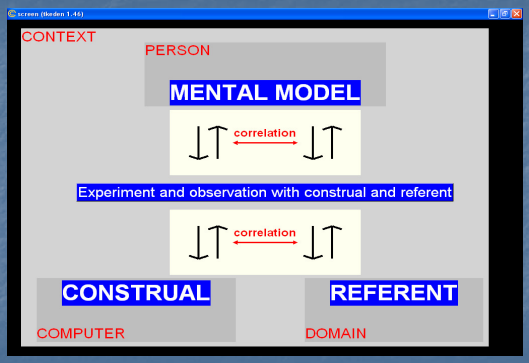
CS405 Intro to EM

Modelling with definitive scripts

Empirical Modelling

- empirical = based on observation and experiment
- empirical = given in experience
- *modelling* because it is intended to support an activity that relies upon establishing a correlation between the experience offered by the computer and some external experience moment by moment ... and thus is (as if) carried out in a situation in which there is a referent

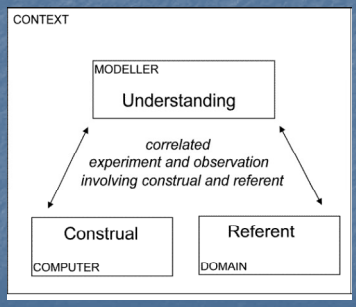
Model making as construing



Modelling state

- spreadsheet
- "now" + "being-in-the-moment"
- state-as-experienced
- phenomenology
- identity crisis: Bose-Einstein condensation
  http://www.colorado.edu/physics/2000/bec/#
- dependency: entanglement
  http://www.signandsight.com/features/614.html
- pragmatism: James and Dewey

Empirical Modelling as *Construction*



Background and History

A *definitive notation* = a simple formal language in which to express definitions

A set of definitions is called a *definitive script*

Definitive notations different according to
types of the variables that appear on the LHS of definitions and **operators** that can be used in formulae on the RHS. These are termed the *underlying algebra* for the notation.

The definitive notation concept

Todd relational algebra query language ISBL
Brian & Geoff Wyvill's interactive graphics languages
spreadsheets
style definition in word processors

The term "definitive notation" first introduced by Beynon

"Modelling with Definitive Scripts" is fundamental to EM
[Rungrattanaubol's PhD Thesis: **A treatise on MWDS**]

Related developments

spreadsheets with visualisation mechanisms

spreadsheet-style environments for end-user programming (e.g. AgentSheets)

generalised spreadsheet principles in application-builders (e.g. ACE), development tools (WPF)

"object-linked embedding" in Windows

What does *definitive* mean?

definition has a technical meaning in this module
definitive means "definition-based"

"definitive" means
more than informal use of a programming technique.

Definitive notations are
a means to *represent state* by definitive scripts
and *how* scripts are interpreted is highly significant.

Significance of interpretation …

Miranda *can* be viewed as a definitive notation over an underlying algebra of functions and constructors
BUT this interpretation emphasises
program design as a state-based activity
rather than
declarative techniques for *program specification*.

[cf. 'admira' application and contrast with KRC]

