

Human-Computer Interaction

Lecture 6: Programming languages

USABILITY OF NOTATIONS

Cognitive Dimensions of Notations

- ‘Discussion tools’ for use when considering alternative designs of programming languages, and other complex information systems
 - Suitable for analytic evaluation before, during and after a design process (e.g. iterative prototyping)
 - But not a checklist of ideal features
- We have to escape ‘superlativism’
 - I think the best programming language is ... !
- All real design is about trade-offs
 - What is better – a Lamborghini or a tractor?
 - Do they have design principles in common?

Where do we find information structures?

- Not only programming languages, but anything with internal structure (relationships, dependencies etc)
 - UML diagrams, Spreadsheets, Travel bookings, Musical compositions, Technical manuals, Novels
- Structured information devices involve:
 - a notation
 - an environment
 - a medium
- Consider example dimension: *Viscosity*
 - simplified preview definition:
“a viscous system is hard to modify”

Example: modifying structure of text

- **Notations:**
 - inserting text in a novel is easier than in more structured formats like a newspaper
- **Environment:**
 - structures in a word processor are easier to modify, on pencil and paper are harder to modify
- **Media:**
 - any part of a text on paper can be accessed easily, but harder on a dictaphone (example – Philip Pullman).

Definitions

- **Notation:**
 - The perceived marks or symbols (as covered in visual representation lecture), and the correspondence to what they are supposed to mean
- **Environment:**
 - The operations and tools provided for users to navigate, read and manipulate the perceived marks
- **Medium:**
 - Where the marks are being made (screens, paper, Post-Its, tangible objects, augmented reality)

User experience of notational systems

- Interaction is viewed as building, modifying and navigating an information structure
- Usability depends on the structure of the notation and the tools that the environment provides for manipulating marks within the medium
- Dimensions like viscosity draw attention to aspects of user experience when interacting with the information structure
- Different *activities* have different profiles (e.g. the facilities you need when reading a technical manual are different from those you need when writing one)

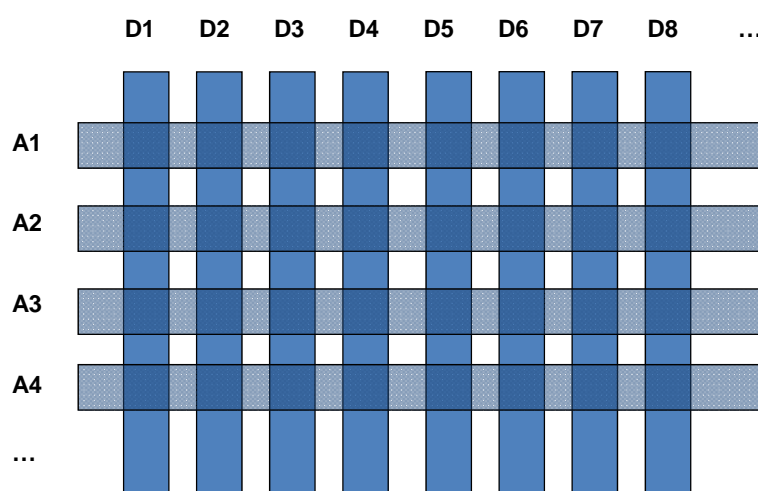
Construction activities: building information structure

- Incrementation
 - add a new formula to a spreadsheet
- Transcription
 - convert an equation to a spreadsheet formula
- Modification
 - change spreadsheet for a different problem
- Exploratory design
 - programming on the fly (“hacking”)

