COMPARISON OF KLM AND CMN GOMS MODELS

1) What is GOMS model?

a) Goals.

Goals are what the user has to accomplish. Goals are often broken down into sub-goals; all of the subgoals must be accomplished in order to achieve the overall goal. For example, collaborative-writing tasks top most GOAL is "writing an article". Sub-goals include formatting the bibliography, send the current draft to the second author, or incorporate marked-up comments into the text file. Examples of sub-goals for editing part could be *EDIT-MANUSCRIPT* and its subgoals might be *MOVE-TEXT, DELETE-PHRASE* and *INSERT-WORD.*

All of the subgoals must be accomplished to accomplish the higher-level goal. Goals and sub-goals are often arranged hierarchically. Figure 1 shows an example of editing text.

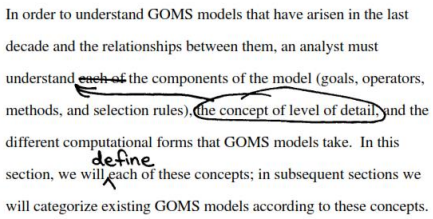

Figure 1. The example task: editing a marked-up manuscript.

b) Operators:

An operator is an action performed in service of a goal. Operators can be perceptual, cognitive, or motor acts, or a composite of these. Operators can change the user's internal mental state or physically change the state of the external environment. The important parameters of operators, in particular execution time, are assumed to be independent of how the user or the system got into the current state (i.e., independent of the history of operators).

Execution time may be approximated by a constant, by a probability distribution, or by a function of some parameter. For instance, the time to type a word might be approximated by a constant (e.g., the average time for an average word by an average typist), or a statistical distribution, or by a function involving the number of letters in the word and the time to type a single character (which could, in turn be approximated by a constant or a distribution).

The accuracy of execution time predictions obtained from a GOMS model depends on the accuracy of this assumption and on the accuracy of the duration estimates. In our text-editing example, with the goal-hierarchy defined above, some operators could be MOVE-MOUSE, CLICK-MOUSE-BUTTON, SHIFT-CLICK-MOUSE-BUTTON and HIT-DELETE-KEY.

c) Methods:

Methods are sequences of operators and subgoal invocations that accomplish a goal. The content of the methods depends on the set of possible operators and on the nature of the

tasks represented. One method for accomplishing the goal *DELETE-PHRASE* (in the text editor we are using to write this paper) would be to MOVE-MOUSE to the beginning of the phrase, CLICK-MOUSE-B UTTON, MOVE-MOUSE to the end of the phrase, SHIFT-CLICK-MOUSE-BUTTON, and finally, HIT-DELETE-KEY (the *mark-and-delete* method).

d) Selection rules:
Selection rules are necessary to represent the user's knowledge of which method should be applied. Typically such rules are based on specific properties of the task instance. Selection rules can arise through a user's personal experience with the interface or from explicit training. For instance, instead of the *mark-and-delete* method, another method could be MOVE-MOUSE to the end of the phrase, CLICK-MOUSE-BUTTON, and HIT-DELETE-KEY 11 times (the *delete-characters* method).

2) How are Goals and Operators different?
The difference between a goal and an operator in a GOMS analysis is based on the level of detail chosen by the analyst. For a goal, the analyst provides lower-level specifications about what need to be done, whereas operators are not broken down any further. There could be more than one operator type but there are not broken down further like say MOUSE CLICK cannot be broken further down.

Continuing the text-editing example, a GOMS analysis could have only one goal (*EDIT-MANUSCRIPT*) and a few high-level operators (e.g., MOVE-TEXT, DELETE-PHRASE and INSERT-WORD). Or, if a finer level of detail is required, the analysis could have four goals *EDIT-MANUSCRIPT*
Subgoals:
- *MOVE-TEXT*
- *DELETE-PHRASE*
- *INSERT-WORD*

Finer-grained operators like MOVE-CURSOR, CLICK-MOUSE-BUTTON, DOUBLE-CLICK-MOUSE-BUTTON, SHIFT-CLICK-MOUSE- BUTTON and HIT-DELETE-KEY to accomplish these goals.

3) How are KLM and CMN-GOMS different?

KLM	CMN GOMS
A sequence of operators are listed and their individual execution times are totaled to compute the overall T_{exec}	A hierarchical structure of goals, sub goals, methods, operations are made. Then a similar process as in KLM is followed.
The analyst must specify the method used to accomplish each particular task instance	Multiple alternate methods could be used. The model predicts the method based on the task situation.
Only keystroke-level primitive operators are considered	Low level cognitive tasks operations are also considered.
KLM Is limited to tasks that can be usefully approximated by a series of	Parallelism possible since we are listing the goals and sub goals of different tasks under

operators, with no parallel activities, no interruptions, and no interleaving of goals.	one main Goal. Some sub goals could be performed in parallel, T_{exec} can be computed in such cases.

Some similarities

- There is a one-to-one mapping between the physical operators in the CMN-GOMS
- model and the **K**s and **P**s in the KLM.
- The VERIFY-LOCATION and VERIFY-HIGHLIGHT, subgoal invocations, and selection rules of the CMNGOMS model are represented as the **M** operators in the KLM. That is, such operators appear in the CMN-GOMS model in groups that roughly correspond to the placement of **M**s in the KLM.

Roughly, the VERIFY operators can also occur in the middle or beginning. The figure below shows an estimate of time taken to edit task using KLM

Moving text with the *MENU-METHOD*

Description	Operator	Duration
Mentally prepare by Heuristic Rule 0	M	1.35
Move cursor to beginning of phrase	P	1.10
(no M by Heuristic Rule 1)		
Click mouse button	K	0.20
(no M by Heuristic Rule 0)		
Move cursor to end of phrase	P	1.10
(no M by Heuristic Rule 1)		
Shift-click mouse button		
(one average typing K)	K	0.28
(one mouse button click K)	K	0.20
Mentally prepare by Heuristic Rule 0	M	1.35
Move cursor to Edit menu	P	1.10
(no M by Heuristic Rule 1)		
Press mouse button	K	0.10
Move cursor to Cut menu item	P	1.10
(no M by Heuristic Rule 1)		
Release mouse button	K	0.10
Mentally prepare by Heuristic Rule 0	M	1.35
Move cursor to insertion point	P	1.10
Click mouse button	K	0.20
Mentally prepare by Heuristic Rule 0	M	1.35
Move cursor to Edit menu	P	1.10
(no M by Heuristic Rule 1)		
Press mouse button	K	0.10
Move cursor to Paste menu item	P	1.10
(no M by Heuristic Rule 1)		
Release mouse button	K	0.10
TOTAL PREDICTED TIME		14.38

From the slides, a CMN-GOMS estimate also shows 14.38 secs. The estimates for the physical operators are identical to the ones in the KLM. The VERIFY-HIGHLIGHT and VERIFY- POSITION operators are assigned 1.35 sec, the same value as the KLM's **M** operator because this is CMN's best estimate of mental time in the absence of other information. Thus, the CMN-GOMS model produces the same estimate for task completion as the KLM.

However, they suggested that at more detailed levels of analysis cognitive activity might become more important. Also notice that where the KLM puts **M**s at the beginning of sub-procedures, the CMN-GOMS model puts the mental time in verify operators at the end of sub-procedures. Since mental time is observable only as pauses between actions, they used them like that. But depending on the tasks, the estimates could vary between KLM and GOMS.

References:

The GOMS Family of User Interface Analysis Techniques: Comparison and Contrast
Bonnie E. John, David E. Kieras, 10 June 1996