Definitive notations

The tkeden interpreter uses many definitive notations

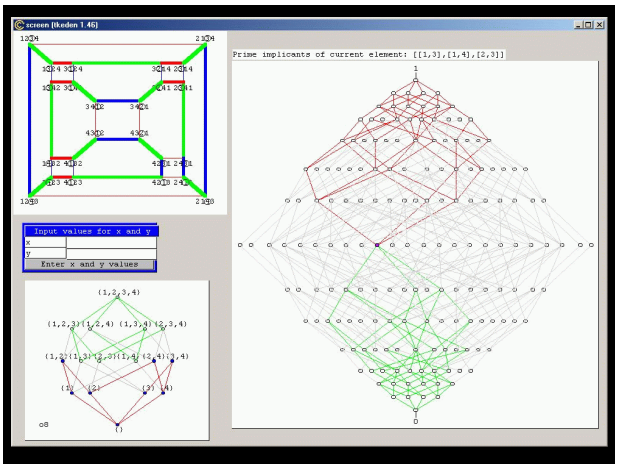
eden: scalars, strings, lists

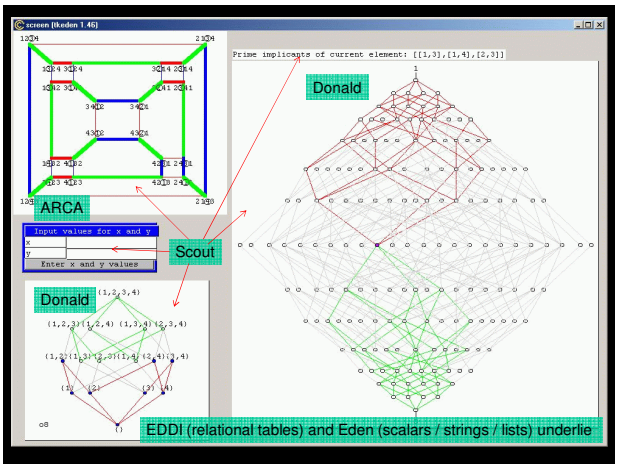
DoNaLD: for 2-d line drawing

SCOUT: displays, windows, screen locations, attributes

EDDI: relational tables and operators

ARCA: edge-coloured digraphs in n-space





DoNaLD: a definitive notation for line-drawing

Donald = a definitive notation for 2-d line-drawing

underlying algebra has 6 primary data types:
integer, **real**, **bool**ean, **point**, **line**, and **shape**

A **shape** = a set of points and lines

A **point** is represented by a pair of scalar values {x,y}.

Defining shapes in DoNaLD

Two kinds of shape variable in DoNaLD:
these are declared as **shape** and **openshape**

An **openshape** variable S is defined componentwise as a collection of points, lines and subshapes

Other mode of definition of shape in DoNaLD is
shape RSQ
RSQ=rotate(SQ)
- illustrated in definition of vehicle in VCCS model.

Projects relevant at this point

In EM archive at:
`http://empublic.dcs.warwick.ac.uk/projects`
jugsBeynon1988, jugsPavelin2002
roomYung1989
roomviewerYung1991
cruisecontrolBridge1991

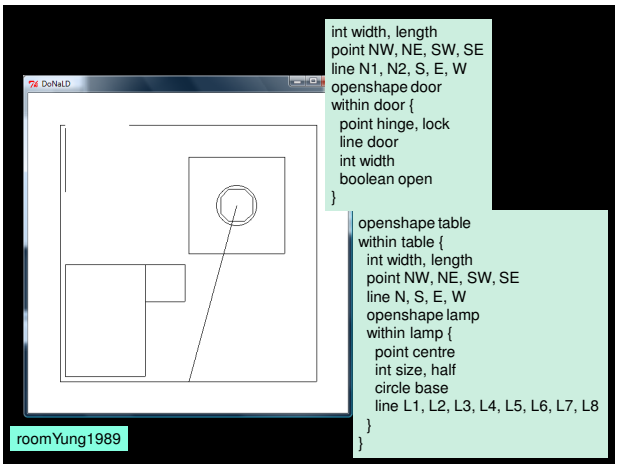
room3dMacDonald1998
graphicspresHarfield2007
room3dsasamiCarter1999