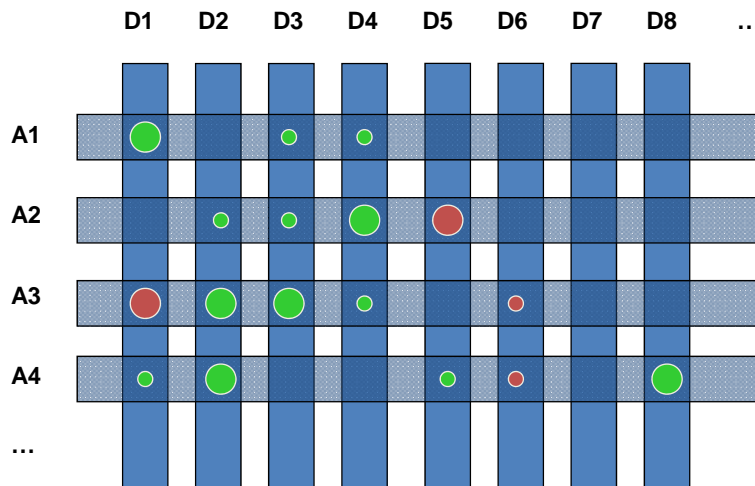
Interpretation activities: reading information structures

- Search
 - find a value specified in a spreadsheet
- Comparison
 - fault-finding, checking correctness
- Exploratory understanding (sensemaking)
 - analyse a business plan presented in a spreadsheet

Dimensions and Activities are orthogonal



Profiles describe desirable combinations



SOME DETAILED DIMENSIONS

Dimensions covered today:

- Abstraction
 - types and availability of abstraction mechanisms
- Hidden dependencies
 - important links between entities are not visible
- Premature commitment
 - constraints on the order of doing things
- Secondary notation
 - extra information in means other than formal syntax
- Viscosity
 - resistance to change
- Visibility
 - ability to view components easily

Not covered in detail today:

- | | |
|--|--|
| <ul style="list-style-type: none"> • Closeness of mapping <ul style="list-style-type: none"> – closeness of representation to domain • Consistency <ul style="list-style-type: none"> – similar semantics expressed in similar forms • Diffuseness <ul style="list-style-type: none"> – verbosity of language • Error-proneness <ul style="list-style-type: none"> – notation invites mistakes • Hard mental operations <ul style="list-style-type: none"> – high demand on cognitive resources | <ul style="list-style-type: none"> • Progressive evaluation <ul style="list-style-type: none"> – work-to-date checkable any time • Provisionality <ul style="list-style-type: none"> – degree of commitment to actions or marks • Role-expressiveness <ul style="list-style-type: none"> – component purpose is readily inferred • And more ... <ul style="list-style-type: none"> – Research continues to identify new dimensions |
|--|--|

Viscosity

- ***Resistance to change: the cost of making small changes.***
- Repetition viscosity:
 - e.g. manually changing US spelling to UK spelling throughout a long document
- Domino (was “Knock-On”) viscosity:
 - e.g. inserting a figure in a document means updating all later figure numbers, their cross-references, the list of figures, the index ...

Viscosity features

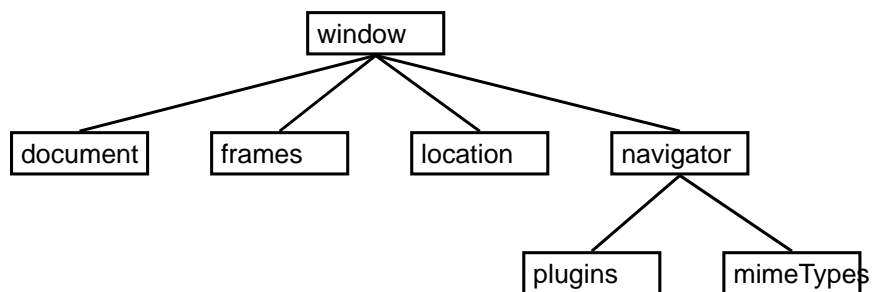
- Viscosity becomes a problem when you need to change your plan: it is a function of the work required to change a plan element.
- It is a property of the system as a whole
- May be different for different operations
- Often happens when designers assume system use will only involve incrementation, but that users will never change the structure.

Viscosity examples

- Repetition viscosity example:
 - When the user has one document in mind, but it is stored as a collection of files, which must be edited separately to change style in all.
- Domino viscosity example:
 - In structures with high inter-dependency, such as timetables.
- Combinations of the two are the worst!

