DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF TORONTO

CSC 428F/2514F

HUMAN-COMPUTER INTERACTION

Lecture 22

ADVANCED MODELS OF ROUTINE COGNITIVE SKILLS — PROJECT ERNESTINE: THE DESIGN AND USE OF A TELEPHONE OPERATOR'S WORKSTATION

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22.1 Toll and Assistance Operators and their Tasks

Job function: Handle calls where person has dialed “0”, e.g.
- Person-to-person calls
- Collect calls
- Credit card calls
- Calls billed to a third number
- Directory assistance calls (not)

A variety of call categories and tasks in these job functions
- 15 representative tasks identified
- Perhaps best understood in terms of scenarios (Fig. 22.1)

Figure 22.1: Sample TAO Task Scenario for Credit-Card Call (N&L, 1995, p. 253)

Caller dials 0-305-555-6748 and waits for operator to answer.
TAO's headset beeps; display shows this is a dialled call and then shows it connected

TAO:	Great Lakes Telephone, may I help you?
Caller:	Can I charge this to my credit card, please?
TAO:	Card number, please.
	Presses CARD-NUMBER key.
Caller:	412-555-6789-4321.
TAO:	*Enters 14-digit number;*
	Waits for display of billing rate, presses RATE-CONFIRM key.
	Waits for display of credit-card authorization.
	Thank you.
	Presses CALL-RELEASE key.

Economic benefits of time savings for Nynex
- 25 offices X 100 operators/office X $25K/yr. = $62.5M/yr.
- Average time/task = 20 seconds
- Cost savings of reducing this by 2 seconds/task > $6M/yr.

22.2 The TAO Workstation and its Redesign

Current workstation
- Text-only terminal
- 300 baud link to central computer

Proposed workstation
- High-resolution graphical display
- 1200 baud link
- Redesign of keyboard layout to place frequently used keys in optimal positions
- Redesign of command language to reduce the number of required keystrokes

22.3 The TAO Workstation Field Trial

A field experiment
- 12 new workstations replaced 12 current workstations
- 24 workstations used for 4 months by 48 experienced TAOs
- All work monitored and recorded
- Analysis applied to 15 most frequently occurring call categories of 23 TAOs in each group
- Result: a sample size of 72390 calls

Results
- *Increase* of 1.3 seconds (6%) in ave. time for handling calls
- Statistically significant, $p<0.02$, that result was due to factors other then change of workstation
- A learning effect?
  - Difference was 9% in the first month
  - Difference was 3.4% ($p<0.05$) in last 3 months
- Likely cost increase to Nynex of $2M per year

Tendency for disbelief, so attempt at “scientific” explanation

22.4 The CPM-GOMS Modelling Technique

Thus far, GOMS and Keystroke techniques have modelled behaviour in terms of sequential processing

Gross oversimplification, because there are concurrent threads of system response, human perceptual response to visual our auditory input, human cognitive processing, human motor actions, human verbal response, etc. (Fig. 22.2)

Figure 22.2: Parallel model of pressing two keys and saying "Thank you" (N&L, 1995, p. 260)

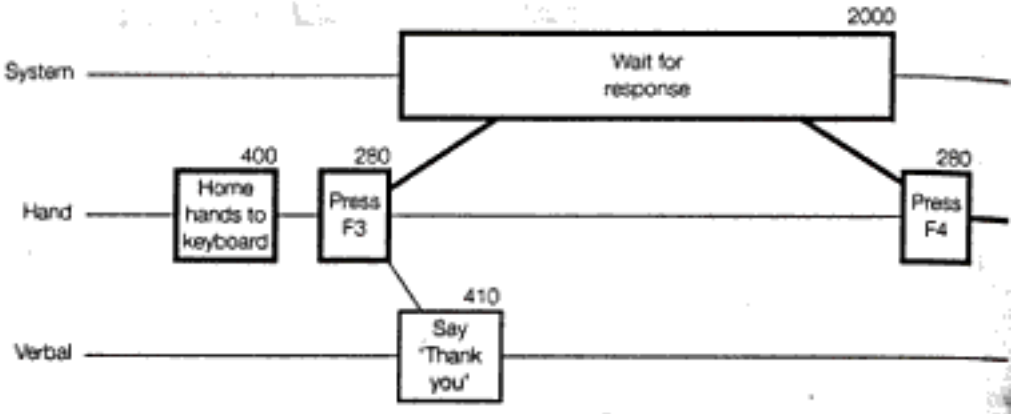

Figure A.5 The same diagram as Figure A.4, drawn with the operators scaled according to their duration. This notation is not used in CPM-GOMS modelling, however, in order to save space.

Bonnie John developed an extension of GOMS, called CPM-GOMS. that can deal with this

We use different horizontal lines on a *schedule chart* for the different threads of sensory-cognitive-motor behaviour

We use the method of *critical paths* to determine which operators limit the performance of the overall task

The critical path is shown by heavier lines

This tells us where speedups in individual operators can result in speedups of the overall task

For example, talking faster won't help in the example above, as it is limited by the system response time

22.5 The CPM-GOMS Models of TAO Tasks

30 models constructed (15 call categories X 2 workstations)
Relatively simple benchmark tasks, e.g., for a credit-card call:

TAO: Great Lakes Telephone, may I help you?
Caller: Operator, bill this to 412-555-6789-4321.
TAO: Thank you.

Part of a typical model for a credit-card call is shown in Fig. 22.3.

