MMD 107
Design for User Interaction

Lesson 5: Analyze

Objectives

- What is Task Analysis?
  - Approaches to task analysis
  - Task Decomposition
  - Diagrammatic HTA
  - Knowledge Based Analyses
- Entity-Relationship Techniques
  - Objects
  - Attributes
  - Actions
  - Events
- Dialogue Notations and Design
  - State transition networks (STN)
  - Concurrent dialogues Petri nets
  - State charts
  - Flowcharts
  - Semantics Alexander SPI
  - Dangerous States
  - Lexical Issues

What is Task Analysis?

Methods to analyse people's jobs:

- what people do
- what things they work with
- what they must know

An Example

- in order to clean the house
  - get the vacuum cleaner out
  - fix the appropriate attachments
  - clean the rooms
  - when the dust bag gets full, empty it
  - put the vacuum cleaner and tools away
- must know about:
  - vacuum cleaners, their attachments, dust bags,
    cupboards, rooms etc.

Approaches to task analysis

- Task decomposition
  - splitting task into (ordered) subtasks
- Knowledge based techniques
  - what the user knows about the task and how it is organised
- Entity/object based analysis
  - relationships between objects, actions and the people who perform them
- lots of different notations/techniques

general method

- observe
- collect unstructured lists of words and actions
- organize using notation or diagrams

Differences from other techniques

Systems analysis **vs.** **Task analysis**

system design - focus - the user

Cognitive models **vs.** **Task analysis**

internal mental state - focus - external actions

practiced `unit' task - focus - whole job

Task Decomposition

Aims:

describe the actions people do
structure them within task subtask hierarchy
describe order of subtasks

Variants:

Hierarchical Task Analysis (HTA)
most common
CTT (CNUCE, Pisa)
uses LOTOS temporal operators

Textual HTA description

Hierarchy description ...

0. in order to clean the house
    1. get the vacuum cleaner out
    2. get the appropriate attachment
    3. clean the rooms
        3.1. clean the hall
        3.2. clean the living rooms
        3.3. clean the bedrooms
    4. empty the dust bag
    5. put vacuum cleaner and attachments away

... and plans
Plan 0: do 1 - 2 - 3 - 5 in that order. when the dust bag gets full do 4
Plan 3: do any of 3.1, 3.2 or 3.3 in any order depending on which rooms need cleaning

N.B. only the plans denote order

Generating the hierarchy

1 get list of tasks
2 group tasks into higher level tasks
3 decompose lowest level tasks further

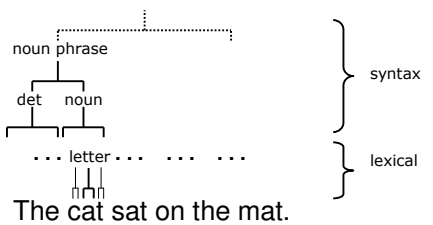
Stopping rules
How do we know when to stop?
Is “empty the dust bag” simple enough?
Purpose: expand only relevant tasks
Motor actions: lowest sensible level

Tasks as explanation

- imagine asking the user the question:
  what are you doing now?
- for the same action the answer may be:
  typing ctrl-B
  making a word bold
  emphasising a word
  editing a document
  writing a letter
  preparing a legal case

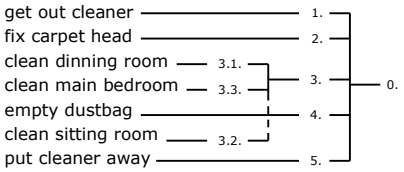
HTA as grammar

- can parse sentence into letters, nouns, noun phrase, etc.