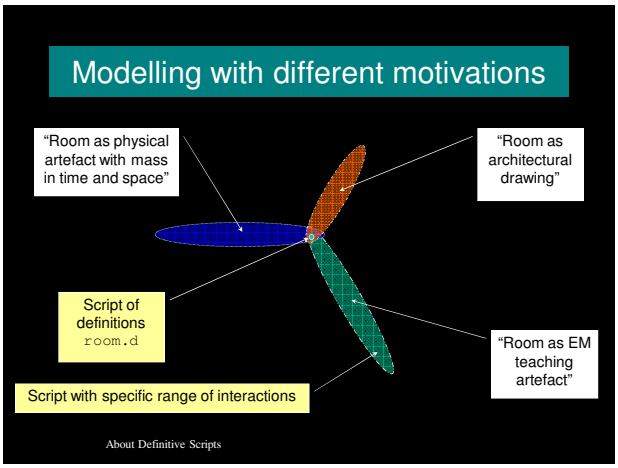
Agents and semantics

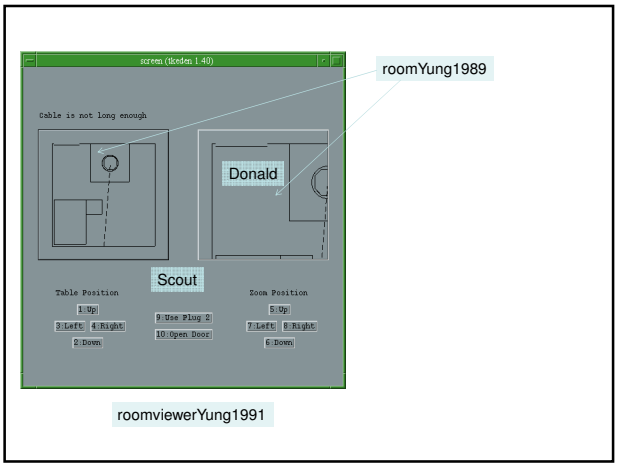
Archetypal use of MWDS: human-computer interaction
"single-agent modelling"

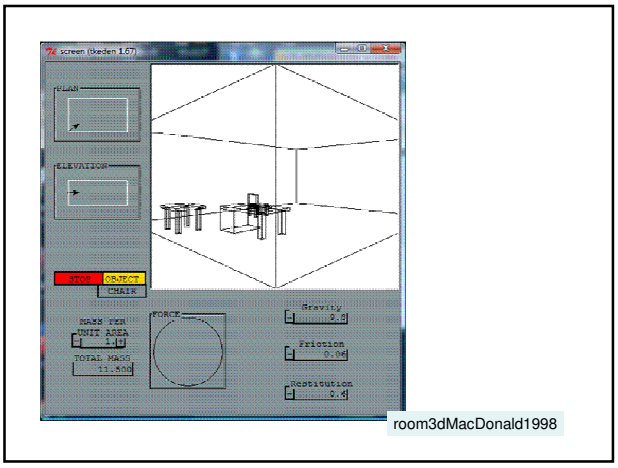
Variables in a definitive script represent
- the values that the user can observe
- the parameters that the user can manipulate
- the way that these are linked indivisibly in change
definitive script can model physical experiments

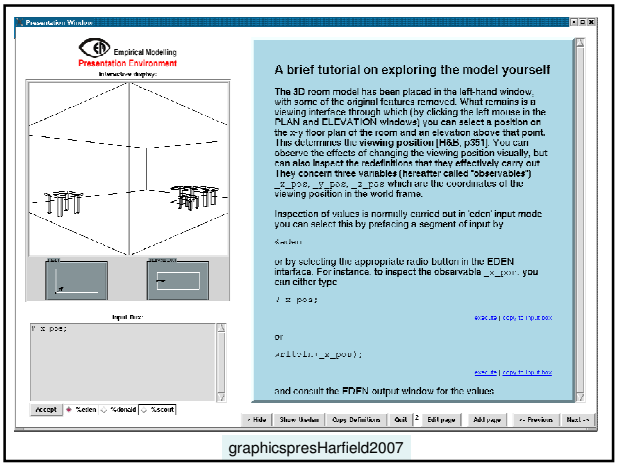
[cf the role of spreadsheets in describing and predicting]

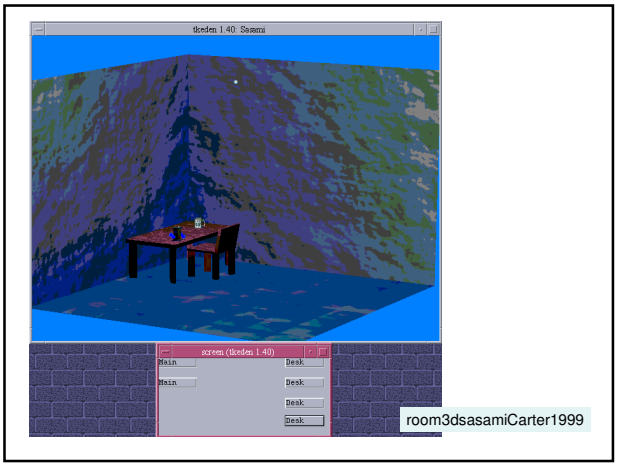

DoNaLD
int width, length
point NW, NE, SW, SE
line N1, N2, S, E, W
openshape door
within door {
point hinge, lock
line door
int width
boolean open
}
openshape table
within table {
int width, length
point NW, NE, SW, SE
line N, S, E, W
openshape lamp
within lamp {
point centre
int size, half
circle base
line L1, L2, L3, L4, L5, L6, L7, L8
}
}
roomYung1989


