Support for Constructing Knowledge Models in CmapTools

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Introduction

The *CmapTools* software suite allows users to construct concept maps representing their understanding of a domain of knowledge. In the case of a large domain, or of a detailed representation of a domain, a single concept map can become unmanageable for the user to comprehend, display, and manipulate. To facilitate the construction of large representations, *CmapTools* allows the user to split them into collections of concept maps (Cmaps). To show the relationships between the Cmaps in the set, the software facilitates the linking of Cmaps, enabling the navigation from one Cmap to another. Additionally, the user can establish links to other types of resources (e.g. images, videos, sound clips, text) that help explain and complement the information in the map.

A set of concept maps and associated resources about a particular domain of knowledge is referred to as a *Knowledge Model*. *CmapTools* provides a rich collection of features that allow users to easily construct *Knowledge Models* (create the Cmaps and establish the links between Cmaps and resources), and publish and share them through *Places* (servers) or the WWW.

This document explains how to construct and manipulate *Knowledge Models* using the *CmapTools* software.

Knowledge Model: a Collection of Cmaps and Resources

Figure 1 shows several opened windows, the result of navigating through a *Knowledge Model* on Mars (Briggs 2001). The "Mars" Cmap is the top-level map, the entry point to this *Knowledge Model*. Some concepts in the "Mars" Cmap have small icons underneath them. These icons indicate that there are other resources (e.g. images, text, videos, Web pages, other Cmaps) that contain additional information, refer to, or further explain that particular concept. By clicking the "concept map" icon underneath a concept, a list of available Cmaps is displayed, which the user can select and open. For example, by clicking on the "concept map" icon underneath the "Exploration Strategy" concept, from the list of Cmaps displayed, the user can select and open a

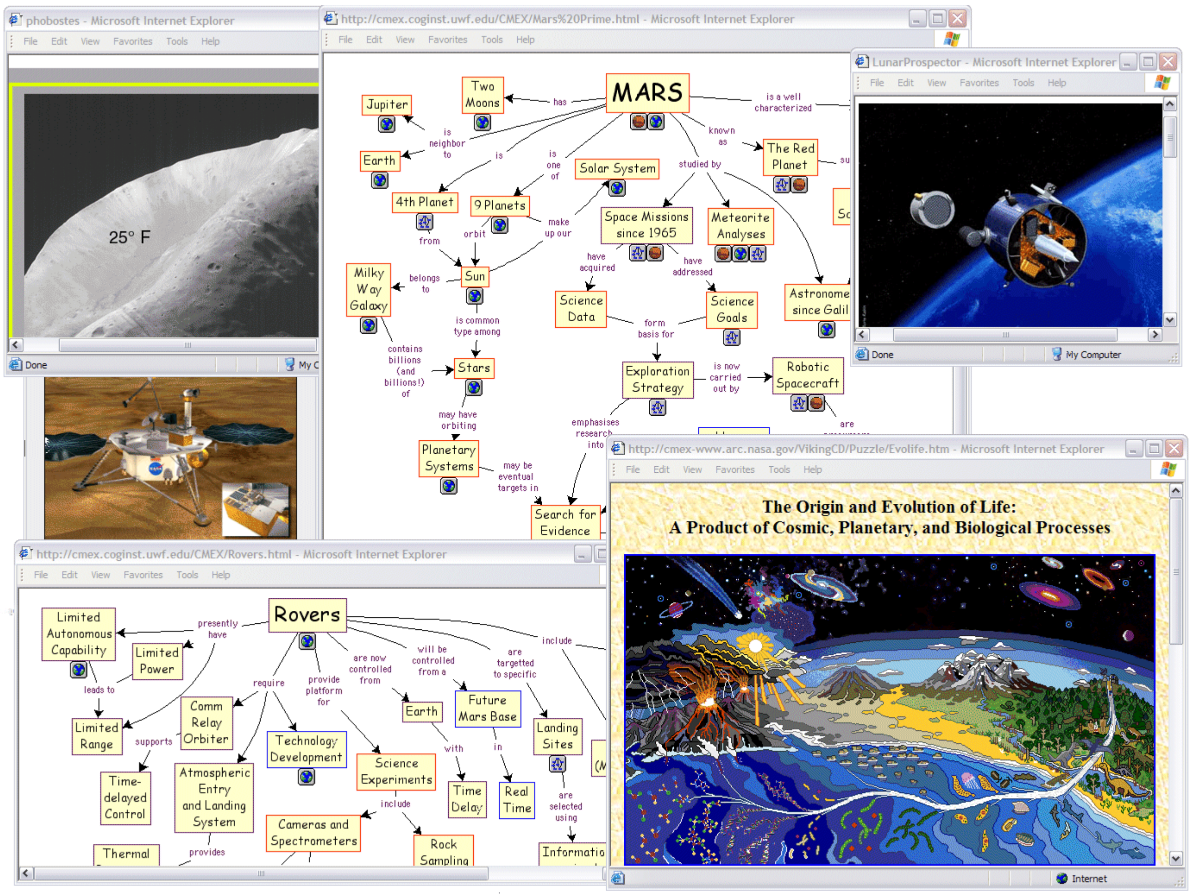
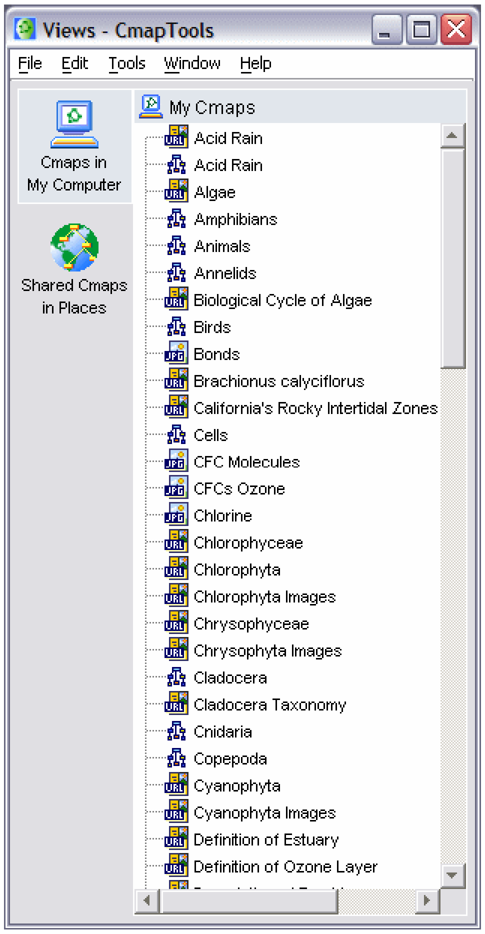

