1a) Project Title.

Intelligent Information Retrieval and Presentation in Public Historical Multimedia Databases (I^2RP)

1b Acronym

I2RP

1c) Principal Investigator.
Prof. dr. L.R.B. Schomaker, KI/RUG

2) Classification.

a) Op welk toepassingsgebied is het voorgestelde onderzoek gericht?
Opleiding & Cultuur
b) Welk(e) onderzoekscluster(s) betreft het voorgestelde onderzoek?
(Gebruiker, Data of Kennisveredeling en Kennisoverdracht)

Gebruiker
Kennisoverdracht

c) Welk(e) bedrijven en instanties hebben direct of indirect baat bij het voorgestelde onderzoek? (Geef ook de naam van het relevant lid van de Gebruikerscommissie)

Afnemer	Vertegenwoordiging Gebruikerscommissie
Rijksmuseum Amsterdam	Schoemaker

Verdere gebruikers: GlobalArtVillage, Den Haag (J. Pieters).

3) Composition of the Research Team.

Prof. dr. L.R.B. Schomaker (coordinator) *image retrieval and user interfacing*	KI/RUG	Grote Kruisstraat 2/1 9712 TS Groningen 050-3637908 schomaker@ai.rug.nl
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Dr. N. Taatgen *cognitive modeling*	KI/RUG	Grote Kruisstraat 2/1 9712 TS Groningen 050-3636435 niels@ai.rug.nl
Ms. Dr. H.L. Hardman *multimedia user interaction*	CWI	Kruislaan 413 PO Box 94079 1090 GB Amsterdam 020 592 9333 Lynda.Hardman@cwi.nl
Dr. J.R. van Ossenbruggen *hypermedia generation, SMIL*	CWI	Kruislaan 413 PO Box 94079 1090 GB Amsterdam 020 592 4141 Jacco.van.Ossenbruggen@cwi.nl
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Dr. F.J. Wiesman *information retrieval / ontologies*	IKAT/UM	Universiteit Maastricht Department of Computer Science P.O. Box 616 6200 MD Maastricht 43 38 83379 wiesman@cs.unimaas.nl

Additionally, funding for **six** researchers is requested in total, distributed over the four institutes which are involved: KI/RUG (1), Psy/RUL (2), CWI (2), IKAT/UM (1). A more detailed overview is presented in the table in section 5 of this proposal.

4) Description of the Proposed Research.

Current advances in information technology have lead to a situation where systems have become very advanced at the lower levels of processing. Although powerful functionality is present within such systems ('under the hood') the paradox is that an increased amount of effort is expected from the user in terms of the required amount of input which is needed to provide the parametrization of the desired advanced functionality. Furthermore, there exist many new information processing and rendering functions, which were not available in the world of paper-based information processing and which were unimaginable during the early stages of computer development. For these new functionalities, many new interaction approaches have been introduced. As a consequence, current computer software requires a level of user competence which is beginning to limit the effectiveness of information and communication technology.
A case in point concerns those multimedial applications which give the regular computer user acces to historical information in large databases. The ARIA and Adlib databases, developed by the Rijkmuseum in Amsterdam, contain thousands of images and several hundreds of thousands textual database records concerning paintings and works of art. The problems in searching, accessing and utilizing the available multimedial information are huge. As an example, one cannot require the general user to specify his/her database-search query in a formal language such as SQL. Neither is it likely that a single design solution for a WWW-page in HTML (e.g., a form) will suit all possible types of access to such a database. Given the presence of advanced database software and pattern-recognition tools, the challenge will be to translate the available technical functionality into a form which is convenient for the end user. Consequently, there are a number of research questions:

- How can we translate a conceptual internal knowledge representation (containing, e.g., a specific item of knowledge on a topic in Art and History) into understandable language (Dutch), in a format which is adapted to the current user and the current context of usage? (Theme: Knowledge Enrichment)
- How can we render hypermedia content in a way which is adapted to the prevailing constraints within the usage context and the actual system hardware which is being used? (Theme: Rendering)
- How can we design system architectures which understand user behavior and which actively support the user and his/her typical (time-variant) interests and preferences? (Themes: Navigation, Knowledge Enrichment, Adaptivity).

The proposed research will leverage on the current international developments on Web-based agent-technology and ontologies in the context of the "Semantic Web" (E.g. activities stimulated by European 5th and 6th Framework, DARPA/DAML and W3C). While these developments focus on "under the hood" technologies, our research will focus on making these technologies available for the average user.

Within this general framework, a number of research perspectives can be identified. For each of these perspectives, subtasks are defined within the project at large.

Name	Problem Area	Task Title	Institutes
Optima	User-Input Support User Modeling	A User-Agent for Object-based Image Search	KI/RUG
Spreekbuis	Language Output	Performance Grammar Workbench: a Dutch sentence generator	RUL
Cuypers	Presentation generation	Automatic user-centric hypermedia generation	CWI
GO	Knowledge visualization	Graphical Ontologies	IKAT/UM

An essential aspect of the proposed research is its focus on working systems. User groups and potential user groups will be regularly requested to participate in **annual workshops**, in which the results are demonstrated. Although the goal of system implementation is usually in conflict with the goal of scientific publication, our proposed approach is supported and safeguarded by means of the financial/organisational matching resources provided by the participating institutes.

Optima: Optimal Personalized Interface by Man-Imitating Agents

Current developments in software, the internet and consumer electronics are characterized by increases in functionality, but also by increases in complexity of the user interface. In general developers try to achieve a design that optimally fits the preferences and capabilities of the average user. The problem with this approach is that it is often impossible to define an average user, and that this definition is sometimes useless anyway. An example of this situation in which an individual user only uses part of the functionality of an application intensively, and the rest not at all. Applications in which the user has to **navigate** through large amounts of data, such as Electronic encyclopediae, web portals and other online information sources all fit into this category. Users vary wildly in their needs for information, and also vary in the way they search for information most comfortably.

A better solution is to make the user interface **adaptive**, such that the interface becomes optimized for an individual user. More in particular, the interface should adapt itself to support the strategies, knowledge level and proficiencies of a particular user. The general goal of the project Optima is to design a methodology to make adaptive user interfaces, based on the metaphor of the intelligent agent. The basis for the agent will be the ACT-R architecture, which is both a theoretical model of human information processing and a simulation environment for human cognition. The agent acts as if it looks over the shoulder of the user, so that it goes through the same learning process. The agent acquires information based on the behavior of the user: the choices that are made, reaction times, errors, etc. The result of the learning process is an agent that exhibits characteristics of the user. The interface can use information from the agent to adapt itself to the individual user. The implementation of the adaptation process itself will be realized in cooperation with the Cuypers project. An interesting secondary component of this research is that the individual models can be reused in a cluster analysis, to detect general tendencies in the population. This will show what parts of possible user knowledge are general, and what parts are individual. In the project proposed here, the Optima agent-methodology will be developed in the context of a system to search images in large databases. The platform for this system has been developed during the first phase of ToKeN2000 at NICI/KUN under the supervision of the applicant.

For the research within the Optima framework and the realization of the actual user agent, KI/RUG will cooperate with CWI. The CWI contribution focuses on the aspects of adaptive information rendering (see subtask Cuypers).

Spreekbuis: Automatic concept-to-speech generation in Dutch

> *Spreekbuis: 'mouthpiece', a person, newspaper etc. that conveys the opinions or sentiments of another or others; spokesman (Webster's)*

In the area of language technology, the number of projects concerning the generation of written and spoken Dutch on the basis of meaning input is very limited. No full-fledged concept-to-speech generation system is currently available. Existing Dutch-language information presentation systems (e.g. in the internet or in mobile telephony) are based on syntactic templates and allow little flexibility. The printed or spoken texts they produce tend to be stereotyped, awkward and insufficiently cohesive/coherent. Furthermore, although high-quality speech synthesis software for Dutch is available, algorithms for controlling prosodic features (intonation contours, accents, duration, pausing) on the basis of pragmatic, semantic and morphosyntactic properties are still in their infancy. Language output generation constitutes an important core aspect of the **rendering** research theme in ToKeN2000.

The goal of this project is to develop a sophisticated concept-to-speech generator for Dutch, taking into account the following two constraints: (1) Its design should maximize adaptability of the system to a variety of information presentation applications; and (2) It should utilize and integrate existing high-quality linguistic data, algorithms and modules that are already available commercially or otherwise. In view of the state of the art outlined above, we will focus our work on

- elaborating (diversifying) and improving the lexical and syntactic modules that we have implemented in the first year of ToKeN2000 (based on the Performance Grammar formalism)
- designing and implementing a new logical-semantic representation formalism that is compatible with the current lexical and syntactic modules
- adapting the various linguistic modules to the needs of prosody control.
- upgrading the current graphical-interactive "Performance Grammar Workbench" to a user-friendly tool that supports software adaptations necessitated by a new application (e.g. defining and testing new lexical items an syntactic constructions needed in the new application).

The first application will be defined in close cooperation with the other participants of I2RP. One option is to build a generator that describes pictures in the ARIA and Adlib databases of the Rijksmuseum, as well as the objects, characters and scenes depicted in them. The grammatical and prosodic form of the description should be sensitive to preceding utterances by the user and by the system. The semantic representation language will include concepts defined in the Graphical Ontology project of IKAT/UM. In order to enable the user to make accurate selections of to-be-described objects/persons/scenes in a picture, we will use pen tools developed at NICI/KUN. After the Optima project of KI/RUG has produced user modeling software, we will consider using it to fine-tune generator output to user characteristics.

The Spreekbuis project will be carried out at the Experimental and Theoretical Psychology Unit of Leiden University in close collaboration with the Departments of Computer Science and of General Linguistics, and with the Institute for Dutch Lexicology, also in Leiden. The IPO/TUE in Eindhoven will contribute phonetic and prosodic expertise. Part of the financial resources will be used to purchase software (e.g. a lexical database, speech synthesis software). In order to facilitate software portability, we will implement as many system components as possible in JAVA.

Cuypers: A User-Centred Hypermedia Presentation Generator

The work of CWI will focus on the presentation aspects of personalized, media-centric hypermedia-interfaces.

The Cuypers proof-of-concept prototype, constructed in the first phase of ToKeN2000, currently focuses on the **adaptation** of hypermedia presentations to various end-user devices. For example, a desk-top computer, a hand-held device or a mobile phone. This device-driven approach was developed to validate our constraint-driven approach to hypermedia presentation generation.

In the following phase of ToKeN2000, the device-driven approach will be integrated with a more user-centric approach, based on explicit user profile information. In order to adapt hypermedia presentations to an individual user's task and preferences, adequate user models need to be developed. Research to address this issue will be carried out in cooperation with KI/RUG in the context of the Optima project.

To be able to convey the results of a multimedia database query to a user effectively, the individual multimedia objects need to be related by placing them in the context of a unified hypermedia presentation. This process of **enriching** the database content requires a number of steps. First, research is needed into appropriate rhetorical and narrative structures to guide the overall flow of the presentation. Second, research is needed into the process of mapping the rhetorical and narrative structures onto hypermedia presentation patterns. This process is driven by high-level hypermedia design rules which also have to be developed. Finally, research is needed into the realization of these hypermedia patterns in terms of a concrete hypermedia presentation format driven by lower-level design rules and qualitative and quantitative presentation constraint processing.

Collaboration will continue with the Rijksmuseum on providing added value by generating adaptive user-centric hypermedia presentations as a personalized interface to both the museum's internal databases (the Adlib database which is intended for museum experts) and external database (ARIA, intended for the general public).

To benefit directly from the state-of-the-art in the relevant Web-technoloy, the proposed research will capitalize on CWI's close links with W3C. Research aspects focusing on agents for personalized adaptation will be carried out in cooperation with KI/RUG in the context of the Optima project, while the cooperation with IKAT/UM will stress the role of ontologies in the agent-driven user interaction that characterizes both the Cuypers and the GO subtasks.

GO: Graphical Ontologies

The subtask GO will be performed by IKAT/UM.
Currently, ample interest exists in ontologies for use in Internet interoperability [Bern2000]. Especially in digital libraries, ontologies are vital for searching heterogeneous information databases. To enable the building, maintenance, and use of ontologies various formalisms and tools are available (see, e.g., [Deck2000]). The proposed project aims at a generic tool for searching (**navigating**), accessing, and editing ontologies. It will be generic in the sense that it is independent of the representation formalism used.

In the first phase of ToKeN 2000, a metabrowser for information retrieval was developed, with a special focus on the presearch (i.e., the phase where the user has not yet started searching for documents but is searching for the relevant concepts). The idea is to present the user with a partial view of the thesaurus (ontology), which changes depending on filters chosen by the user (an earlier version was reported on in [Wies97]). This metabrowser will be the basis for the ontology tool.

The main research questions are:

- How can structural information be extracted from ontologies in a generic way? (Theme: Knowledge Enrichment)
- For users, how can tangled hierarchies best be visualized? (Theme: Rendering)
- For software, how should structure information be conveyed? (Theme: Rendering)

Starting points will include the domain ontology for the annotations of the Rijksmuseum's ARIA database (as used in the Spreekbuis subtask) and an ontology for describing user profiles (as used in the Cuypers subtask and possibly the Optima subtask).

5) Requested Budget

Nr.	Position	Inst.	Backgr.	Name	Task Title	yrs	Amount	Supervisor
1	postdoc	KI/RUG	cog		Optima	2	250 kfl	Schomaker,Taatgen
2	postdoc	RUL	cog		Spreekbuis	2	250 kfl	Kempen
3	OIO	RUL	cog		Spreekbuis	4	250 kfl	Kempen
4	postdoc	CWI	inf		Cuypers	2	250 kfl	Kersten
5	OIO	CWI	inf		Cuypers	4	250 kfl	Hardman
6	postdoc	IKAT/UM	inf	F. Wiesman	GO	2	250 kfl	v.d. Herik
	Total						1500 kfl	

Optima, 1x postdoc KI/RUG

postdoc	2 yrs	f.	225.000	
travel		f.	7.350	
materials		f.	17.650	
Total		f.	250.000	
Matching 25%	Schomaker	-f.	39.312	(f 126,00 * 312 hours)
	Taatgen	-f.	23.188	(f 74,33 * 312 hours)
Funding	requested	f.	187.500	

Spreekbuis, 1x postdoc RUL

postdoc	2 yrs	f.	225.000	
travel		f.	7.000	
materials		f.	18.000	
Total		f.	250.000	
Matching 25%	Kempen	-f.	63.000	(5 hrs/week)
Funding	requested	f.	187.000	

Spreekbuis, 1x OIO RUL

OIO	4 yrs	f.	228.000	
travel		f.	22.000	
Total		f.	250.000	
Matching 25%	Kempen	-f.	63.000	(5 hrs/week)
Funding	requested	f.	187.000	

Cuypers, 1x postdoc CWI/INS2

postdoc	2 yrs	f.	190.000	(fl 95.000 * 2 years)
travel		f.	15.000	
materials		f.	45.000	
Total		f.	250.000	
Matching 25%	Kersten	-f.	62.500	(fl. 125,00 * 500 hours)
Funding	requested	f.	187.500	

Cuypers, 1x Phd student (OIO) CWI/INS2

OIO	4 yrs	f.	228.000	
travel		f.	22.000	(fl. 5500 * 4 years)
Total		f.	250.000	
Matching 25%	Hardman	-f.	62.500	(fl. 680,00 * 92 days)
Funding	requested	f.	187.500	

GO, 1x postdoc IKAT/UM

postdoc	2 yrs	f.	225.000	
travel		f.	7.350	
materials		f.	17.650	
Total		f.	250.000	
Matching 25%	vd Herik	-f.	23.984	(0.05 fte=f. 11.992/annum)
	Sprinkhuizen	-f.	39.016	(0.20 fte=f. 19.508/annum)
Funding	requested	f.	187.500	

6a) Literature

[Bern2000] Berners-Lee, T., Fischetti, M., and Dertouzos, M.L. (2000). *Weaving the Web: The Original Design and Ulitmate Desitiny of the World Wide Web.* Harper, San Francisco.

[Deck2000] Decker, S., Melnik, S., Harmelen, F. van, Fensel, D., Klein, M., Broekstra, J., Erdmann, M. and Horrocks, I. (2000). The Semantic Web: The Roles of XML and RDF. *IEEE Internet Computing, Vol. 4, No. 5.*

[Wies97] Wiesman, F. and Hasman, A. (1997). Graphical information retrieval by browsing meta-information. *Computer Methods and Programs in Biomedicine, Vol. 53, No. 3,* pp. 135-152.

6b) Key publications

Harbusch, Karin & Kempen, Gerard (2000). *Complexity of linear order computation in Performance Grammar, TAG and HPSG.* In: Proceedings of Fifth International Workshop on Tree Adjoining Grammars and Related Formalisms (TAG+5), Universite Paris 7, May 2000. [pp. 101-106]

Jacco van Ossenbruggen, Frank Cornelissen, Joost Geurts, Lloyd Rutledge, and Lynda Hardman (2001). *Towards second and third generation Web-based multimedia* In: The Tenth International World Wide Web Conference, May 1-5 2001, Hong Kong.