Modelling with different motivations
"Room as physical artefact with mass in time and space"
"Room as architectural drawing"
Script of definitions
room.d
"Room as EM teaching artefact"
Script with specific range of interactions
About Definitive Scripts


screen (tkeden 1.40)
Cable is not long enough
Donald
Scout
Table Position
Zoom Position
roomYung1989
roomviewerYung1991


screen (tkeden 1.67)
PLAN
ELEVATION
STOP
OBJECT
CHAIR
FORCE
Gravity
Friction
Restitution
room3dMacDonald1998


Empirical Modelling
Presentation Environment
A brief tutorial on exploring the model yourself
The 3D room model has been placed in the left-hand window, with some of the original features removed. What remains is a viewing interface through which (by clicking the left mouse in the PLAN and ELEVATION windows) you can select a position on the x-y floor plan of the room and an elevation above that point. This determines the viewing position [H&B, p351]. You can observe the effects of changing the viewing position visually, but can also inspect the redefinitions that they effectively carry out. They concern three variables (hereafter called "observables") _x_pos, _y_pos, _z_pos which are the coordinates of the viewing position in the world frame.
Inspection of values is normally carried out in 'eden' input mode: you can select this by pressing a segment of input by
or by selecting the appropriate radio button in the EDEN interface. For instance, to inspect the observable _x_pos, you can either type
_x_pos;
or
and consult the EDEN output window for the values
graphicspresHarfield2007


tkeden 1.40 Sasami
screen (tkeden 1.40)
Main
Desk
room3dsasamiCarter1999

Observables, Dependency, Agency

The observables, dependencies and agency that are topical relate to the situation and the way in which a script is being interpreted.

In the architectural drawing, don't observe time.

In the physical room, observe mass, time, force.

In teaching EM, we observe the screen display itself and seek to interpret "absurd" definitions

Observables

Observables are entities

whose identity is established through experience

whose current status can be reliably captured by experiment

Can be physical, scientific, private, abstract, socially arbitrated, procedurally defined etc.

Dependency and Agency

An *agent* is an observable (typically composed of a family of co-existing observables) that is construed to be responsible for changes to the current status of observables

A *dependency* is a relationship between observables that - in the view of a state-changing agent - expresses how changes to observables are indivisibly linked in change

Single Agent modelling

In the primary and most primitive form of Empirical Modelling, the modeller is the only state-changing agent – though they may act *in the role* of different agents: e.g. room user or designer, architect, Empirical Modelling lecturer.

The dependencies between observables are then those that are experienced by the modeller acting in the situation: they express the way in which changes to observables are connected.

Negotiated and evolving interpretations

The situation surrounding the interpretation of a script is never completely closed or well-specified.

The modeller always has to exercise discretion to achieve a degree of closure. Situations can blend.

Definitions stabilise as meanings are negotiated.

Stable definitions reflect established experience.

Skills and insights can give rise to new definitions.

Illustrative examples

Definitions stabilise as meanings are negotiated.

The model of the desk drawer gets improved.

Stable definitions reflect established experience.

The door location and mechanism gets fixed.

Skills and insights can give rise to new definitions.

We connect the door opening with the light coming on, or learn to use a touch-sensitive switch.

Introduction to EDEN

From a practical perspective …

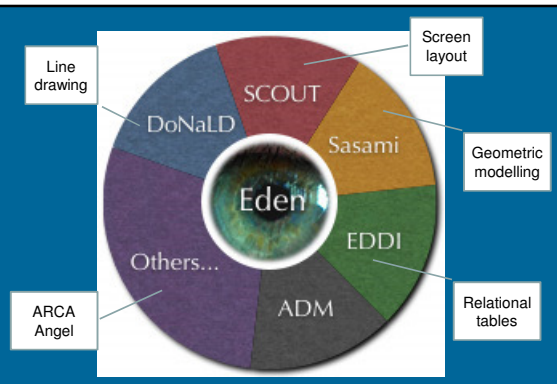
Background

EDEN interpreter due to Y W (Edward) Yung (1987)