phobostes - Microsoft Internet Explorer
25° F
http://cmex.coginst.uwf.edu/CMEX/Mars%20Prime.html - Microsoft Internet Explorer
MARS
Two Moons
Jupiter
Earth
4th Planet
9 Planets
Solar System
Sun
Milky Way Galaxy
Stars
Planetary Systems
Space Missions since 1965
Meteorite Analyses
The Red Planet
Science Data
Science Goals
Astronomers since Galileo
Exploration Strategy
Robotic Spacecraft
Search for Evidence
LunarProspector - Microsoft Internet Explorer
http://cmex-www.arc.nasa.gov/VikingCD/Puzzle/Evolife.htm - Microsoft Internet Explorer
The Origin and Evolution of Life:
A Product of Cosmic, Planetary, and Biological Processes
http://cmex.coginst.uwf.edu/CMEX/Rovers.html - Microsoft Internet Explorer
Rovers
Limited Autonomous Capability
Limited Power
Limited Range
Comm Relay Orbiter
Time-delayed Control
Atmospheric Entry and Landing System
Technology Development
Science Experiments
Cameras and Spectrometers
Earth
Future Mars Base
Landing Sites
Time Delay
Real Time
Rock Sampling
Thermal
Information

Figure 1: A *Knowledge Model* on the Mars domain, consisting of over 100 linked Cmaps and over 600 MBs of resources.

"Mars Exploration Strategy" Cmap (not displayed in Figure 1). In this Cmap, a concept labeled "Robotic Exploration" has a "concept map" icon that leads to a "Space Missions to Mars" Cmap (not displayed in Figure 1); the "Space Missions to Mars" Cmap has a concept map icon that leads to the "Rovers" Cmap shown in Figure 1. The other images shown are opened by a similar navigation through the icons in the Cmaps. Using Concept Maps as a browser for navigation through a large domain is particularly effective, as is discussed in Carnot *et al* (19XX).



- Acid Rain
- Acid Rain
- Algae
- Amphibians
- Animals
- Annelids
- Biological Cycle of Algae
- Birds
- Bonds
- Brachionus calyciflorus
- California's Rocky Intertidal Zones
- Cells
- CFC Molecules
- CFCs Ozone
- Chlorine
- Chlorophyceae
- Chlorophyta
- Chlorophyta Images
- Chrysophyceae
- Chrysophyta Images
- Cladocera
- Cladocera Taxonomy
- Cnidaria
- Copepoda
- Cyanophyta
- Cyanophyta Images
- Definition of Estuary
- Definition of Ozone Layer