Combined domino/repetition

- Common in graphic structures, genealogical trees, hypertexts ...
 - e.g. tree showing part of JavaScript hierarchy



Workarounds & trade-offs

- Separate exploratory & transcription stages
 - e.g. pencil sketch before ink
- Introduce a new abstraction
 - e.g. AutoNumber facility
- Change the notation
 - e.g. quick dial codes for telephone

Hidden Dependencies

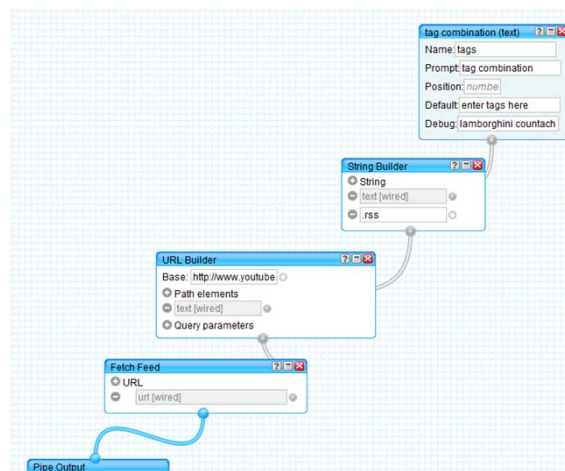
- ***A relationship between components such that one is dependent on the other, but the dependency is not fully visible.***
- The one-way pointer:
 - e.g. your Web page points to someone else's - how do you know when they move it?
- Local dependency:
 - e.g. which spreadsheet cells use the value in a given cell?

Hidden Dependency features

- Hidden dependencies slow up information finding.
- Tolerable in exploratory design, but not in modification
- May be responsible for high frequency of errors in spreadsheets.

Hidden Dependency examples

- GOTO statements didn't have a corresponding COME-FROM.
 - Block structure brings symmetry
- Data-flow makes dependencies explicit



Workarounds & trade-offs

- Require explicit cueing
 - e.g. import and export declarations
- Highlight different information
 - e.g. data-flow language
- Provide tools
 - e.g. spreadsheets which highlight all cells that use a particular value

Premature Commitment / Enforced Lookahead

- ***Constraints on the order of doing things force the user to make a decision before the proper information is available.***

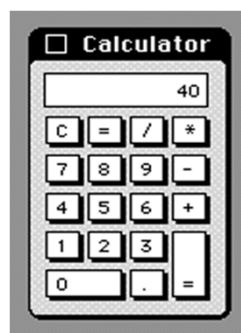
PREMATURE
COMMITMENT

Premature commitment features

- Only occur if three conditions hold:
 - target notation contains internal dependencies
 - access to both source and target is order-constrained
 - the constrained order is inappropriate
- Happens when designer's view of "natural sequence" is at variance with user's needs
- Results in 2nd and 3rd attempts at task

Premature commitment examples

- Telephone menu systems
- Four-function calculator
 - $(1.2 + 3.4 - 5.6) / ((8.7 - 6.5) + (4.3))$



More types and examples

- Defining database schemas before the data
- Filing systems (library shelving by Dewey)
- Surreptitious order constraints
 - Provisional relationships in E-R diagram
- Effect of medium
 - Exacerbated when 'marks' are transient (e.g. in an auditory medium)

Workarounds & trade-offs

- Decoupling
 - e.g. the signwriter paints the sign elsewhere
- Ameliorating
 - premature commitment is not so bad if viscosity is low & bad guesses can be corrected
- Deconstraining
 - e.g. GUI interfaces often remove constraints on order of actions

Abstractions

- ***An abstraction is a class of entities or grouping of elements to be treated as one entity*** (thereby lowering viscosity).
- Abstraction barrier:
 - minimum number of new abstractions that must be mastered before using the system (e.g. Z)
- Abstraction hunger:
 - require user to create abstractions

Abstraction features

- Abstraction-tolerant systems:
 - permit but do not require user abstractions (e.g. word processor styles)
- Abstraction-hating systems:
 - do not allow definition of new abstractions (e.g. spreadsheets)
- Abstraction *changes the notation*.

