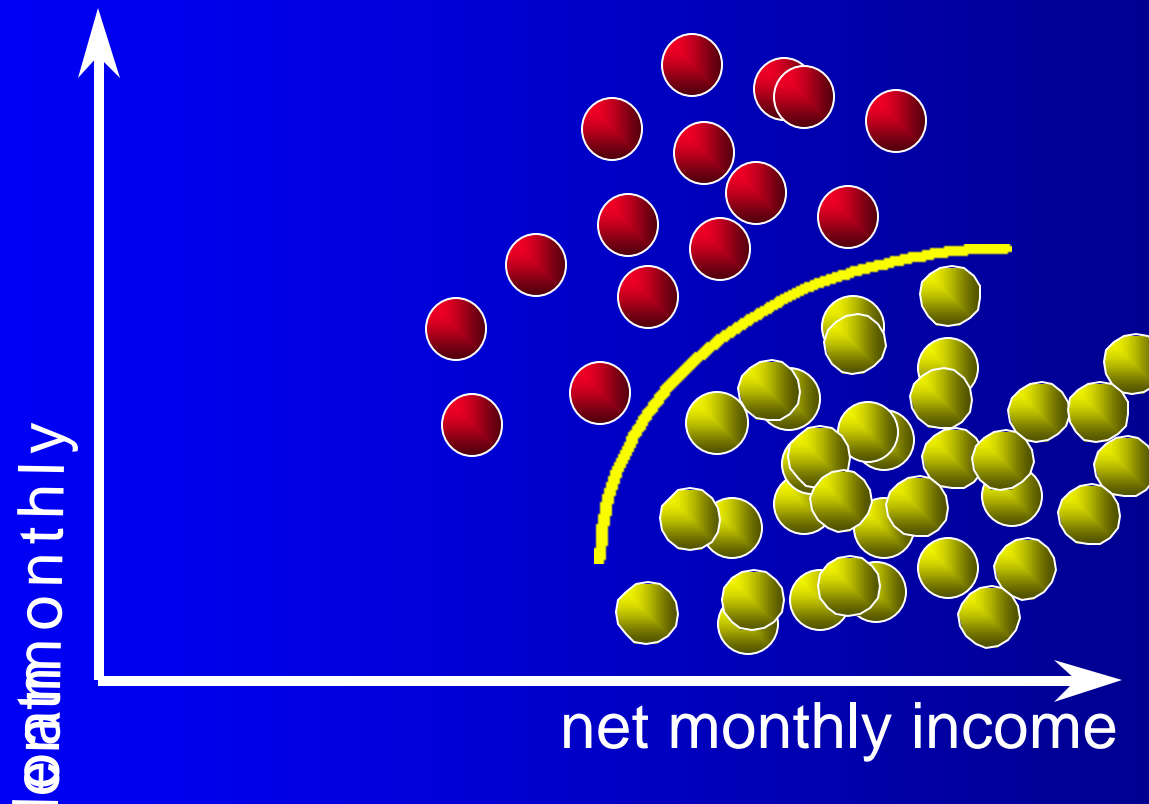
How Does CBR Work?

- the system is learning to differentiate good and bad loans better



How Does CBR Work?

- as more cases are acquired its performance improves



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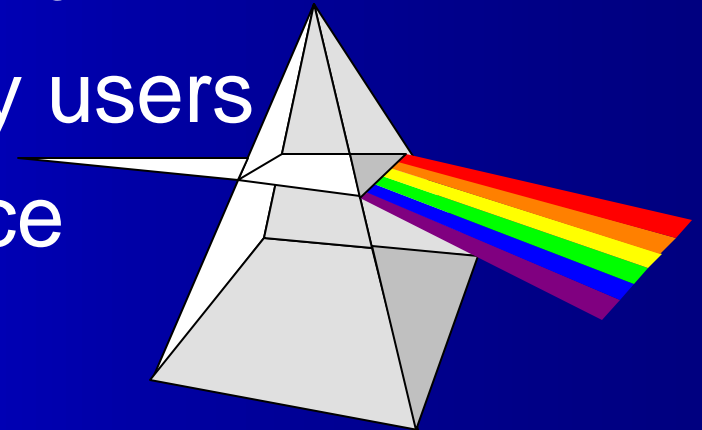
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- tolerant of noise & missing data

How Does CBR Work?