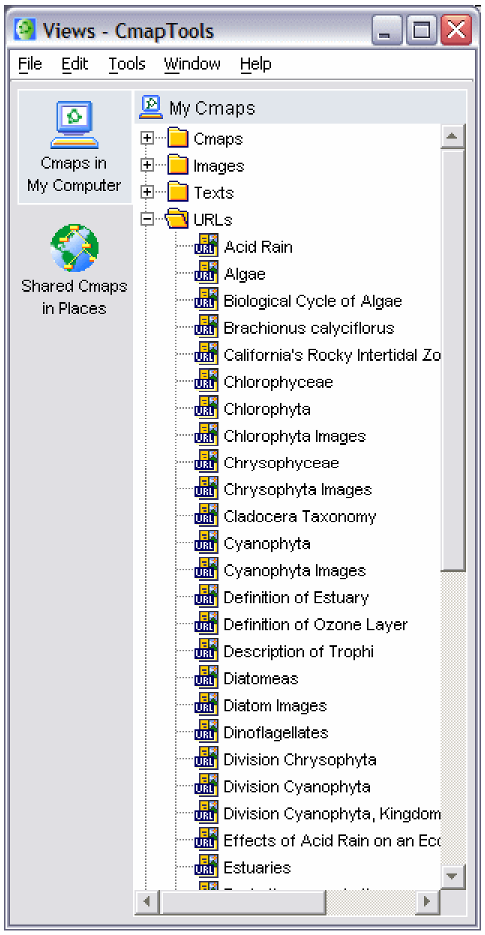
Figure 2

Organizing *Knowledge Models* in the *Views*

The organization of the Cmaps and other resources used in *Knowledge Models* is done in the *Views* windows of *CmapTools*. Figure 2 shows a collection of Science Cmaps, images, texts, videos, links to Web pages (URLs) and other resources that have already been imported into the *My Cmaps View*. *My Cmaps* displays the *Cmaps* and other resources that are stored in your computers' hard drive. (Clicking on the *Shared Cmaps in Places* button will display *Places* on Internet that contain *Knowledge Models* created and shared by users all over the world). The simplest way to add an image, text, Word document or any other resource into this window is to "drag and drop" it from wherever it is located in your computer onto this window (see the Document on Working with *Views* in *CmapTools*).

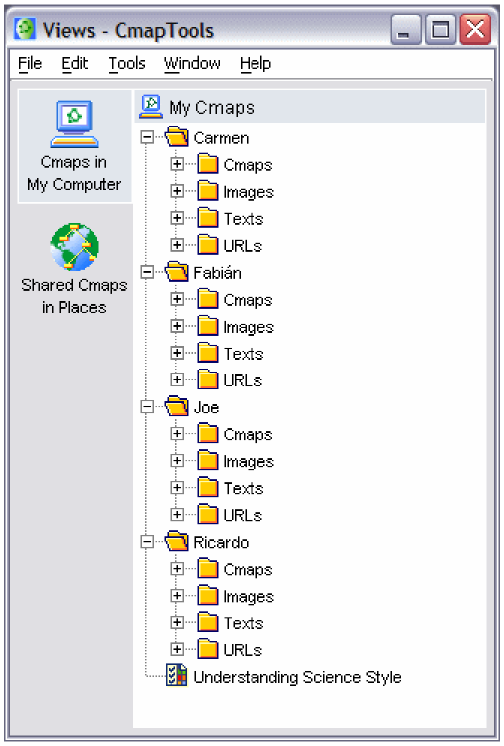
As the number of *Cmaps* and other resources grows, manipulating them in a flat structure as displayed in Figure 2 becomes unmanageable. *CmapTools* offers the possibility of creating a hierarchical structure of folders to organize the resources better. Using the File/New Folder menu entry in the *Views* window or right-clicking on the background of the *Views*' list of resources the user can create as many nested folder as needed.

Figure 3 shows the result of creating various folders to organize the resources by type: a folder for *Cmaps*, and others for Images, Texts, URLs, etc. After creating the folders, moving the resources to the folders is done by "drag and dropping" them to the appropriate folder. Links to resources are not lost as the resources are moved within *My Cmaps* or within the same *Place*. Double-clicking on a folder opens another window with the content of the folder, making it easy to rearrange resources in the folders by "dragging and dropping" them from one window to another.



My Cmaps
- Cmaps
- Images
- Texts
- URLs
  - Acid Rain
  - Algae
  - Biological Cycle of Algae
  - Brachionus calyciflorus
  - California's Rocky Intertidal Zo
  - Chlorophyceae
  - Chlorophyta
  - Chlorophyta Images
  - Chrysophyceae
  - Chrysophyta Images
  - Cladocera Taxonomy
  - Cyanophyta
  - Cyanophyta Images
  - Definition of Estuary
  - Definition of Ozone Layer
  - Description of Trophi
  - Diatomeas
  - Diatom Images
  - Dinoflagellates
  - Division Chrysophyta
  - Division Cyanophyta
  - Division Cyanophyta, Kingdom
  - Effects of Acid Rain on an Ec
  - Estuaries