Abstraction implications

- Abstractions are hard to create and use
- Abstractions must be maintained
 - useful for modification and transcription
 - increasingly used for personalisation
- Involve the introduction of an *abstraction manager* sub-device
 - including its own viscosity, hidden dependencies, juxtaposability etc.

Abstraction examples

- Persistent abstractions:
 - Style sheets, macros, telephone memories
- Definitions and exemplars
 - Powerpoint templates, CAD libraries
- Transient abstractions:
 - Search and replace, selection aggregates

- 📄 Word Work File D 3838
- 📄 CDs Notes - Closeness oMapping
- 📄 Word Work File D 2822
- 📄 CDs Notes - Prem Com
- 📄 CDs Notes - Hidden Deps
- 📄 CDs Notes - Second Not
- 📄 CDs Notes - Vis & Juxt
- 📄 CDs Notes - Visco

Workarounds & trade-offs

- Incremental abstractions
 - low abstraction barrier, tolerates new additions, provides alternatives (but may confuse)
- Overcoming abstraction-repulsion
 - abstractions decrease viscosity, but increase problems for occasional / end-users
- Programming by example?
 - can introduce abstract hidden dependencies

Secondary Notation

- ***Extra information carried by other means than the official syntax.***
- Redundant recoding:
 - e.g. indentation in programs, grouping control knobs by function
- Escape from formalism:
 - e.g. annotation on diagrams

Secondary Notation features

- Redundant recoding
 - ➔ easier comprehension
 - ➔ easier construction.
- Escape from formalism
 - ➔ more information
- Is secondary notation ever bad?
 - what about the brevity bigots?
- Designers often forget that users need information beyond the “official” syntax.
 - and even try to block the escapes people use

Secondary Notation examples

- Redundant recoding
 - Telephone number layout
 - Front panel of a car radio
 - Functional grouping

0114 225 5335
or
0 11 42 25 53 35?

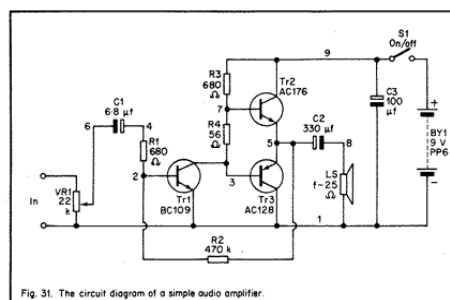
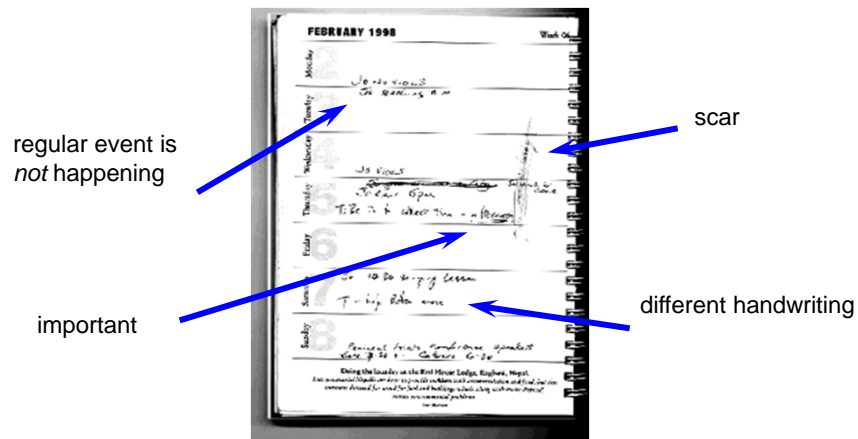


Fig. 31. The circuit diagram of a simple audio amplifier.

Secondary Notation examples

- Escape from formalism
 - Usage of calendars and diaries.