- in real life the problem space is N dimensional
- feature vectors can be weighted to reflect their relative importance
- new features can be added if they become relevant
- tolerant of noise & missing data
- termed **Nearest Neighbour** Retrieval

CBR is Transparent

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



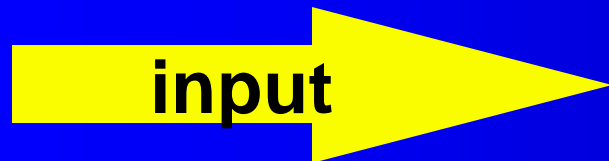
CBR is Transparent

- 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



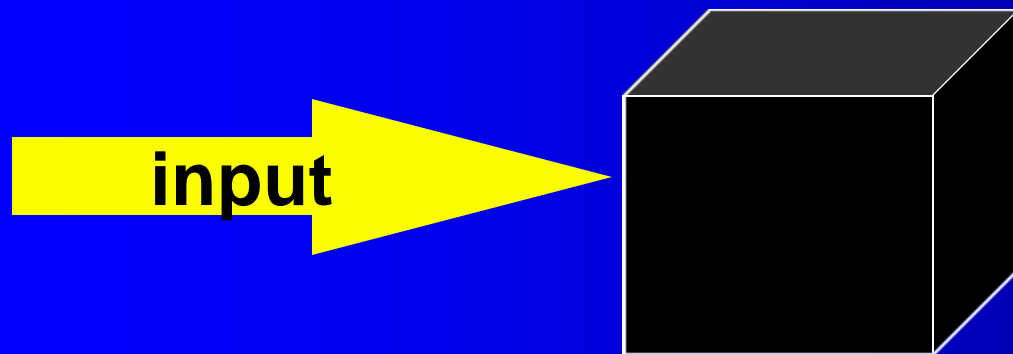
CBR is Transparent

- neural nets and genetic algorithms cannot justify their decisions



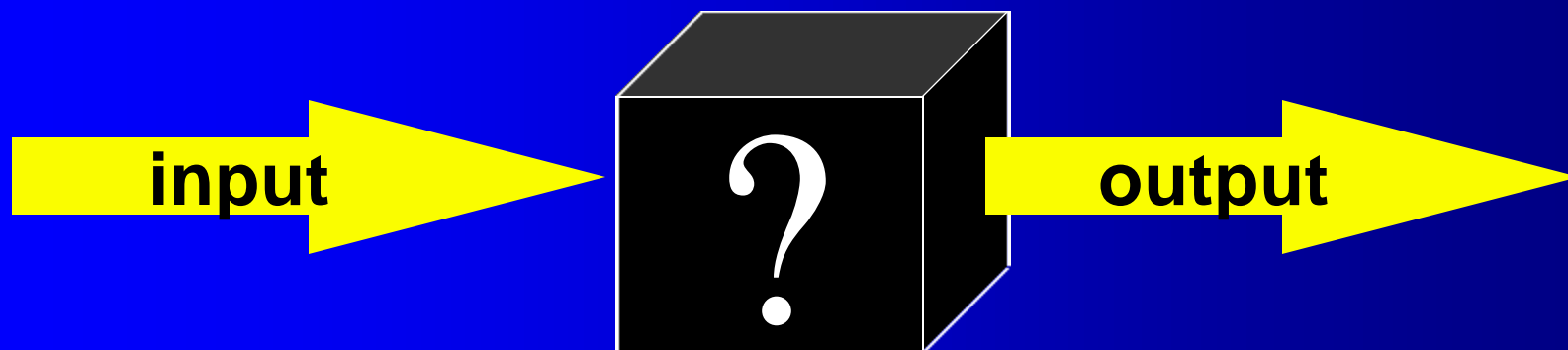
CBR is Transparent

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



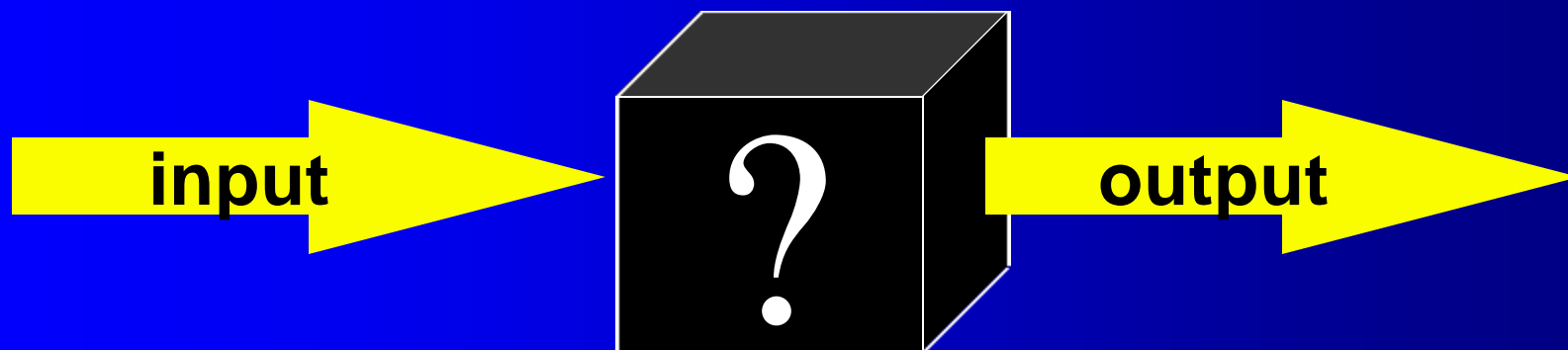
CBR is Transparent

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