The cat sat on the mat.

parse scenario using HTA



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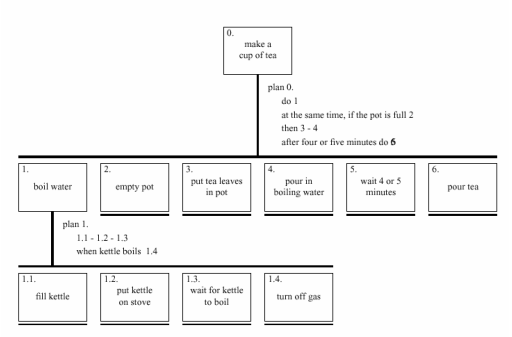
Diagrammatic HTA



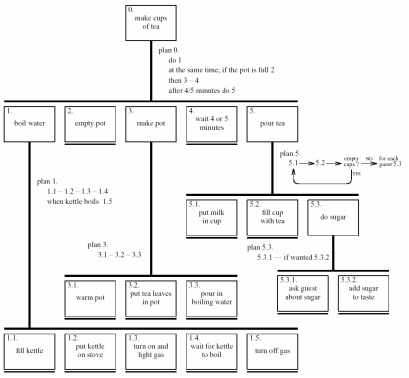
Refining the description

Given initial HTA (textual or diagram)
How to check / improve it?

Some heuristics:

- paired actions e.g., where is `turn on gas'
- restructure e.g., generate task `make pot'
- balance e.g., is `pour tea' simpler than making pot?
- generalise e.g., make one cup ….. or more

Refined HTA for making tea



Types of plan

fixed sequence- 1.1 then 1.2 then 1.3

optional tasks - if the pot is full 2

wait for events - when kettle boils 1.4

cycles - do 5.1 5.2 while there are still empty cups

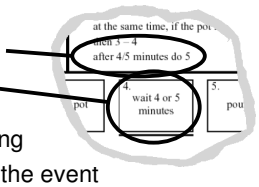
time-sharing - do 1; at the same time ...

discretionary - do any of 3.1, 3.2 or 3.3 in any order

mixtures - most plans involve several of the above

waiting …

- is waiting part of a plan?
  … or a task?
- generally
  - task – if 'busy' wait
    - you are actively waiting
  - plan – if end of delay is the event
    - e.g. "when alarm rings", "when reply arrives"
- in this example …
  - perhaps a little redundant …
  - TA not an exact science



Knowledge Based Analyses

Focus on:

Objects – used in task

Actions – performed

+ Taxonomies –
represent levels of abstraction

Knowledge–Based Example …

```
motor controls
   steering  steering wheel, indicators
   engine/speed
       direct   ignition, accelerator, foot brake
       gearing  clutch, gear stick
   lights
       external  headlights, hazard lights
       internal  courtesy light
   wash/wipe
       wipers   front wipers, rear wipers
       washers  front washers, rear washers
   heating  temperature control, air direction,
            fan, rear screen heater
   parking  hand brake, door lock
   radio  numerous!
```

Task Description Hierarchy

Three types of branch point in taxonomy:

XOR – normal taxonomy
object in one and only one branch

AND – object must be in both
multiple classifications

OR – weakest case
can be in one, many or none

```
wash/wipe AND
    function XOR
          wipe    front wipers, rear wipers
          wash    front washers, rear washers
    position XOR
          front    front wipers, front washers
          rear     rear wipers, rear washers
```

Larger TDH example

```
kitchen item AND
/____shape XOR
/    |___dished  mixing bowl, casserole, saucepan,
/    |           soup bowl, glass
/    |___flat    plate, chopping board, frying pan
/____function OR
     {___preparation mixing bowl, plate, chopping board
     {___cooking    frying pan, casserole, saucepan
     {___dining XOR
          |____for food   plate, soup bowl, casserole
          |____for drink  glass
```

N.B. '/ | {' used for branch types.

More on TDH

Uniqueness rule:

– can the diagram distinguish all objects?

e.g., plate is:

```
kitchen
  item/shape(flat)/function{preparation,din
  ing(for food)}/
```

nothing else fits this description

Actions have taxonomy too:

```
kitchen job OR
|____ preparation  beating, mixing
|____ cooking frying, boiling, baking
|____ dining  pouring, eating, drinking
```

Abstraction and cuts

After producing detailed taxonomy
'cut' to yield abstract view

That is, ignore lower level nodes

e.g. cutting above shape and below dining, plate becomes:

```
kitchen item/function{preparation,dining}/
```

This is a term in Knowledge Representation Grammar (KRG)