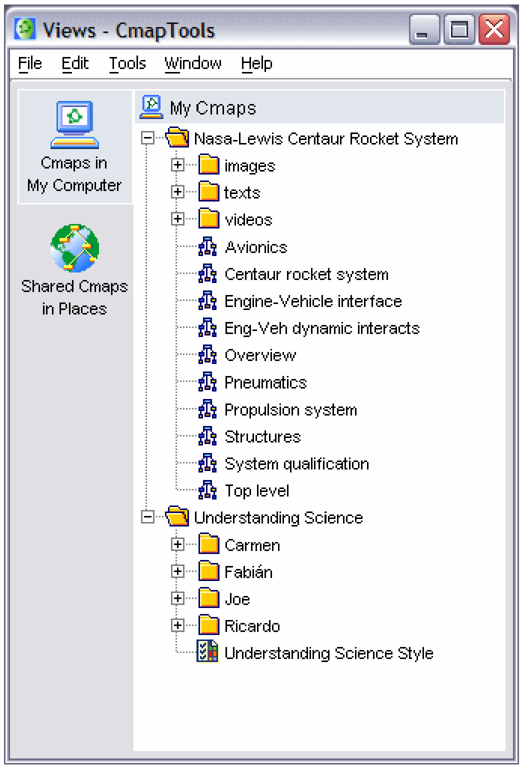
Figure 3



My Cmaps
- Carmen
  - Cmaps
  - Images
  - Texts
  - URLs
- Fabián
  - Cmaps
  - Images
  - Texts
  - URLs
- Joe
  - Cmaps
  - Images
  - Texts
  - URLs
- Ricardo
  - Cmaps
  - Images
  - Texts
  - URLs
- Understanding Science Style

Figure 4

Figure 4 shows an alternative organization scheme for the set of resources in Figures 2 and 3. In this case, folders were created for each of the members of the team working on the project. Within each member's folder, folders were added for the different resource types. (This organization would be more appropriate if these resources were stored in a *Place* where the members of the team can access them concurrently).



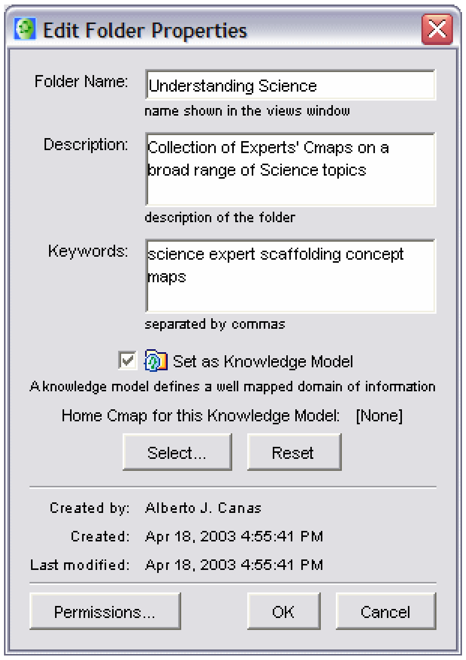
My Cmaps
- Nasa-Lewis Centaur Rocket System
  - images
  - texts
  - videos
  - Avionics
  - Centaur rocket system
  - Engine-Vehicle interface
  - Eng-Veh dynamic interacts
  - Overview
  - Pneumatics
  - Propulsion system
  - Structures
  - System qualification
  - Top level
- Understanding Science
  - Carmen
  - Fabián
  - Joe
  - Ricardo
  - Understanding Science Style

Figure 5

Users can tailor the hierarchical organization of the folders according to their needs. Additionally, if the folders are in a shared *Place*, permissions can be set to the folders to control the access by different users (see the document "Permissions and Access Control in CmapTools").

If the user is working on more than one knowledge domain, then one higher level of classification would be necessary, as shown in Figure 5, to separate the Cmaps and resources from the different domains. In Figure 5, the two top-level folders refer to two domains of knowledge: "Nasa-Lewis Centaur Rocket System" and "Understanding Science". The folders under each of these are used for organizational purposes within those domains. "Nasa-Lewis Centaur Rocket System" and "Understanding Science" are *Knowledge Models*: collections of linked resources about a particular domain of knowledge.

CmapTools provides a mechanism for distinguishing folders that designate *Knowledge Models* from other folders. *Knowledge Models* are recognized by the software and are treated differently from "regular" folders. A set of features are available that only be apply to *Knowledge Models*.



Folder Name: Understanding Science
name shown in the views window

Description: Collection of Experts' Cmaps on a broad range of Science topics
description of the folder

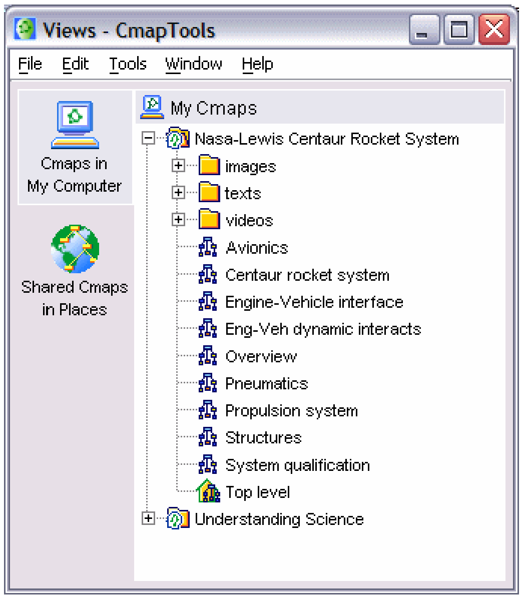
Keywords: science expert scaffolding concept maps
separated by commas

[✓] Set as Knowledge Model
A knowledge model defines a well mapped domain of information

Home Cmap for this Knowledge Model: [None]

Created by: Alberto J. Canas
Created: Apr 18, 2003 4:55:41 PM
Last modified: Apr 18, 2003 4:55:41 PM

Figure 6


Views - CmapTools

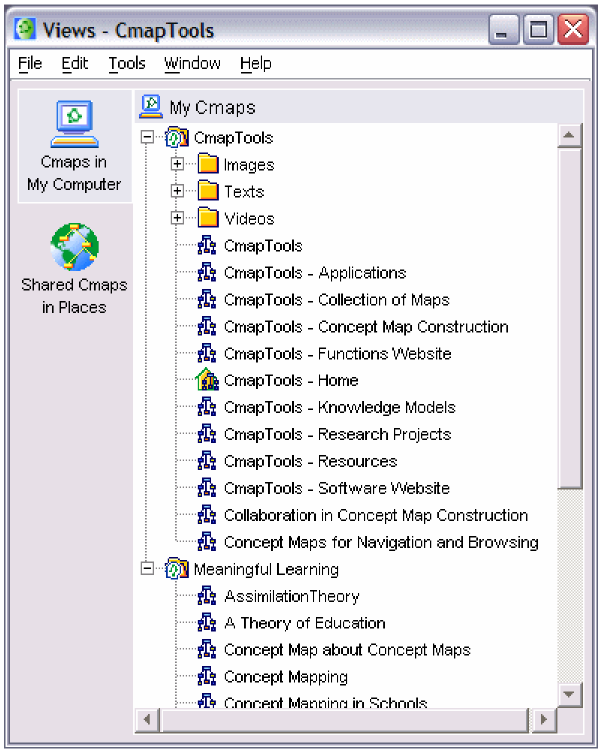
File Edit Tools Window Help

Cmaps in My Computer

Shared Cmaps in Places

My Cmaps
- Nasa-Lewis Centaur Rocket System
  - images
  - texts
  - videos
  - Avionics
  - Centaur rocket system
  - Engine-Vehicle interface
  - Eng-Veh dynamic interacts
  - Overview
  - Pneumatics
  - Propulsion system
  - Structures
  - System qualification
  - Top level
- Understanding Science

Figure 7


Views - CmapTools

File Edit Tools Window Help

Cmaps in My Computer

Shared Cmaps in Places

My Cmaps
- CmapTools
  - Images
  - Texts
  - Videos
  - CmapTools
  - CmapTools - Applications
  - CmapTools - Collection of Maps
  - CmapTools - Concept Map Construction
  - CmapTools - Functions Website
  - CmapTools - Home
  - CmapTools - Knowledge Models
  - CmapTools - Research Projects
  - CmapTools - Resources
  - CmapTools - Software Website
  - Collaboration in Concept Map Construction
  - Concept Maps for Navigation and Browsing
- Meaningful Learning
  - AssimilationTheory
  - A Theory of Education
  - Concept Map about Concept Maps
  - Concept Mapping
  - Concept Mapping in Schools

Figure 8

To designate a folder as *Knowledge Model*, the *Set as Knowledge Model* checkbox in the folder's *Properties* dialogue box must be set as show in Figure 6 (to display the dialogue box, select the folder, and then click on the *Edit/Properties* menu entry or right-click on the folder and select *Properties*). Figure 7 shows the result of setting both "Nasa-Lewis Centaur Rocket System" and "Understanding Science" as *Knowledge Models*. Notice the different icon that indicates that designation.

This dialogue box in Figure 6 also allows the user to select the *Home Cmap* for the *Knowledge Model* (click on the *Select…* button). The *Home Cmap* identifies the recommended initial point for browsing through the *Knowledge Model*. Figure 7 shows the *Cmap* "Top Level" in the "Nasa-Lewis Centaur Rocket System" *Knowledge Model* with a different icon after being selected as the *Home Cmap* for that model.

Knowledge Models can be nested. The "Understanding Science" *Knowledge Model* in Figure 7 could contain, for example, other *Knowledge Models*, e.g. "Ozone", "Energy", "Force", and

"Molecules". There is no restriction on the levels and combinations of nesting of *Knowledge Models* and/or regular folders.

Knowledge Model Path in Link Labels

The *Knowledge Model* also provides the domain context for the *Cmaps* and resources it contains. An instance of this use is the linking of resources across *Knowledge Models*. Figures 8 and 9 provide an example.

The *Views* window in Figure 8 displays two *Knowledge Models*: "CmapTools" (a collection of concept maps about the *CmapTools* software), and "Meaningful Learning" (a set of *Cmaps* on

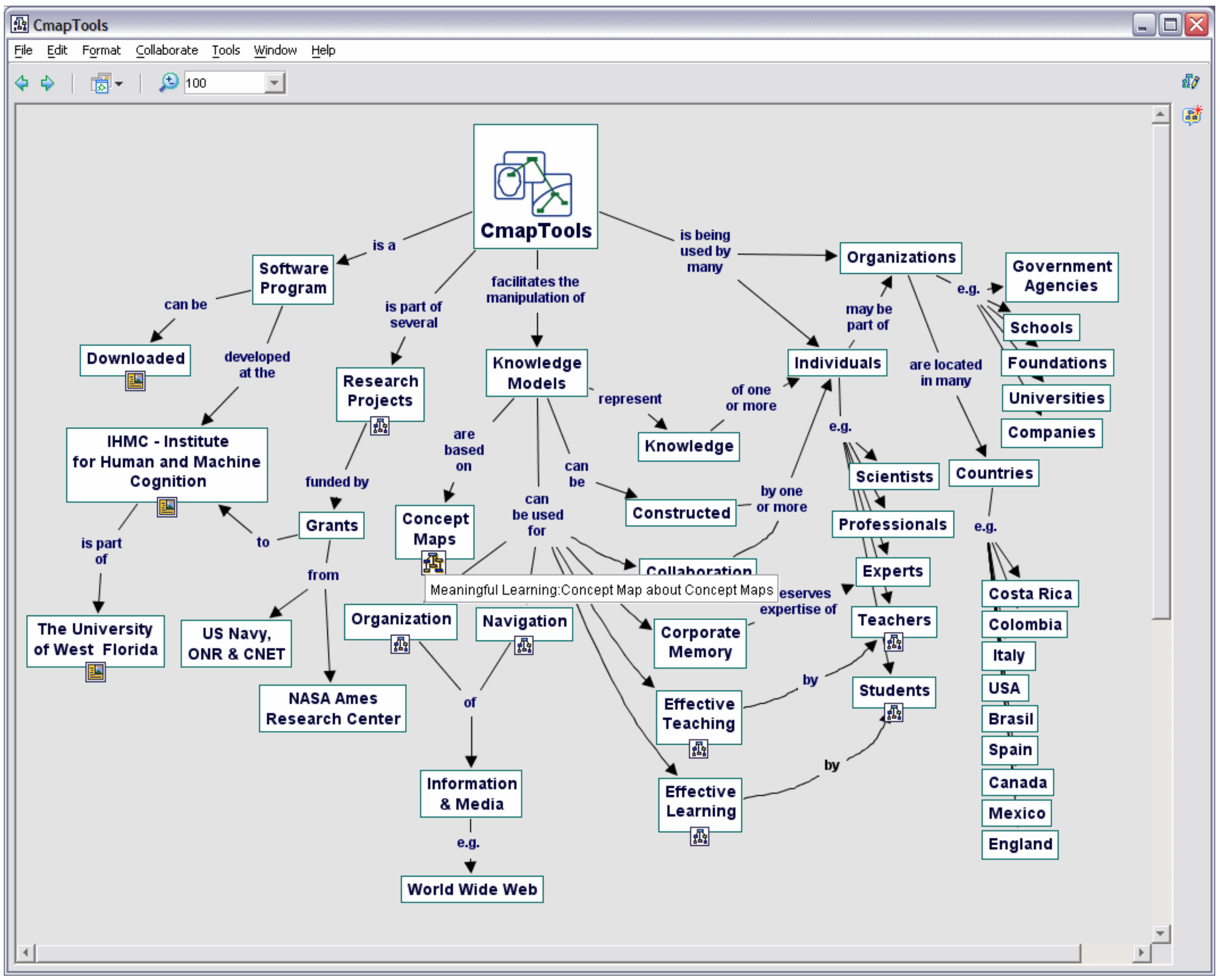


Figure 9

using concept mapping for meaningful learning). When referenced in a link from a *Cmap* in another *Knowledge Model*, a resource label is always preceded by the *Knowledge Model's* name.

Figure 9 shows the opened *Cmap* "CmapTools" from the "CmapTools" *Knowledge Model*. In this *Cmap*, the concept "Concept Maps" has a link to the *Cmap* "Concept Map about Concept Maps" in the "Meaningful Learning" *Knowledge Model*. Notice in Figure 9 that the label underneath the concept's icon reads: "Meaningful Learning: Concept Map about Concept Maps". When setting a link to a resource, if the linked resource is not in the same *Knowledge Model* as the *Cmap* where the link is being set, the destination's *Knowledge Model* name is tagged on to the let of the link label.

The purpose of providing the *Knowledge Model* as part of the label is to inform the user know that following the link implies a change in domain or context. If the label did not indicate that the destination *Cmap* is within the context of "Meaningful Learning", then it would not be until the *Cmap* is opened that the user would discover that the *Cmap* is not what he/she expected. By providing the *Knowledge Model*, when opening the *Cmap*, the user is aware that it is from a different domain.

Not providing semantics in the links is one of the main navigational problems of the WWW: it is not until one opens the destination page of a link that one finds out that its content is not of interest.

If the destination resource is within a hierarchy of *Knowledge Models*, then the path of *Knowledge Models* from the root of the *Place* to the resource (the *Knowledge Model Path*) is tagged on to the left of the link label. This label, however, is static and only set when the link is established. If the destination resource is later moved to another *Knowledge Model*, the link's label is not updated.

Validating Links in a *Knowledge Model*

During the construction of large Knowledge Models, adding, deleting, renaming, replacing, linking, and, in general, the manipulating large numbers of resources leads to broken links. The *Tools/Validate & Fix Links...* menu entry runs a tool that validates links and tries to fix those that are broken. For those links it cannot fix, it gives the user the option to replace manually the broken link with the correct resource. *Validate & Fix Links* can be executed on a single *Cmap* (by selecting the *Cmap* in *Views* or from an opened *Cmap*) or on a folder.

Consider the “Cmaps” folder (within the “CmapTools” folder, which is not designated as a *Knowledge Model*) in Figure 10. If *Validate & Fix Links* is executed on the “Cmap” folder, links are followed for validation throughout *My Cmaps* and to any *Place* that is referenced. If there are broken links, the tool attempts to fix the broken links by looking for resources with the same name and file type. (A link can be broken for many reasons. For example, if the user deleted an image, and later decided to add it again with the same name, links to the image will be broken since each resource is referenced through its unique *resource-id*, and in this case, the new version of the image would have a different *resource-id* from the original). In this case, the search for the target resource only takes place within the “Cmaps” folder and folders contained by it. Therefore, the search will not take place in the folders “Images”, “Texts”, and “Videos” within the “CmapTools” folder, where it would be likely that some of the broken link’s target resources be found.

If the “CmapTools” folder is designated as a *Knowledge Model*, the tool is aware that links in *Cmaps* within the *Knowledge Model* probably target resources within the *Knowledge Model* itself, and so a *Validate & Fix Links* on the “Cmaps” folder generates a search for target resources in broken links that includes all resources contained within “CmapTools” and its subfolders. If resources with the same name and file type are found, the links are fixed automatically. Thus, the software takes advantage of the designation of a folder being a *Knowledge Model* to automatically fix broken links to resources within the *Knowledge Model*.

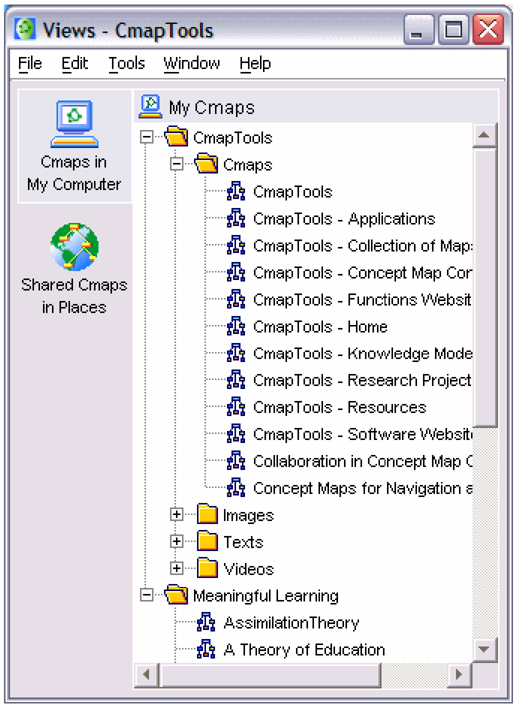

Views - CmapTools
File Edit Tools Window Help
Cmaps in My Computer
Shared Cmaps in Places
My Cmaps
CmapTools
Cmaps
CmapTools
CmapTools - Applications
CmapTools - Collection of Map
CmapTools - Concept Map Cor
CmapTools - Functions Websit
CmapTools - Home
CmapTools - Knowledge Mode
CmapTools - Research Project
CmapTools - Resources
CmapTools - Software Websit
Collaboration in Concept Map C
Concept Maps for Navigation a
Images
Texts
Videos
Meaningful Learning
AssimilationTheory
A Theory of Education

Figure 10

Publishing *Knowledge Models*

Users very often construct their *Knowledge Models* in their *My Cmaps* and periodically copy them to a *Place* for sharing. *Knowledge Models* can grow to be quite large, such as "Return to Mars" shown in Figure 1, which will not fit on a single CD.