CBR is Transparent

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



CBR Systems Learn

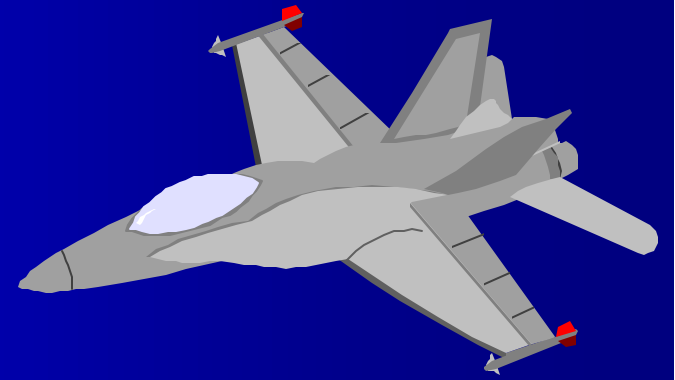
- decision making is dynamic
- CBR systems learn by acquiring new cases
 - no addition of new rules
 - no retraining of neural networks
 - no reevolving new populations with new genomes
 - no reinduction of rules from data

Who Uses CBR?

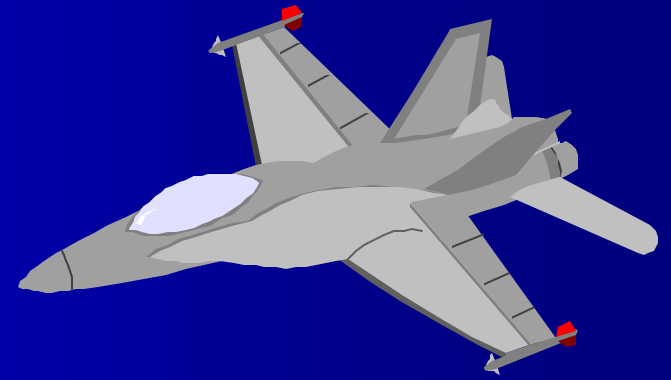
- American Express - credit card risk assessment
- Microsoft – help desks
- Barclaycard - fraud watch
- General Electric – train diagnostics, plastic fabrication
- British Airways – plane maintenance
- Daimler Chrysler – software support
- Analog – component selection
- NASA – space shuttle support
- Swiss Bank - investment management
- Deloitte Touche - fraud assessment