These can be more complex:

e.g. 'beating in a mixing bowl' becomes:

```
kitchen job(preparation) using a
                kitchen item/function{preparation}/
```

Entity-Relationship Techniques

Focus on objects, actions and their relationships

Similar to OO analysis, but …
- includes non-computer entities
- emphasises domain understanding not implementation

Running example
'Vera's Veggies' – a market gardening firm
owner/manager: Vera Bradshaw
employees: Sam Gummage and Tony Peagreen
various tools including a tractor `Fergie'
two fields and a glasshouse
new computer controlled irrigation system

Objects

Start with list of objects and classify them:

Concrete objects:
simple things: spade, plough, glasshouse

Actors:
human actors: Vera, Sam, Tony, the customers
what about the irrigation controller?

Composite objects:
sets: the team = Vera, Sam, Tony
tuples: tractor may be < Fergie, plough >

Attributes

To the objects add attributes:

Object Pump3 **simple** – irrigation pump
Attributes:
status: on/off/faulty
capacity: 100 litres/minute

N.B. need not be computationally complete

Actions

List actions and associate with each:
agent – who performs the actions
patient – which is changed by the action
instrument – used to perform action

examples:
Sam (*agent*) planted (*action*) the leeks (*patient*)
Tony dug the field *with* the spade (*instrument*)

Actions (ctd)

implicit agents – read behind the words
`the field was ploughed' – *by whom?*

indirect agency – the real agent?
`*Vera* programmed the *controller* to irrigate the field'

messages – a special sort of action
`Vera *told* Sam to ... '

rôles – an agent acts in several rôles
Vera as *worker* or as *manager*

example – objects and actions

Object Sam **human actor**
Actions:
S1: drive tractor
S2: dig the carrots

Object Vera **human actor** – the proprietor
Actions: as worker
V1: plant marrow seed
V2: program irrigation controller
Actions: as manager
V3: tell Sam to dig the carrots

Object the men **composite**
Comprises: Sam, Tony

Object glasshouse **simple**
Attribute:
humidity: 0-100%

Object Irrigation Controller **non-human actor**
Actions:
IC1: turn on Pump1
IC2: turn on Pump2
IC3: turn on Pump3

Object Marrow **simple**
Actions:
M1: germinate
M2: grow

Events

… when something happens

- performance of action
  'Sam dug the carrots'
- spontaneous events
  'the marrow seed germinated'
  'the humidity drops below 25%'
- timed events
  'at midnight the controller turns on'

Relationships

- object-object
  social - Sam is subordinate to Vera
  spatial - pump 3 is in the glasshouse
- action-object
  agent (listed with object)
  patient and instrument
- actions and events
  temporal and causal
  'Sam digs the carrots because Vera told him'
- temporal relations
  use HTA or dialogue notations.
  show task sequence (normal HTA)
  show object lifecycle

example – events and relations

Events:
Ev1: humidity drops below 25%
Ev2: midnight

Relations: object-object
location (Pump3, glasshouse)
location (Pump1, Parker's Patch)

Relations: action-object
patient (V3, Sam)
– Vera tells *Sam* to dig
patient (S2, the carrots)
– Sam digs the *carrots* ...
instrument (S2, spade)
– ... *with* the spade

Relations: action-event

before (V1, M1)
– the marrow must be sown *before* it can germinate

triggers (Ev1, IC3)
– *when* humidity drops below 25%, the controller turns on pump 3

causes (V2, IC1)
– the controller turns on the pump *because* Vera programmed it

Sources of Information

Documentation
– N.B. manuals say what is *supposed* to happen
but, good for key words and prompting interviews

Observation
– formal/informal, laboratory/field

Interviews
– the expert: manager or worker? (ask both!)