Workarounds & trade-offs

- Decoupling (if insufficient secondary notation)
 - e.g. print out hard copy, attack it with a pencil
- Enriched resources
 - e.g. tagging and annotation tools
- But extensive secondary notation introduces added viscosity (it gets out of date).
 - e.g. program comments

Visibility & Juxtaposability

- ***Ability to view components easily & to place any two components side by side.***
- Visibility:
 - e.g. searching a telephone directory for the name of a subscriber who has a specified telephone number
- Juxtaposability:
 - e.g. trying to compare statistical graphs on different pages of a book

Visibility & Juxtaposability features

- Structure or indexing information is often invisible because designers assumed it wouldn't be needed.
- Often caused by presenting information in windows, then restricting the number of windows.
- Becomes far worse with small devices (cell-phones, PDAs, wearable computers?).

Visibility & Juxtaposability examples

- Small windows onto invisible control trees:
 - e.g. car radios, fax machines, cameras.
- Shared use displays:
 - e.g. clock-radio: time or alarm or radio station
- Form based systems:

The screenshot shows a web browser window with the title 'EPSRC EPS(eBP)'. The page content includes a header 'FORM Hills & Boon:Utilities:eps_erp Folder:Visibility demo'. Below this is a section titled 'Personal Information' with a disclaimer: 'The EPSRC aims to encourage equal opportunities. If you are willing to so, please provide information on your own and your colleagues' age, sex and ethnic origin. We will **NOT** use this information in the assessment of this research proposal, but only for internal and statistical purposes.' There is a large empty text area with scrollbars. Below that, a prompt says 'Please give details for each investigator below.' followed by a table with columns for 'Date of birth' and 'Gender', and a row for 'Ethnic origin'.

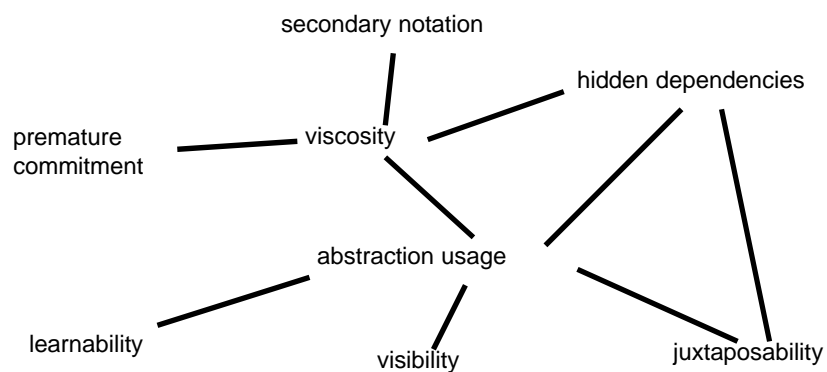
Workarounds & trade-offs

- Working memory
 - refreshed by revisiting items being compared
- External memory
 - e.g. make a hard copy of one component (a new environment that allows side-by-side viewing)
- Adding a browser
 - e.g. class browser, alternative views
- Visibility trades off against clutter, abstraction

Desirable profiles

	<i>transcription</i>	<i>incrementation</i>	<i>modification</i>	<i>exploration</i>
viscosity	acceptable	acceptable	harmful	harmful
hidden dependencies	acceptable	acceptable	harmful	acceptable for small tasks
premature commitment	harmful	harmful	harmful	harmful
abstraction barrier	harmful	harmful	harmful	harmful
abstraction hunger	useful	useful (?)	useful	harmful
secondary notation	useful (?)	–	v. useful	v. harmful
visibility / juxtaposability	not vital	not vital	important	important

Notable trade-offs



Some design manoeuvres

- Potential design approaches to:
 - reduce viscosity
 - improve comprehensibility
 - make premature commitment less expensive
 - remove need for lookahead
 - improve visibility

Design manoeuvres (1)

- Aim: to reduce viscosity
- Manoeuvre
 - add abstractions (so one “power command” can change many instances)
- At this cost
 - increased lookahead (to get right abstractions);
 - raises the abstraction barrier;
 - may increase dependencies among abstractions