Lockheed

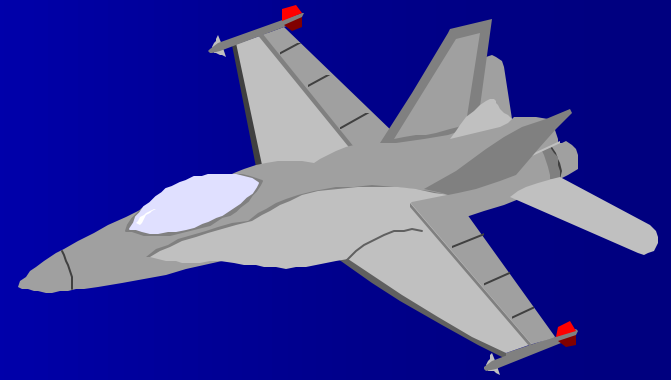


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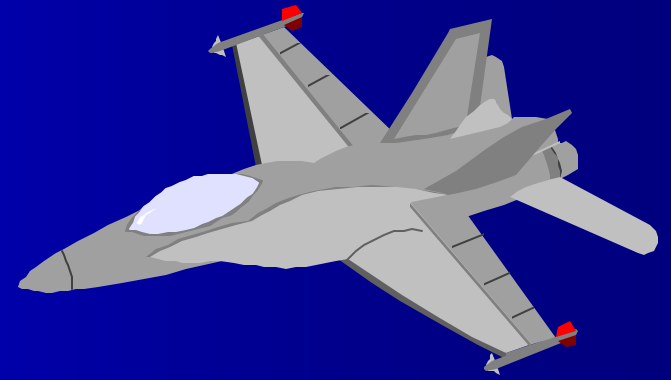
- PROBLEM - how to optimise the loading of an autoclave for curing composite materials

Lockheed



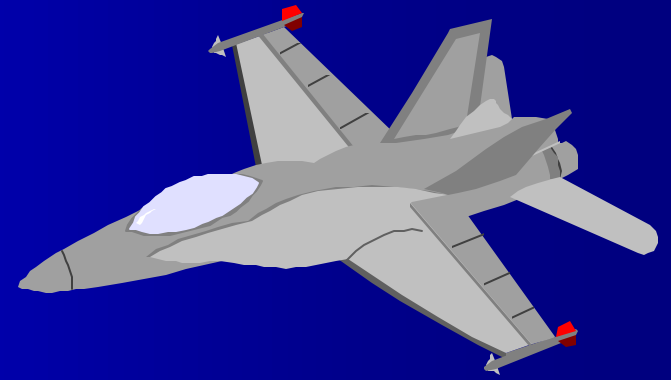
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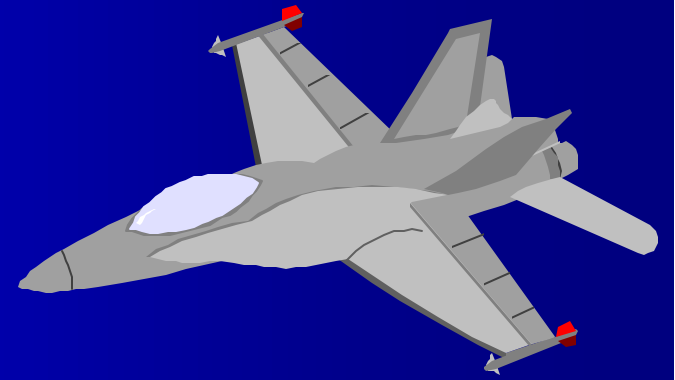
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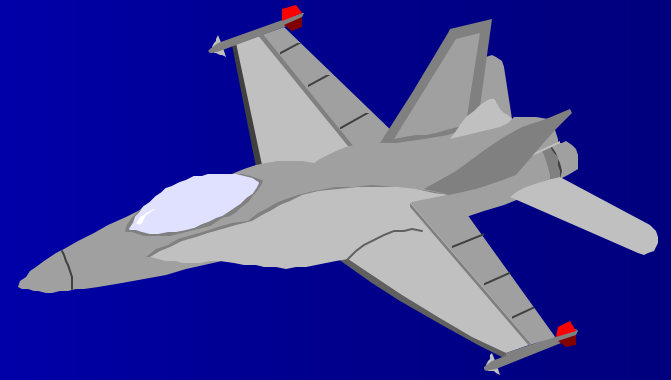


- PROBLEM - how to optimise the loading of an autoclave for curing composite materials
- different materials need different heating & cooling procedures
- materials interact with each other in the autoclave
- mistakes are **VERY** costly