Early analysis

Extraction from transcripts
– list nouns (objects) and verbs (actions)
– beware technical language and context:
`the rain poured' vs. `I poured the tea'

Sorting and classifying
– grouping or arranging words on cards
– ranking objects/actions for task relevance
– use commercial outliner

Iterative process:
data sources ⇔ analysis
…but costly, so use cheap sources where available

Uses – manuals & documentation

Conceptual Manual
– from knowledge or entity–relations based analysis
– good for open ended tasks

Procedural 'How to do it' Manual
– from HTA description
– good for novices
– assumes all tasks known

To make cups of tea

boil water — see page 2
empty pot
make pot — see page 3
wait 4 or 5 minutes
pour tea — see page 4

— page 1 —

Make pot of tea
once water has boiled
warm pot
put tea leaves in pot
pour in boiling water

— page 3 —

Uses – requirements & design

Requirements capture and systems design
- lifts focus from system to use
- suggests candidates for automation
- uncovers user's conceptual model

Detailed interface design
- taxonomies suggest menu layout
- object/action lists suggest interface objects
- task frequency guides default choices
- existing task sequences guide dialogue design

NOTE. task analysis is never complete
- rigid task based design ⇒ inflexible system

dialogue notations and design

Dialogue Notations and Design

- Dialogue Notations
  - Diagrammatic
    - state transition networks, JSD diagrams, flow charts
  - Textual
    - formal grammars, production rules, CSP
- Dialogue linked to
  - the semantics of the system – what it does
  - the presentation of the system – how it looks
- Formal descriptions can be analysed
  - for inconsistent actions
  - for difficult to reverse actions
  - for missing actions
  - for potential miskeying errors

what is dialogue?

- conversation between two or more parties
  - usually cooperative
- in user interfaces
  - refers to the *structure* of the interaction
  - syntactic level of human–computer 'conversation'
- levels
  - lexical – shape of icons, actual keys pressed
  - syntactic – order of inputs and outputs
  - semantic – effect on internal application/data

structured human dialogue

- human-computer dialogue very constrained
- some human-human dialogue formal too …

Minister: do you *man's name* take this woman …
Man: I do
Minister: do you *woman's name* take this man …
Woman: I do
Man: With this ring I thee wed
(places ring on womans finger)
Woman: With this ring I thee wed *(places ring ..)*
Minister: I now pronounce you man and wife

lessons about dialogue

- wedding service
  - sort of script for three parties
  - specifies order
  - some contributions fixed – "I do"
  - others variable – "do you *man's name* …"
  - instructions for ring concurrent with saying words "with this ring …"
- if you say these words are you married?
  - only if in the right place, with marriage licence
  - syntax not semantics

… and more

- what if woman says “I don’t”?
- real dialogues often have alternatives:

Judge: How do you plead guilty or not guilty?
Defendant: *either* Guilty *or* Not guilty

  - the process of the trial depends on the defendants response
- focus on normative responses
  - doesn’t cope with judge saying “off with her head”
  - or in computer dialogue user standing on keyboard!

dialogue design notations

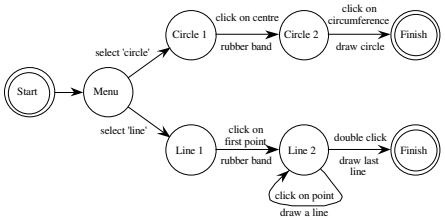
- dialogue gets buried in the program
- in a big system can we:
  - analyse the dialogue:
    - can the user always get to see current shopping basket
  - change platforms (e.g. Windows/Mac)
  - dialogue notations helps us to
    - analyse systems
    - separate lexical from semantoc
- … and before the system is built
  - notations help us understand proposed designs

graphical notations

state-transition nets (STN)
Petri nets, state charts
flow charts, JSD diagrams

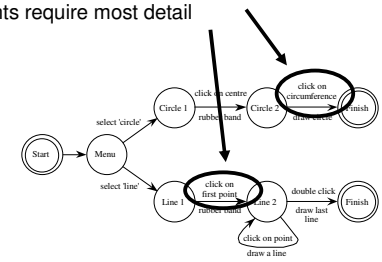
State transition networks (STN)