Design manoeuvres (2)

- Aim: to improve comprehensibility
- Manoeuvre
 - allow secondary notation - let users choose placing, white space, font & colour; allow commenting
- At this cost
 - increases viscosity (because layout, colour etc not usually well catered for by environments)

Design manoeuvres (3)

- Aim: to make premature commitment less expensive
- Manoeuvre
 - reduce viscosity (so that users can easily correct their first guess)
- At this cost
 - see above, re viscosity

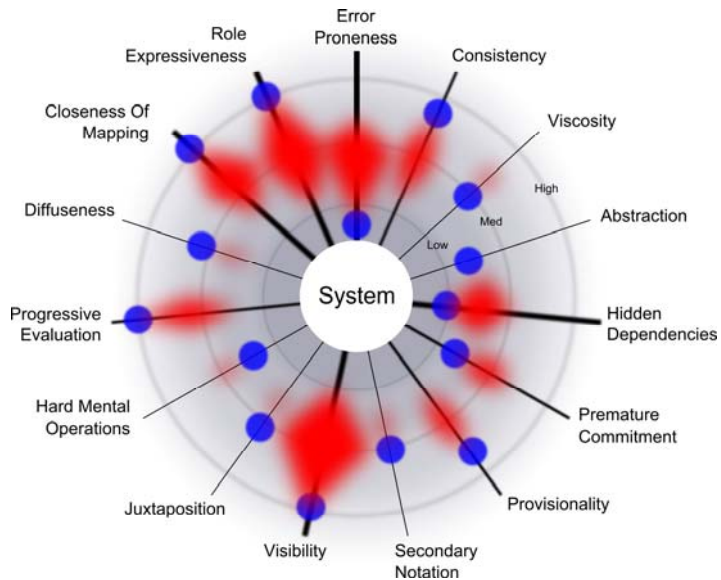
Design manoeuvres (4)

- Aim: to remove need for lookahead
- Manoeuvre
 - remove internal dependencies in the notation;
 - allow users to choose an easier decision order
- At this cost
 - may make notation diffuse, or increase errors
 - allowing free order needs a cleverer system

Design manoeuvres (5)

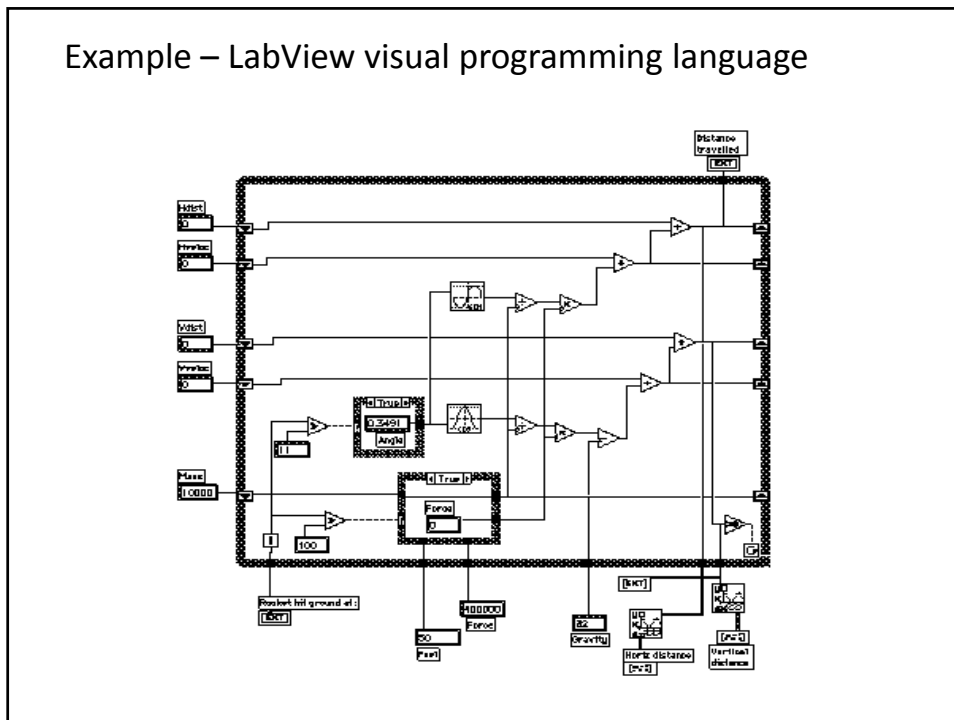
- Aim: to improve visibility
- Manoeuvre
 - add abstractions (so that the notation becomes less diffuse)
- At this cost
 - see above re abstractions