Lockheed

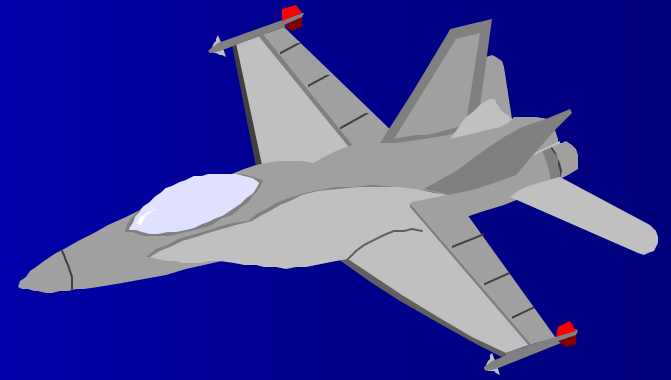


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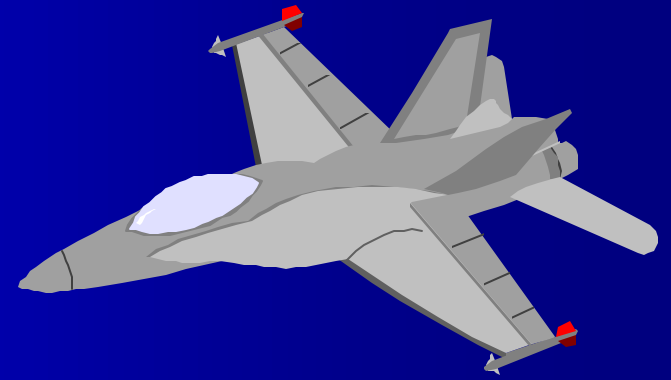
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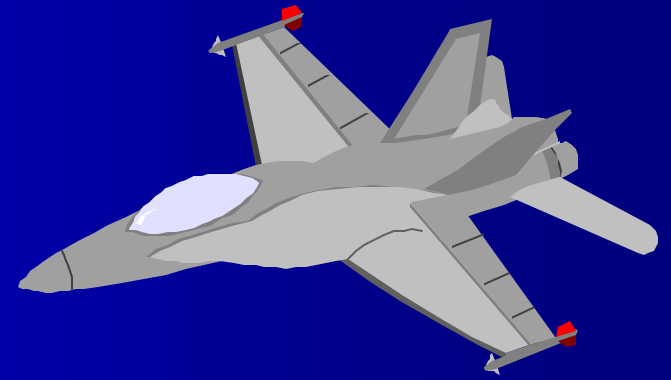
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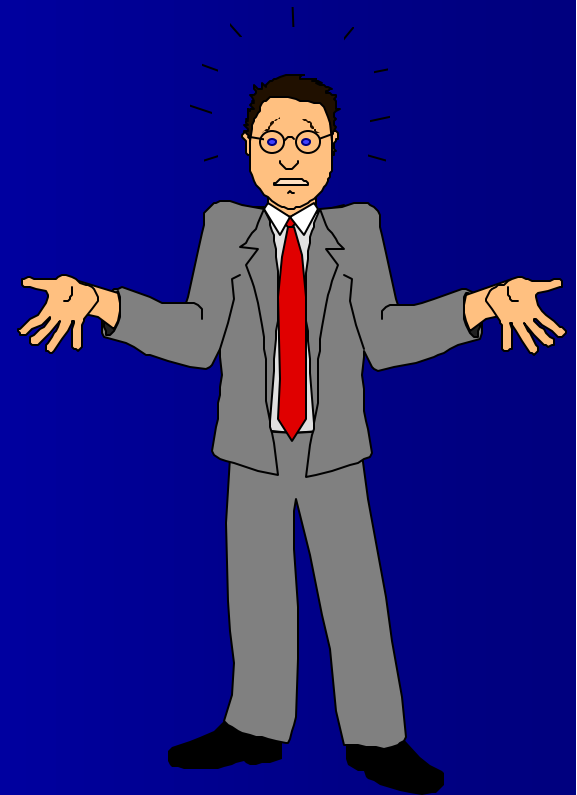
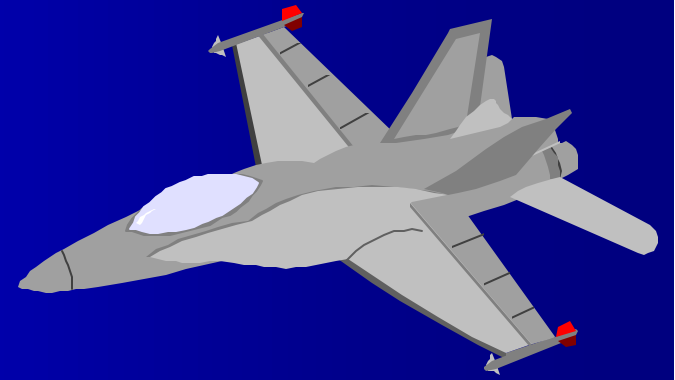
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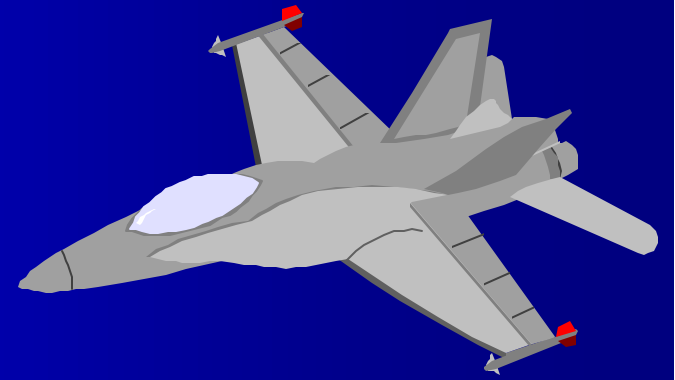