Designed for UNIX/C environment
EDEN = evaluator for definitive notations

"hybrid" tool = definitive + procedural paradigms
… essential to drive UNIX utilities and hw devices

Extensions by Y P (Simon) Yung, Pi-Hwa Sun, Ashley Ward, Eric Chan and Ant Harfield



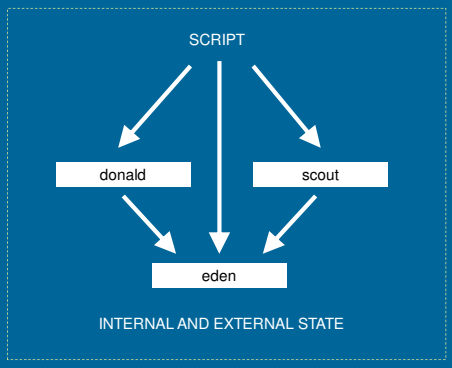
The EDEN interpreter as an engine /evaluator for definitive notations

The use of the word "definitive"

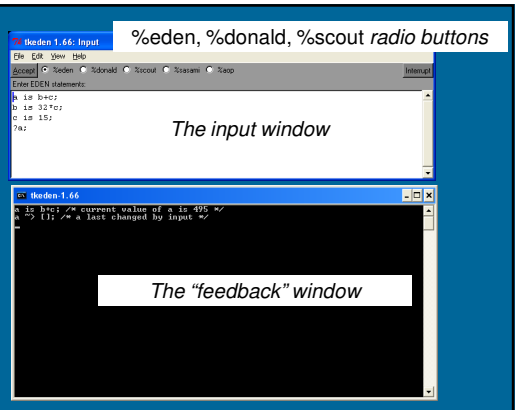
definitive = definition-based

a *definitive notation* = a notation within which definitions of variables can be made

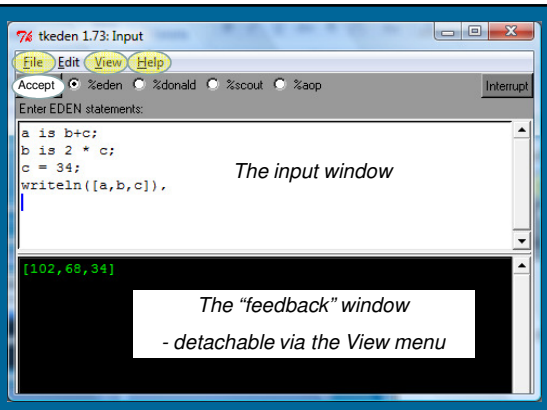
a *definitive script* = a set of definitions expressed in one or more definitive notations



The basic architecture of the EDEN interpreter



Interpreting the eden notation



Basic EDEN interaction

Use the File option to include scripts and to save the history of interaction

Use the View option to inspect the current contents of the script and the command history

Use the Help option to get quick reference information for eden, donald and scout

Use the Accept button (or alt-a) to process script in the input window

Use shortcuts (alt-p, alt-n) to recall previous input

Basic characteristics of EDEN 1

The eden notation uses C-like

- syntactic conventions and data types
- basic programming constructs:

`for`, `while`, `if` and `switch`

Types: `float`, `integer`, `string`, `list`.

Lists can be recursive and need not be homogeneous in type. Comments are prefaced by ## or enclosed in /* .... */.

Basic characteristics of EDEN 2

Two sorts of variables in eden:

formula and *value* variables.

Formula variables are definitive variables.

Value variables are procedural variables.

The type of an eden variable is determined dynamically and can be changed by assignment or redefinition.

Programming / modelling in EDEN

The three primary concepts in EDEN are:

- definition
- function
- action

Informally

definition ~ spreadsheet definition

function ~ operator on values

action ~ triggered procedure

Definitions in eden

A formula variable v can be defined via

```
v is f(a,b,c);
```

EDEN maintains the values of definitive variables automatically and records all the dependency information in a definitive script.

Yellow text indicates eden keywords

Functions in eden

Functions can be defined via

```
func F
/* function to compute result = F(a,b,...,c) */
{
        para a, b, ..., c        /* pars for the function */
        auto result, x, y, …, z      /* local variables */
        <sequence of assignments and constructs>
        return result
}
```

Actions in eden

Actions can be defined via

```
proc P : r, s, …, t
/* proc triggered by variables r, s, …, t */
{
        auto x, y, …, z     /* local variables */
        <sequence of assignments and definitions>
}
```

Action P is triggered whenever one of its triggering variables r, s, … , t is updated / touched

Basic concepts of EDEN 1

Definitions are used to develop a definitive script to describe the current state: change of state is by adding a definition or redefining.