- circles - states
- arcs - actions/events



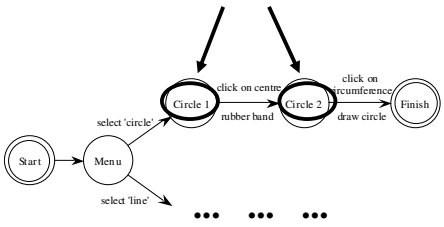
State transition networks - events

- arc labels a bit cramped because:
  - notation is `state heavy‘
  - the events require most detail



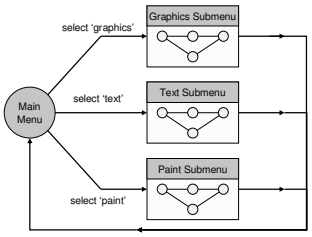
State transition networks - states

- labels in circles a bit uninformative:
  - states are hard to name
  - but easier to visualise



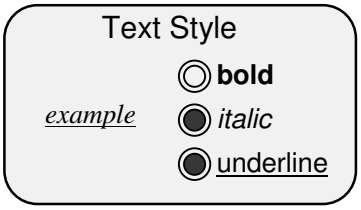
Hierarchical STNs

- managing complex dialogues
- named sub-dialogues



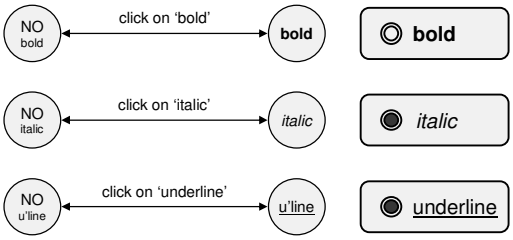
Concurrent dialogues - I

simple dialogue box



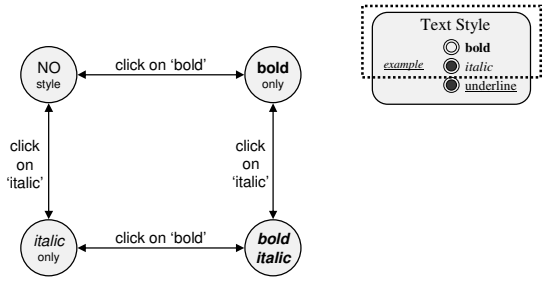
Concurrent dialogues - II

three toggles - individual STNs



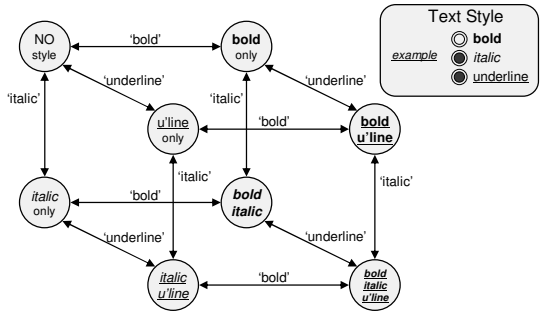
Concurrent dialogues - III

bold and italic combined



Concurrent dialogues - IV

all together - combinatorial explosion



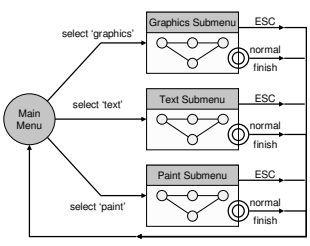
escapes

- 'back' in web, escape/cancel keys
  - similar behaviour everywhere
  - end up with spaghetti of identical behaviours
- try to avoid this

e.g. on high level diagram

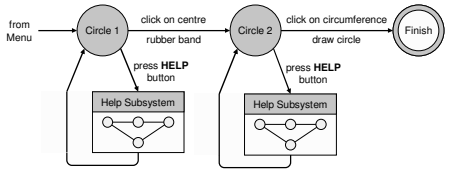
'normal' exit for each submenu

plus separate escape arc active 'everywhere' in submenu



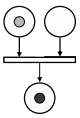
help menus

- similar problems
  - nearly the same everywhere
  - but return to same point in dialogue
  - could specify on STN … but very messy
  - usually best added at a 'meta' level