- 2 experienced operators relied on plans of previously successful layouts
- New layouts were adapted from old
- If successful they were added to a library
- they wanted to develop a decision support tool to assist experts and to retain expertise as a corporate asset

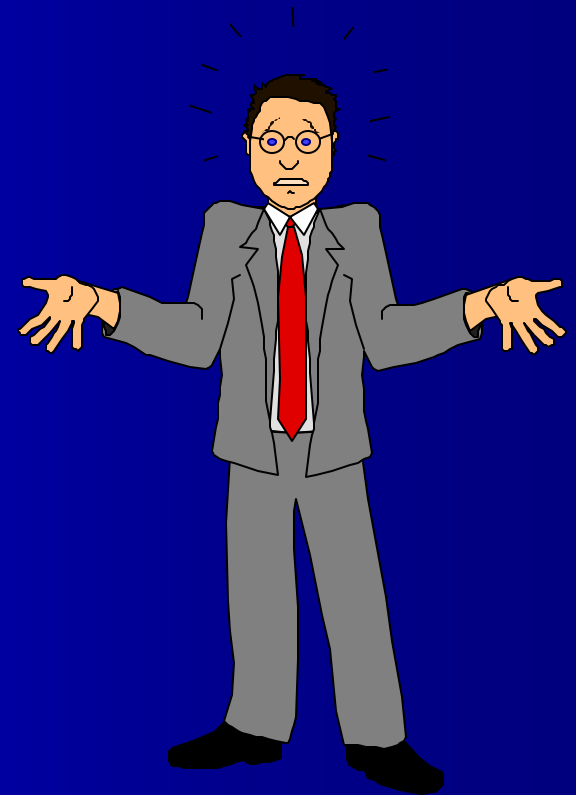
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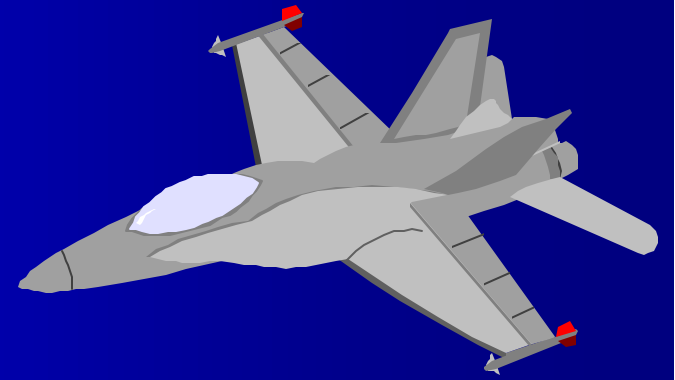