Functions are introduced to extend the range of operators used in definitions.

Actions are introduced to automate patterns of redefinition where this is appropriate.

Evaluator for DEfinitive Notations

Definitions are used to develop a definitive script to describe the current state: change of state is by adding a definition or redefining.

Functions are built-in for the operators in the underlying algebra of a definitive notation.

Actions are introduced to maintain the state of the graphical/perceptual entities specified by the definitive notation.

Basic concepts of EDEN 2

In model-building using EDEN, the key idea is to first build up definitive scripts to represent the current ‘state-as-experienced’.

You then refine the script through observation and experiment, and rehearse meaningful patterns of redefinition you can perform.

Automating patterns of redefinition creates ‘programs’ within the modelling environment

Standard techniques in EDEN

Interrogating values and current definitions of variables in eden. To display:

- the current value of an eden variable v, invoke the procedure call

```
writeln(v)
```

- the defining formulae & dependency status of v, invoke the query

```
?v;
```

Typical EDEN model development

Edit a model in one window (e.g. using Textpad) and simultaneously execute EDEN in another

Cut-and-paste from editor window into interpreter window.

In development process, useful to be able to undo design actions: restore scripts of definitions by re-entering the original definitions.

To record the development history comment out old fragments of scripts in the edited file.

Managing EDEN files

Useful to build up a model in stages using different files.

Can include files using

```
include("filename.e");
```

or via the menu options in the input window.

Can consult / save entire history of interaction.

System also saves recent interaction histories.

Modelling with Definitive Scripts

Definitive scripts

Use scripts of definitions to represent state

Use redefinition to specify change of state

Scripts make use of definitive notations:

- DoNaLD - line drawing
- SCOUT - window layout
- ARCA - combinatorial graphs

Each notation is oriented towards a different metaphor

Definitive notations

Definitive notations are simple languages within which it is possible to formulate definitions for variables ("observables") of a particular type.

A definitive notation is defined by

- an underlying set of data types and operators
- a syntax for defining observables of these types.

Review/illustrate key features of DoNaLD and SCOUT

DoNaLD data types

Donald is a definitive notation for 2-d line-drawing
Its underlying algebra has 6 primary data types:
integer, **real**, **bool**ean, **point**, **line**, and **shape**

A **shape** = a set of points and lines
A **point** is represented by a pair of scalar values {x,y}.
Points can be treated as position vectors: they can be added (p+q) and multiplied by a scalar factor (p*k)
A **line** [p,q] is a line segment joining points p and q

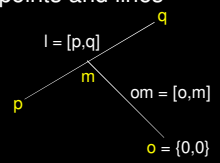
DoNaLD operators

The DoNaLD operators include:
arithmetic operators:
+ * div float() trunc() if ... then ... else ...
basic geometric operators:
.1 .2 .x .y {,} [,] + *
dist() intersects() intersect()
translate() rot() scale()
label() circle() ellipse()

A DoNaLD file should begin with a "%donald"

DoNaLD syntax – points and lines

```
# declaring (NB) and defining points and lines
point o, p, q, m
line l
l = [p,q]
m = (p+q) div 2
line om
# new declarations can be introduced at any stage
o = {0,0}
om = [o,m]
.....
```



DoNaLD syntax – shapes

```
openshape S
within S {
        int m  # this is equivalent to declaring int S/m outside S
        point p, q
        openshape T
        p = {m, 2*m}
        within T {
                point p, q          # this point has the identifier S/T/p
                p, q = ~/q, ~/p
                # a multiple definition: p = ~/q and q=~/p
                # ~/... refers to the enclosing context for T
                # viz. S, so that ~/p refers to the variable S/p
                .....
        }
        ...
}
```


DoNaLD extras

Can define shapes in another way also: e.g.
shape rotsquare = rotate(SQ,….)
where SQ is defined to be a square

The "within X { …" context is reflected in the input window in EDEN

A syntax error in a 'within' context resets to the root context …

… there are NO SEMI-COLONS (;) in DoNaLD !!!