Luke Church's CD Profile Visualisation



A CASE STUDY

Example – LabView visual programming language



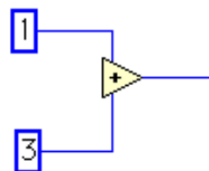
Hidden dependencies

- Visual languages make connections explicit
- But with the trade-off that they need more screen space

BASIC:

```
x = 1
... (possibly
many
pages of
code here...)
y = x + 3
```

LabVIEW:



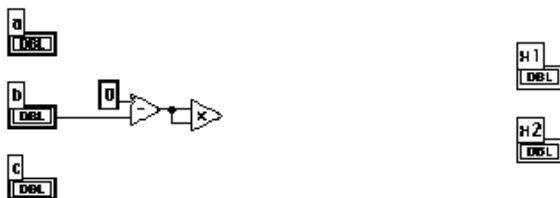
Premature commitment (1)

- Commitment to layout is a common problem e.g. $x = \frac{-b + \text{sqr}(b^2 - 4ac)}{2a}$
- Start with minus b ...



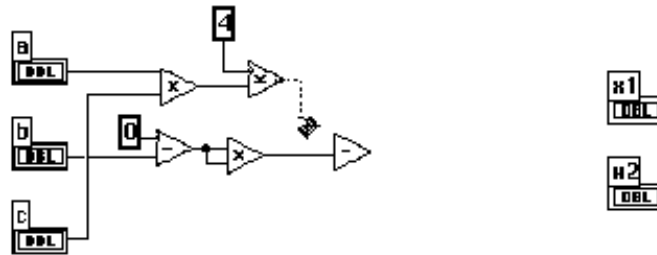
Premature commitment (2)

- ... I'll need b-squared too ...



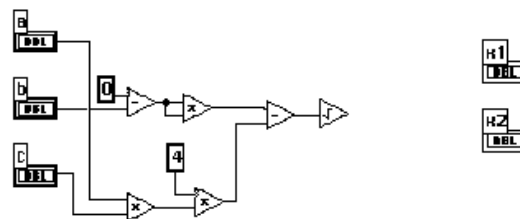
Premature commitment (3)

- ... turn that into b-squared minus 4ac ...



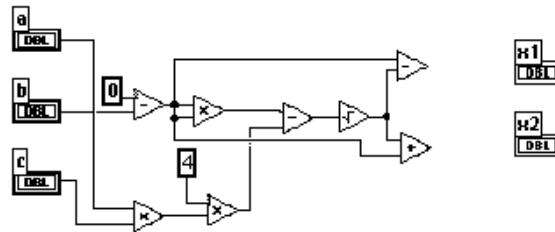
Premature commitment (4)

- ... oops, that's going to be 4ac minus b-squared ... try moving the 4ac chunk down and reconnecting to the 'minus' box ...



Premature commitment (5)

- ... OK, now I need plus or minus that ...



- that's root-b-squared-minus-4ac but I still haven't used b ... or the rest of the formula!

Secondary notation

- Little support for commenting
 - can only attach comment to a single item
- Spatial layout can't easily be used for grouping
- All the visual variables (degrees of freedom) are taken up by the formal syntax

Visibility & Juxtaposability

- Visibility of data flow in LabVIEW is excellent
- But control branches in LabVIEW can't be juxtaposed:

