- To provide a general framework and a reference model for the creation and programming of distributed multimedia applications.
- To allow existing media devices to be interfaced to an application.
- OO programming infrastructure to support the development.
- To recognize the evolution of multimedia system technologies for research tools to mature.
- To certify products that meets QoS and fundamental requirements.

PREMO is being developed at the CWI-Computer Center, Netherlands, and more information about PREMO can be found at its web site: *http://dbs.cwi.nl/cwwwi/owa/*

5. Specification and Design of Multimedia Software Systems

Specification and design of multimedia applications pose new challenge to authoring systems due to temporal and spatial relations. Common design of hierarchical composition of objects needs to be found, thus leading to object-oriented tools. For the specification of multimedia software systems, a new paradigm is espoused: software engineers will do evolutionary design of complex systems through: (1) architecture specification, (2) design rationale capture, (3) architecture V&V, and (4) architecture transformation, using an object-oriented architecture description language [24]. Another recent approach is to extend UML, the Universal Modeling Language, for the modeling of multimedia applications [22]. In what follows, we survey two more formal approaches in specification and design.

5.1. *An actor based approach to multimedia software specification*

Dattolo [11] applies the actor model for modeling software as collections of distributed, cooperative entities, as illustrated in Fig. 2. It is felt that the classical notion of object is too vague to support large-scale concurrency. On the other hand, actors combine object-oriented and functional programming in order to make the management of concurrency easier for the user. An actor reacts to the external environment by executing its procedure skills (scripts). An example for TeleoActor class definition based upon the ESAL (Extended Simple Actor Language) is as follows:

```
(Def TeleoActor
{Actor}
(stor info
hypServices image
inSuggestion brSuggestion cnSuggestion)
[(apply-filter), (visualize), (tree-brws), (grph-brws),]) .
```

The Dexter model for hypermedia is used, which is essentially a two-layer model — runtime layer and storage layer — for hypermedia. The architecture was

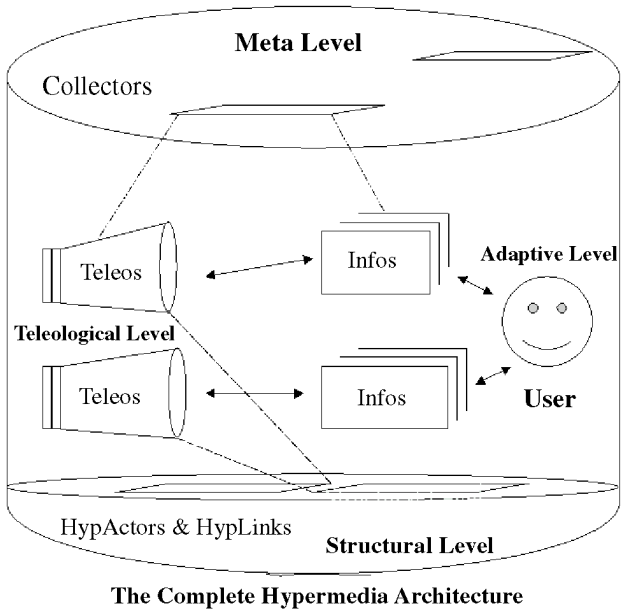

Fig. 2. Hypermedia information system based upon the actor model.

applied in the development of a hypermedia system named DiBlue, which is a distributed version of Blue, a traditional OPLA hypermedia programming environment. It supports an object-oriented logic programming system in OPLA, a hybrid language originated from the marriage between Prolog and CLOS.

5.2. *Teleaction objects for multimedia software specification and prototyping*

Multimedia systems incorporating hyperlinks and user interaction can be prototyped using TAOML, an extension of HTML. TAOML is used to define a Teleaction Object (TAO) which is a multimedia object with associated hypergraph structure and knowledge structure. The user can create and modify the private knowledge of a TAO so that the TAO will react automatically to certain events. The knowledge structure of a TAO is an active index [5], which consists of a collection of index cells (ICs) with behavior similar to that of agents. The hypergraph structure supports the effective presentation and efficient communication of multimedia information. The static aspects of the hypergraph structure are described by a Multimedia Static Specification (MSS). TAOs are valuable since they improve the selective access and presentation of relevant multimedia information [6].

The structure of the multimedia application development system is shown in Fig. 3 below. It mainly consists of two tools. The Formal Specification Tool allows a specification of the MSS to be created. The specification may be either visual or text-based. The specification is then validated using a Symbol Relation (SR)

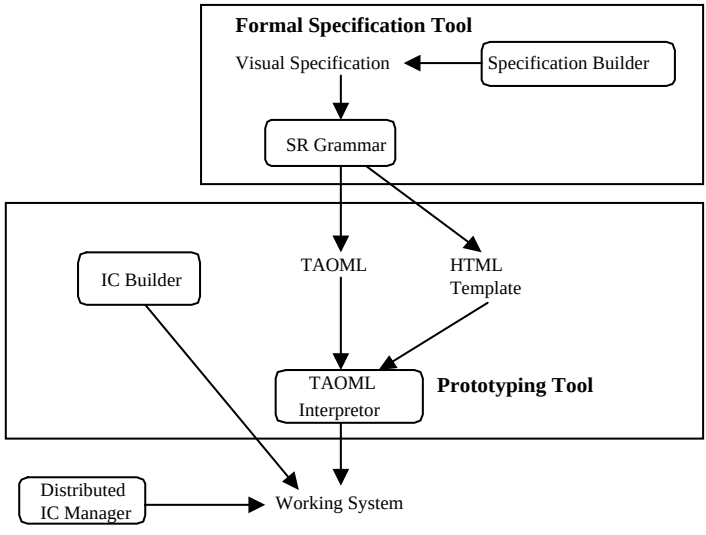

Fig. 3. The structure of the multimedia application development environment.

grammar [2, 3, 13]. Such a multidimensional grammar is particularly attractive for multimedia applications since it can describe the spatial and temporal aspects of an application [7]. If the specification is valid, the tool generates TAOML and an HTML template for the specified system.

The Prototyping Tool includes an IC Builder to create the index cells comprising the knowledge structure of the TAOs. A TAOML interpreter generates HTML code from the TAOML and HTML template from the information produced by the IC builder. The application generated can then be executed from any web browser working with the distributed IC Manager that controls the active knowledge structure built out of active index cells. Multimedia applications in many domains were developed using these tools, mostly notably e-learning [9].

The above described tools provide a way to formally specify the TAOs comprising the application, verify and validate the specification, and rapidly prototype the application. TAOs provide one of the first unified approaches for multimedia software engineering.

6. Model-and Pattern-Based Design Approaches

6.1. *A model-based approach to hypermedia design*

In the model-based approach to hypermedia design, the key concept is to provide a comprehensive model for software specification and design. For instance, the Relationship Management Methodology (RMM) comprises (1) Entity-Relationship design, (2) Application diagram design, (3) M-slice (aggregate) design, (4) Navigational design, (5) User interface design, (6) Protocol conversion design, (7) Run-time behavior, and (8) Construction and testing [18].