SCOUT types

SCOUT is a definitive notation for screen layout

Its primary data type is the **window**
Other types include: **display** (collection of windows, ordered according top to bottom); **integer, point** and **string**.

Windows are generally used to display text or DoNaLD pictures.

SCOUT screen definition

Overall concept

a SCOUT script defines the current computer screen state
screen is a special variable of type *display*
the display is made up out of windows

Simplest definition of **screen** has the form
screen = < win1 / win2 / win3 / win4 / win5 / .... >
where ordering of windows determines how they overlay

Alternatively can define **screen** as union of displays
screen = disp1 & disp2 & disp3 & disp4 & ....

SCOUT window definitions

A SCOUT window definition takes the form

```
window X = {
        fieldname1: …
        fieldname2: …
        …
}
```

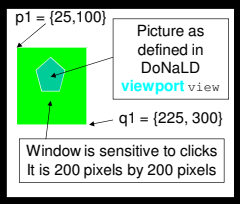
where the choice of *fieldnames* depends on the nature of the window content.

Defining a window to hold a DoNaLD picture

DoNaLD Window		
field name	***type***	***description***
type	content	Must be the value `DONALD`
box	box	The region in which the DoNaLD picture is shown
border	integer	Set the border width of the bounding box
pict	string	The name of the DoNaLD picture
xmin	point	
ymin	point	Show the portion of the DoNaLD picture
xmax	point	bounded by the points (xmin, ymin) and (xmax, ymax)
ymax	point	

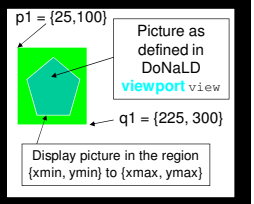
A simple SCOUT DONALD-window

```
point p1 = {25, 100};
point q1 = {225, 300};
window don1 = {
    box: [p1, q1],
    pict: "view",
    type: DONALD,
    border: 1
    bgcolor: “green”
    sensitive: ON
};
# locations of points are in pixels from top left of screen
#  coordinates of DONALD picture {0,0} to {1000, 1000}
```



Another SCOUT DONALD-window

```
window don2 = {
    box: [p1, q1],
    pict: "view",
    type: DONALD,
    xmin: zoomPos.1 - zoomSize/2,
    ymin: zoomPos.2 - zoomSize/2,
    xmax: zoomPos.1 + zoomSize/2,
    ymax: zoomPos.2 + zoomSize/2,
    border: 1
    sensitive: ON
}
```



Defining a window to hold text

Text Window		
field name	***type***	***description***
type	content	Must be the value `TEXT`
string	string	The string to be displayed
frame	frame	The region in which the string is shown
border	integer	Width of the border of the boxes of the frame
alignment	just	`NOADJ`, `LEFT`, `RIGHT`, `EXPAND` and `CENTRE` are the possible values to denote no alignment, left justification, right justification, left and right justification and centre of the text inside each box in the frame
bgcolour	string	Colour name for the background colour of the text
fgcolour	string	Colour name for the (foreground) colour of the text

About Definitive Scripts

A simple SCOUT TEXT-window

```
window doorButton = {
   frame: ([doorButtonPos, 1, strlen(doorMenu)]),
   string: doorMenu,
   border: 1
   sensitive: ON
};
string doorMenu = if _door_open then "Close
   Door" else "Open Door" endif;
```

About Definitive Scripts

SCOUT extras

When aspects of the screen are undefined by the SCOUT script, it will not be drawn / redrawn

Sensitive SCOUT windows generate definitions of associated mouseButton variables: they supply information about the mouse state and location & can be used to trigger EDEN actions