Kempen, Gerard (1999). *Visual Grammar: Multimedia for grammar and spelling instruction in primary education.* In: K.C. Cameron (Ed.). CALL: Media, design, and applications. Lisse: Swets & Zeitlinger. [pp. 223-238]

Kempen, Gerard (1996). Computational models of syntactic processing in human language comprehension. In: Dijkstra, T & De Smedt, K. (Eds.), Computational psycholinguistics: symbolic and subsymbolic models of language processing. London: Taylor & Francis. [pp. 192-220]

Kempen, Gerard (1992). *Language generation.* In: W. Bright (Ed.) International Encyclopedia of Linguistics. New York: Oxford University Press.[pp. pp. 59-61]

Lloyd Rutledge, Jim Davis, Jacco van Ossenbruggen, and Lynda Hardman (2000). *Inter-dimensional Hypermedia Communicative Devices for Rhetorical Structure* In: Proceedings of International Conference on Multimedia Modeling 2000 (MMM00), November 13-15, Nagano, Japan.

Lloyd Rutledge, Brian Bailey, Jacco van Ossenbruggen, Lynda Hardman, and Joost Geurts (2000). *Generating Presentation Constraints from Rhetorical Structure* In: Proceedings of the 11th ACM conference on Hypertext and Hypermedia (pages 19-28), May 30 -- June 3 2000, San Antonio, Texas, USA.

Lloyd Rutledge, Lynda Hardman, Jacco van Ossenbruggen, and Dick C.A. Bulterman (1998). *Implementing Adaptability in the Standard Reference Model for Intelligent Multimedia Presentation Systems* In: The International Conference on Multimedia Modeling (pages 12-20), 12-15 October.

Plamondon, R., Lopresti, D.P., Schomaker, L.R.B. and Srihari, R. (1999). *On-line handwriting recognition.* In: J.G. Webster (Ed.). Wiley Encyclopedia of Electrical & Electronics Engineering, 123-146, New York: Wiley, ISBN 0-471-13946-7.

Schomaker, L., Vuurpijl, L. & de Leau, E. (1999). *New use for the pen: outline-based image queries.* Proceedings of the 5th International Conference on Document Analysis and Recognition (ICDAR '99). Piscataway (NJ): IEEE. pp. 293-296.

Schomaker, L.R.B. (1993). Using Stroke- or Character-based Self-organizing Maps in the Recognition of On-line, Connected Cursive Script. *Pattern Recognition, 26(3)*, 443-450.

Schomaker, L. & Segers, E. (1999). Finding features used in the human reading of cursive handwriting *International Journal on Document Analysis and Recognition, 2*, 13-18.

Schomaker, L., de Leau, E. & Vuurpijl, L. (1999). *Using pen-based outlines for object-based annotation and image-based queries.* In: D.P. Huijsmans and A.W.M. Smeulders (Eds.). Visual Information and Information Systems, New York: Springer, pp. 585-592.

Smedt, Koenraad De & Kempen, Gerard (1996). *Discontinuous constituency in Segment Grammar.* In: Bunt, Harry & Horck, Arthur van (Eds.), Discontinuous Constituency. Berlin/New York: Mouton de Gruyter. [pp. 141-163]

Taatgen, N.A. & Wallach, D. (in press). Whether skill acquisition is rule or instance based is determined by the structure of the task. *Cognitive Science Quarterly*.

Taatgen, N.A. (1999). *Explicit Learning in ACT-R.* In U. Schmid, J.F. Krems, F. Wysotki (Eds.), Mind Modelling: A Cognitive Science Approach to Reasoning, Learning and Discovery. Berlin: Pabst Science Publishers.

Taatgen, N.A. (1999). *A model of learning task-specific knowledge for a new task.* Proceedings of the 21th annual conference of the cognitive science society (pp. 730-735). Mahwah, NJ: Erlbaum.

Taatgen, N.A. (1999). Cognitief Modelleren: Een nieuwe kijk op individuele verschillen. *Nederlands tijdschrift voor de psychologie, 54 (4),* 167-176.

Vosse, Theo & Kempen, Gerard (2000). Syntactic structure assembly in human parsing: A computational model based on competitive inhibition and a lexicalist grammar. *Cognition, 75*, 105-143.