When working with large *Knowledge Models*, copying all the resources every time the shared *Knowledge Model* needs to be updated becomes time-consuming, particularly if working over a low bandwidth connection.

CmapTools offers the option to *Publish* a *Knowledge Model* (option *Tools/Publish* in the Views menus). The first time a *Knowledge Model* is *Published*, it is copied to the destination selected by the user.

Figure 11 shows the dialogue box presented to the user the first time the *Knowledge Model* is *Published*. *The New Location* button in the dialogue box allows the user to select the destination directory where the *Knowledge Model* should be copied to.

As with a *Copy* of a folder, the links within the group of resources being copied are updated so that they point to each other at the destination. If the source *Knowledge Model* is in *My Cmaps*, the destination is in a *Place*, and there are links to resources outside the *Knowledge Model*, the program will warn that other users will not be able to follow the links to those resources.

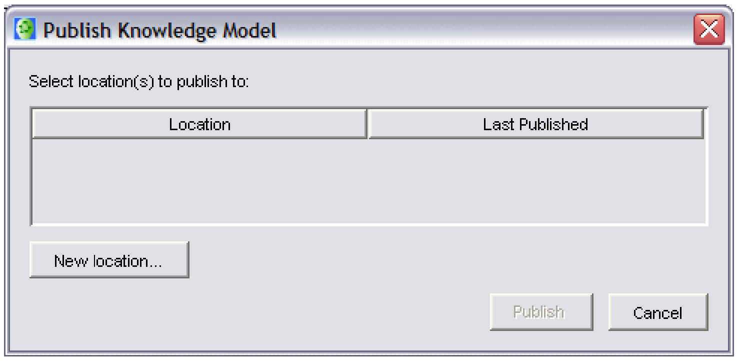
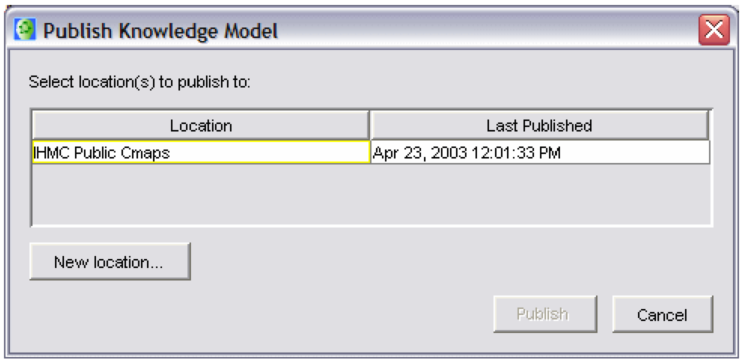


Figure 11

In contrast to a regular *Copy* operation, *CmapTools* takes note and "remembers" that the *Knowledge Model* has been published, and where it has been *Published* to. A *Knowledge Model* can be *Published* to more than one destination. The next time the *Publish* tool is executed for that *Knowledge Model*, the user is presented with the destinations where it has been *Published*, as shown in Figure 12. Once the user selects the appropriate destination, the program updates the destination *Knowledge Model*, by only copying new resources and those resources that have been modified since the last *Publish* date. Thus, the *Publish* option allows a user to make changes to a *Knowledge Model* and, in a single operation, make sure the *Published* version is up-to-date, copying only changes made to the *Knowledge Model* since the last *Publish* operation.


Publish Knowledge Model

Select location(s) to publish to:

Location	Last Published
IHMC Public Cmaps	Apr 23, 2003 12:01:33 PM

Figure 12

Publish is not meant to be a mechanism by which users collaborate in the construction of a *Knowledge Model*. It is designed for a single user constructing a *Knowledge Model* that needs to be shared. If a group of users needs to collaboratively build a *Knowledge Model*, synchronous and asynchronous collaboration tools for constructing the *Cmaps* in a *Place* are provided by *CmapTools* (see document “Synchronous and Asynchronous Collaboration in *CmapTools*).

To make sure the *Published Knowledge Model* is protected, the first *Publish* operation copies the permissions of the source *Knowledge Model* to the destination. The user can then refine those permissions at the destination. Subsequent *Publish* operations do not copy or alter the permissions.

Map of Cmaps

References

Briggs, G. (2001). Return to Mars 202, http://cmex.coginst.uwf.edu.

Carnot, M. J., B. Dunn, A J. Cañas, P. Graham, J. Muldoon (2001) Concept Maps vs. Web Pages for Information Searching and Browsing, Manuscript in preparation.