Mouse clicks show up in the command history

About Definitive Scripts

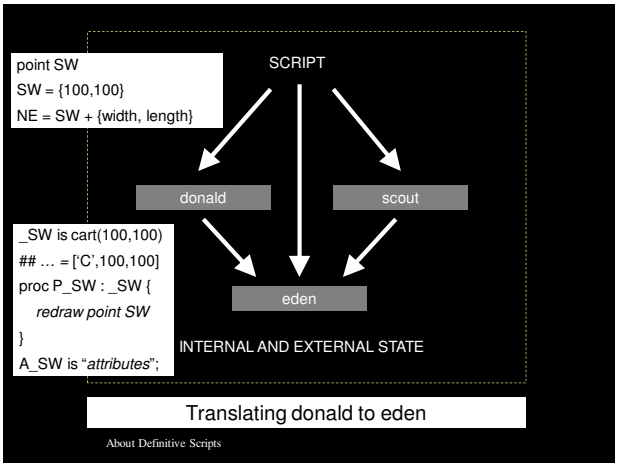
SCOUT & DoNaLD extras

By default, a DoNaLD picture is displayed in a system generated SCOUT window, and has coordinates between {0,0} and {1000,1000}

SCOUT observables can be accessed in EDEN by the same names

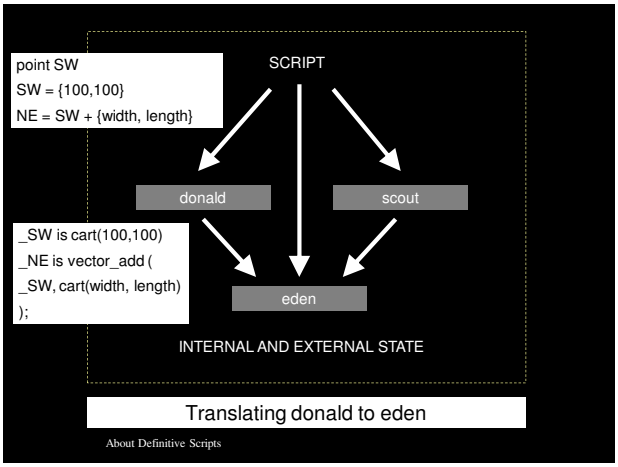
A DoNaLD observable X/t can be accessed in EDEN and SCOUT by _X_t etc.

About Definitive Scripts



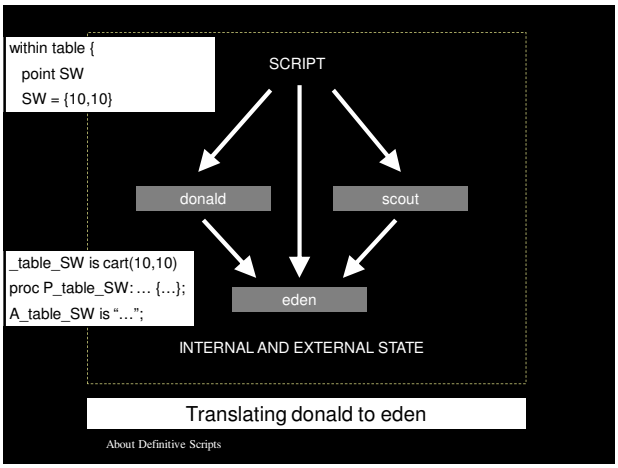
Translating donald to eden

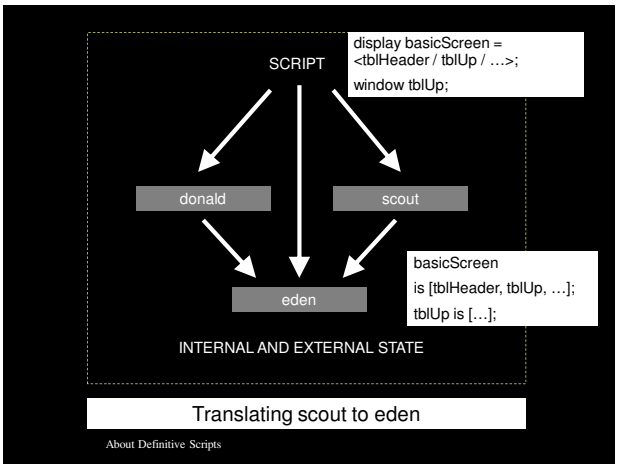
About Definitive Scripts



Translating donald to eden

About Definitive Scripts





Examples of definitive notations

Notation	*Basis for underlying algebra*
eden	scalars, recursive lists, strings
donald	points, lines, shapes
scout	windows, displays (window = template + content)
arca	diagrams, vertices, incidences
sasami	polygonal meshes, renderings
eddi	relational database tables and views

Each notation is adapted to the metaphorical representation of different kinds of observable

About Definitive Scripts