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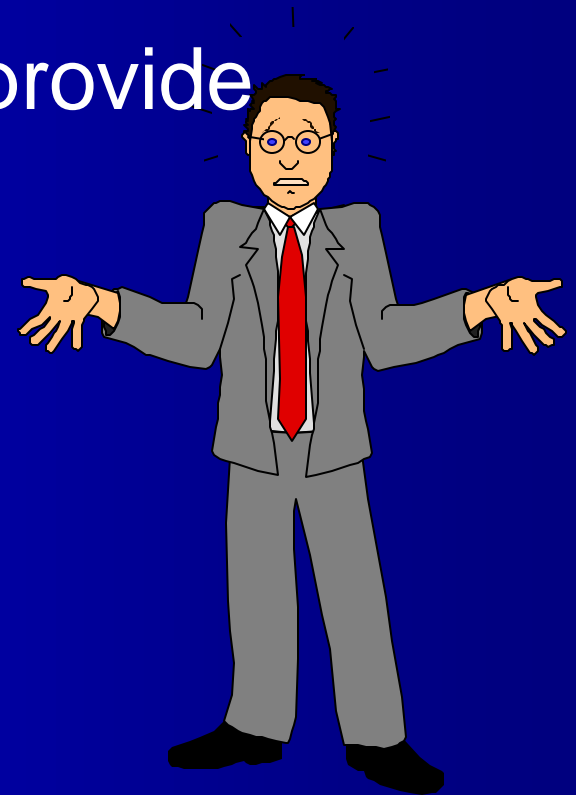
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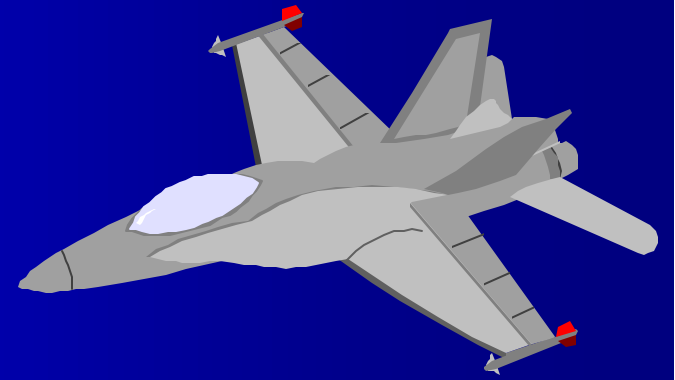
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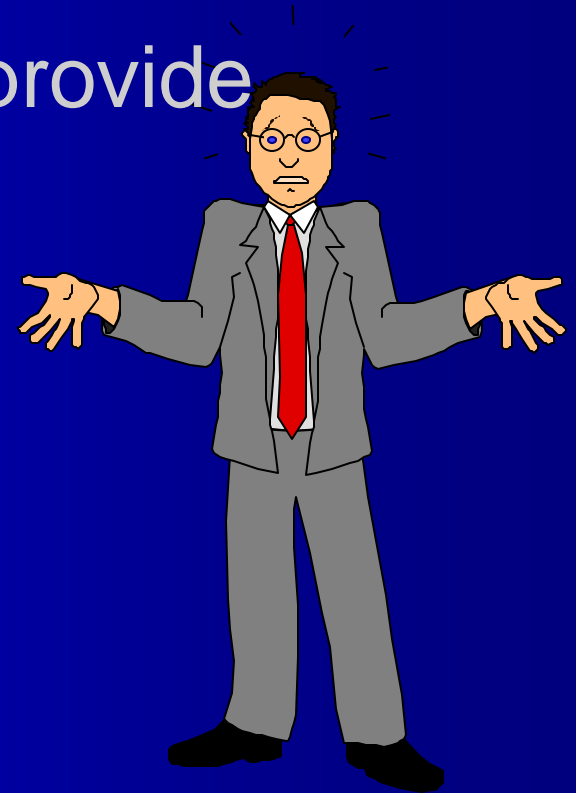
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- the manufacturers could not provide one



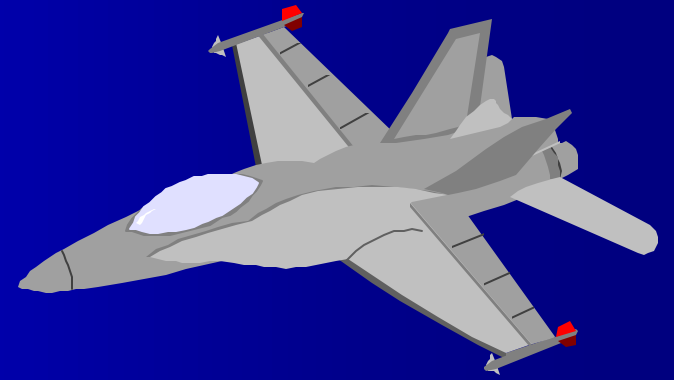
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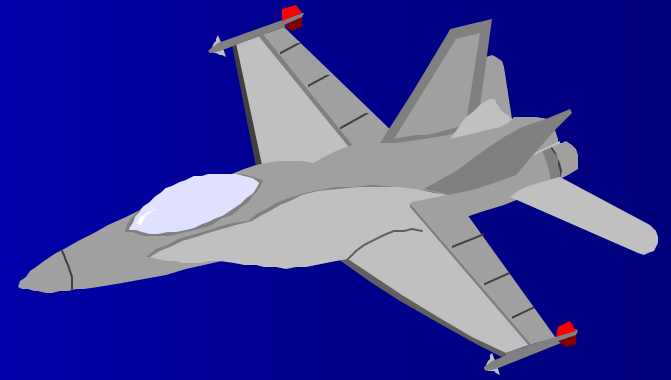
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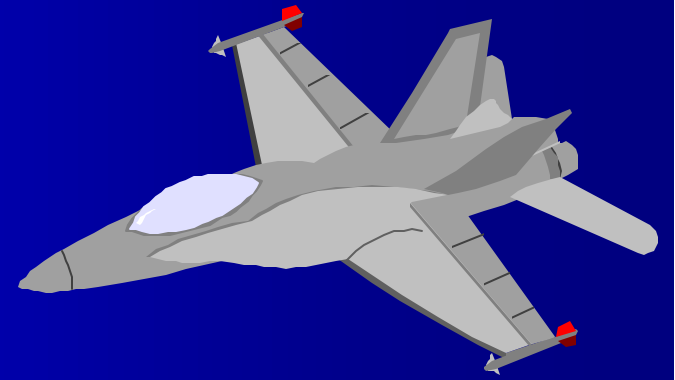
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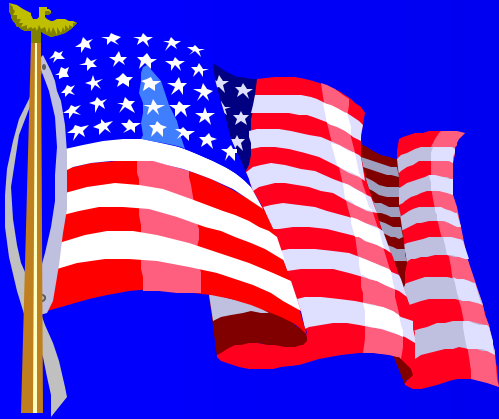


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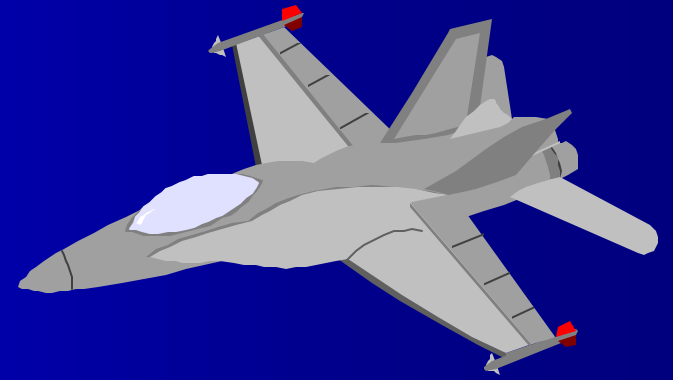


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- the manufacturers could not provide one
- layouts did not repeat
- materials were constantly changing
- designs constantly change
- elements interact





Lockheed



- their system was implemented in 1990
- CLAVIER started with 20 successful layouts
- CLAVIER now has hundreds of successful layouts
- it retrieves a successful layout or adapts one 90% of the time
- acts as a corporate memory

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- no knowledge elicitation to create rules or methods
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- systems *learn* by acquiring new cases through use
- this makes maintenance easy
- justification through precedent

The Case for CBR

The Case for CBR

- CBR is easy to understand

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- and easy to sell to management and users

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

When to Apply CBR?

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- when a domain model is difficult or impossible to elicit

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- when the system will require constant maintenance

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- when a domain model is difficult or impossible to elicit
- when the system will require constant maintenance
- when records of previously successful solutions exist

When to Apply CBR?

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

AI-CBR

www.ai-cbr.org

- an Internet service for the CBR community
- an electronic mailing list with over 700 members (academics & industry)
- an Internet site with information on CBR research, places, people, papers, conferences, and much much more....
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