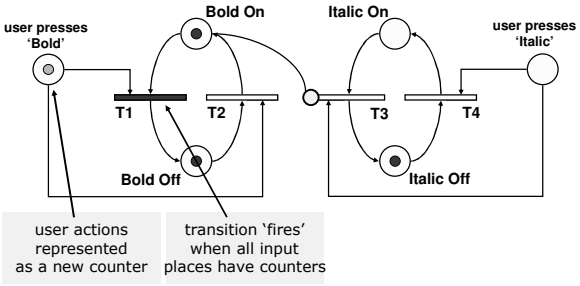


Petri nets

- one of the oldest notations in computing!
- flow graph:
  - places – a bit like STN states
  - transitions – a bit like STN arcs
  - counters – sit on places (current state)
- several counters allowed
  - concurrent dialogue states
- used for UI specification (ICO at Toulouse)
  - tool support – Petshop

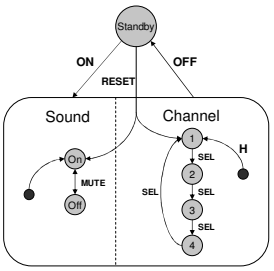


Petri net example



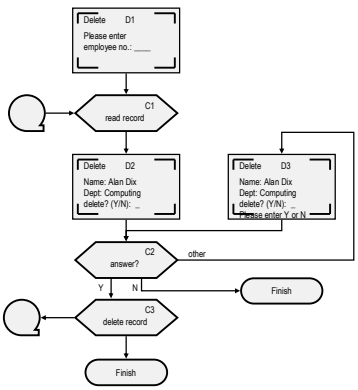
State charts

- used in UML
- extension to STN
  - hierarchy
  - concurrent sub-nets
  - escapes
    - OFF always active
  - history
    - link marked H goes back to last state on re-entering subdialogue



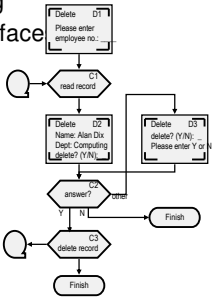
Flowcharts

- familiar to programmers
- boxes
  - process/event
  - not state
- use for dialogue (not internal algorithm)



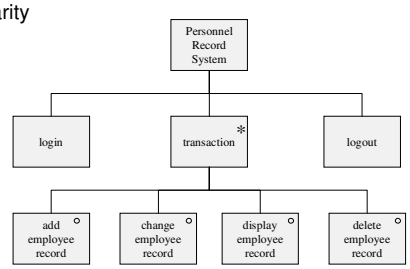
it works!

- formal notations – too much work?
- COBOL transaction processing
  - event-driven – like web interface
  - programs structure ≠ dialogue structure
- used dialogue flow charts
  - discuss with clients
  - transform to code
  - systematic testing
  - 1000% productivity gain
- formalism saves time!!



JSD diagrams

- for tree structured dialogues
  - less expressive
  - greater clarity



textual notations

grammars
production rules
CSP and event algebras

Textual - Grammars

- Regular expressions

```
sel-line click click* dble-click
```

- compare with JSD
  - same computational model
  - different notation
- BNF

```
expr ::= empty
       | atom expr
       | '(' expr ')' expr
```

- more powerful than regular exp. or STNs
- Still NO concurrent dialogue

Production rules

- Unordered list of rules:

  if *condition* then *action*

  - condition based on state or pending events
  - every rule always potentially active

- Good for concurrency
- Bad for sequence

Event based production rules

```
Sel-line → first
C-point first → rest
C-point rest → rest
D-point rest → < draw line >
```

- Note:
  - events added to list of pending events
  - '`first`' and '`rest`' are internally generated events
- Bad at state!

Prepositional Production System

- State based
- Attributes:

  Mouse: { mouse-off, select-line, click-point, double-click }

  Line-state: { menu, first, rest }

- Rules (feedback not shown):

  select-line → mouse-off first

  click-point first → mouse-off rest

  click-point rest → mouse-off

  double-click rest → mouse-off menu

- Bad at events!