Figure 22.3: Portions of a CPM-GOMS model of a credit-card call (N&L, 1995, p. 264)

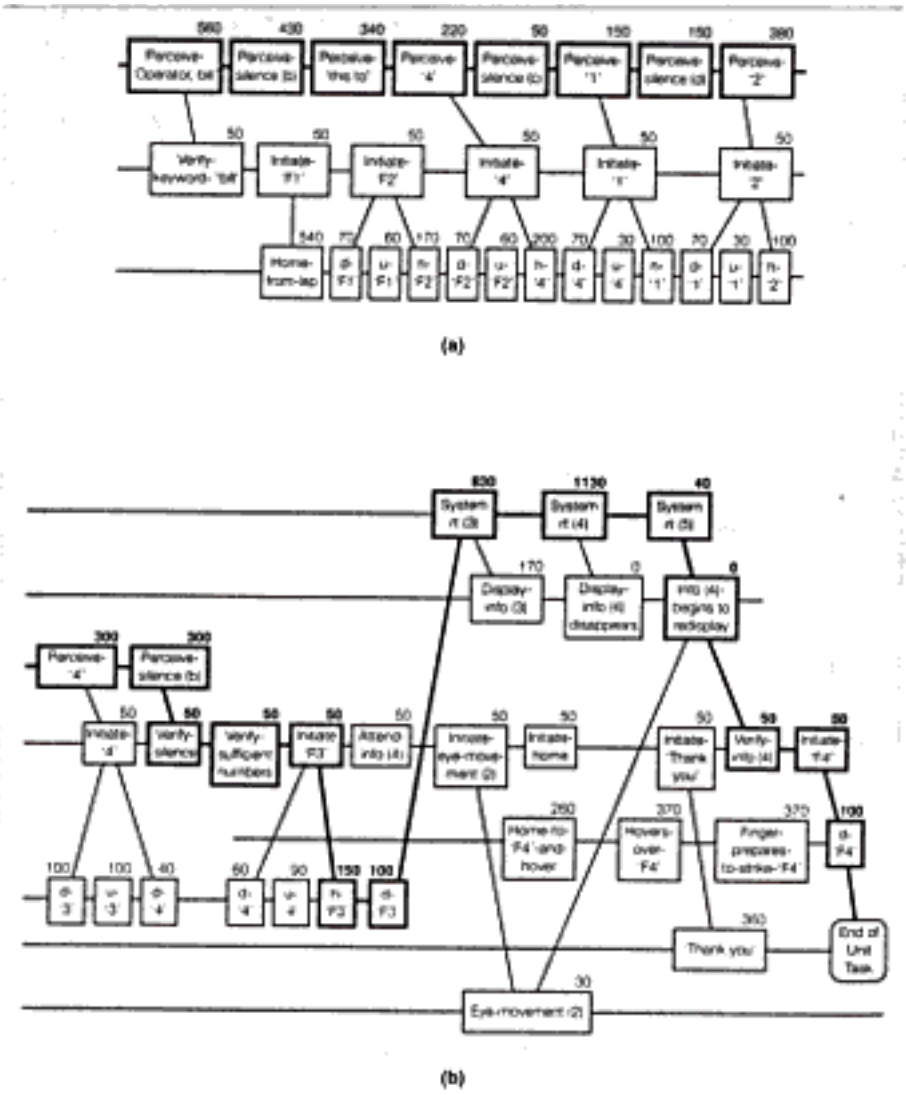

Figure A.8 Portions of the CPM-GOMS model of a credit-card call: (a) in the early stages of handling the call; (b) the final stage of the same model. Home, down and up strokes are abbreviated as 'h-', 'd-' and 'u-'. Horizontal lines represent, in (a), from top to bottom, the following operators: perceptual-aural, cognitive, motor right-hand; in (b): system response, perceptual-visual, perceptual-aural, cognitive, motor left-hand, motor right-hand, motor verbal, motor eye-movement. From Gray *et al.* (1993).

22.6 Results of the Modelling Exercise

Field trial data: New workstation slower by 0.65 seconds
Model predictions: New workstation slower by 0.63 seconds
Individual call-time predictions
- Difference between measured and modeled times:
  - 11.3% for the current workstation
  - 11.9% for the proposed workstation
- Correlations between observed and predicted times:
  - $r^2 = 0.69$ for the current workstation
  - $r^2 = 0.65$ for the proposed workstation

Reasons are even more interesting

22.7 Analysis and Interpretation

Reasons for failure of the new workstation
- Lack of benefit from the keyboard's redesign
  - Few function-key operators on the critical path
  - Close placement of commonly used keys hurt, because it discouraged two-handed use
- Lack of benefit from the new display
  - Although 4 times faster, it now took 1/2 second longer to display the first line of text
  - Display of first few lines was all that really mattered
- Effects of redesigning keystroke sequences
  - Some redesigns were improvements, while others were not, as shown by the CPM-GOMS diagrams
- Limited opportunities for speedup — Analysis showed that
  - 64% of time spent in conversation
  - 16% of time spent in waiting for system response
  - ...
  - Only 11% spent in keying and reading, where workstation redesign could help

A faster design could have been achieved by using pre-recorded initial greeting messages

Project Ernestine a success
- Real-world validation of GOMS style of analytic modelling
- Extensions of GOMS technique
- Successful real-world application of experimental methods
- Significant monetary savings to Nynex

22.8 References

Atwood, M.E., Gray, W.E., and John, B.E. (1996). Project Ernestine: Analytic and Empirical Methods Applied to a Real-World CHI Problem. In Rudisill, M., Lewis, C., Polson, P., and McKay, T. (Eds.) (1996), *Human-Computer Interface Design: Success Cases, Emerging Methods, and Real-World Context*. Morgan Kaufmann, pp. 101-121.

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