CSP and process algebras

- used in Alexander's SPI, and Agent notation
- good for sequential dialogues

```
Bold-tog = select-bold? → bold-on → select-bold? →
                                    bold-off → Bold-
  tog
Italic-tog = . . .
Under-tog = . . .
```

- and concurrent dialogue

```
Dialogue-box = Bold-tog || Italic-tog || Under-tog
```

- but causality unclear

Dialogue Notations - Summary

- Diagrammatic
  - STN, JSD, Flow charts
- Textual
  - grammars, production rules, CSP
- Issues
  - event base vs. state based
  - power vs. clarity
  - model vs. notation
  - sequential vs. concurrent

Semantics Alexander SPI (i)

- Two part specication:
  - EventCSP - pure dialogue order
  - EventISL - target dependent semantics
- dialogue description - centralised
- syntactic/semantic trade-off - tollerable

Semantics Alexander SPI (ii)

- EventCSP

```
Login  = login-mess -> get-name -> Passwd
Passwd = passwd-mess -> (invalid -> Login [] valid -> Session)
```

- EventISL

```
event: login-mess
    prompt: true
    out: "Login:"
event: get-name
    uses: input
    set: user-id = input
event: valid
    uses: input, user-id, passwd-db
    wgen:  passwd-id = passwd-db(user-id)
```

Semantics - raw code

- event loop for word processor
- dialogue description
  - very distributed
- syntactic/semantic trade-off
  - terrible!

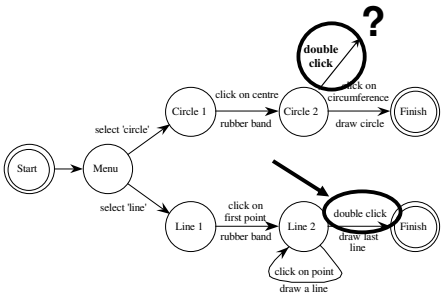
```
switch ( ev.type ) {
  case button_down:
    if ( in_text ( ev.pos ) ) {
        mode = selecting;
        mark_selection_start(ev.pos);
    }
    ...
  case button_up:
    if ( in_text ( ev.pos )
            && mode == selecting ) {
        mode = normal;
        mark_selection_end(ev.pos);
    }
    ...
  case mouse_move:
    if (mode == selecting ) {
        extend_selection(ev.pos);
    }
    ...
} /* end of switch */
```

Action properties

- completeness
  - missed arcs
  - unforeseen circumstances
- determinism
  - several arcs for one action
  - deliberate: application decision
  - accident: production rules
- nested escapes
- consistency
  - same action, same effect?
  - modes and visibility

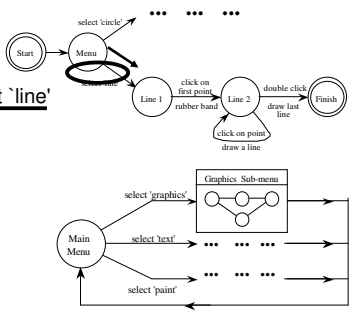
Checking properties (i)

- completeness
  - double-click in circle states?



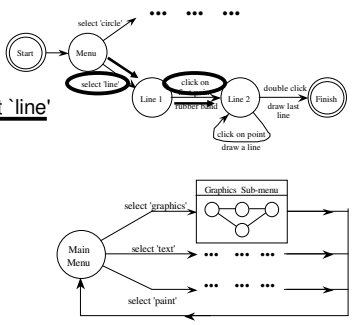
Checking properties (ii)

- Reversibility:
  - to reverse select `line'



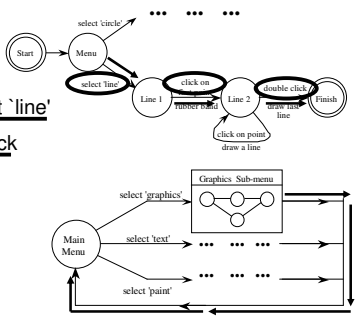
Checking properties (ii)

- Reversibility:
  - to reverse select `line'
  - click



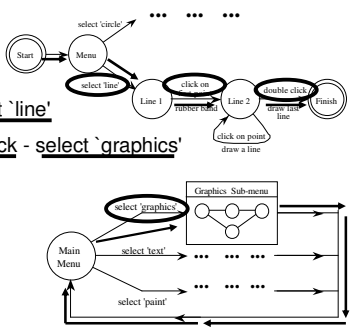
Checking properties (ii)

- Reversibility:
  - to reverse select `line'
  - click - double click



Checking properties (ii)

- Reversibility:
  - to reverse select `line'
  - click - double click - select `graphics'
  - (3 actions)
- N.B. not undo

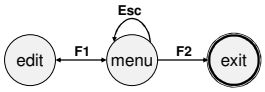


State properties

- reachability
  - can you get anywhere from anywhere?
  - and how easily
- reversibility
  - can you get to the previous state?
  - but NOT undo
- dangerous states
  - some states you don't want to get to

Dangerous States

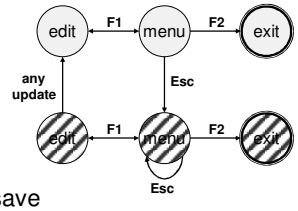
- word processor: two modes and exit
  - F1 - changes mode
  - F2 - exit (and save)
  - Esc - no mode change



but ... Esc resets autosave

Dangerous States (ii)

- exit with/without save ⇒ dangerous states
- duplicate states - semantic distinction



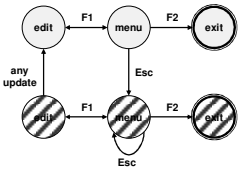
F1-F2 - exit with save
F1-Esc-F2 - exit with no save

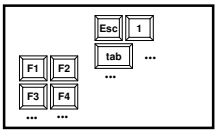
Lexical Issues

- visibility
  - differentiate modes and states
  - annotations to dialogue
- style
  - command - verb noun
  - mouse based - noun verb
- layout
  - not just appearance ...

layout matters

- word processor - dangerous states
- old keyboard - OK



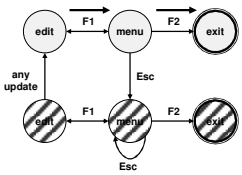


layout matters

- new keyboard layout

intend F1-F2 (save)

finger catches Esc



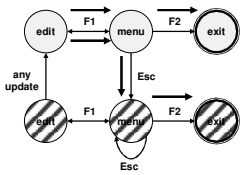
layout matters

- new keyboard layout

intend F1-F2 (save)

finger catches Esc

F1-Esc-F2 - disaster!



Dialogue Analysis - Summary

- Semantics and dialogue
  - attaching semantics
  - distributed/centralised dialogue description
  - maximising syntactic description
- Properties of dialogue
  - action properties: completeness, determinism, consistency
  - state properties: reachability, reversibility, dangerous states
- Presentation and lexical issues
  - visibility, style, layout
  - N.B. not independent of dialogue

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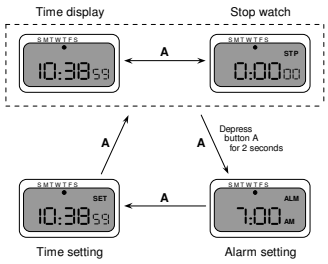
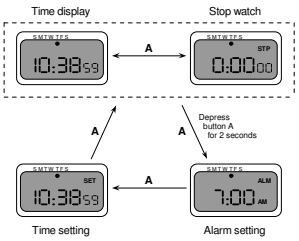
Digital watch – User Instructions

- two main modes
- limited interface
  - 3 buttons
- button A
  changes mode



Digital watch – User Instructions

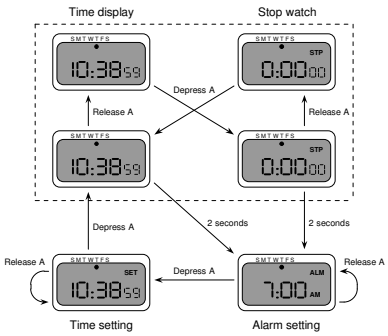
- dangerous states
  - *guarded*
    … by two second hold
- completeness
  - distinguish depress A and release A
  - what do they do in all modes?



Digital watch – Designers instructions

and ...

that's just
one button



Any Questions???