Cognostics and Knowledge Used With Dynamical Processing

Claus-Peter Rückemann
Westfälische Wilhelms-Universität Münster (WWU),
Leibniz Universität Hannover,
North-German Supercomputing Alliance (HLRN), Germany
Email: ruckema@uni-muenster.de

Abstract—**This paper presents the extended research conducted for an implementation creating knowledge-supported dynamical visualisation and computation, which can also be used in combination with dynamical processing. The focus of methodologies, knowledge, and approach is data-centric, especially concentrating on cognostics and knowledge. The methodologies, knowledge resources, data structures, and workflows are very suitable for long-term multi-disciplinary context and creating application components for the use with High End Computing. The core knowledge is based on long-term knowledge resources further developed for several decades and used with many applications scenarios utilising multi-disciplinary and multi-lingual content and context like references, associations, and knowledge container collections. A major goal of the application case studies shown here is creating context-sensitive dynamical program components and algorithms from selected knowledge content. The selections are results of dynamical workflows, which are part of component implementations, e.g., including search processes and result matrix generators. Previous research has shown that long-term knowledge resources are the most important and most valuable component of long-term approaches and solutions. Here, the structures and classifications are used with independent database frameworks and programming interfaces. The results show that the methodological foundations and knowledge resources are very well suitable as long-term core base, as well as for creating dynamical application components, e.g., for visualisation and computation in multi-disciplinary, geoscientific, and spatial context. The knowledge resources can refer to any kind of resources. The overall environment allows to develop and govern extensive content structures and promote their long-term vitality. The long-term knowledge resources and cognostics are an excellent base for supporting dynamical processing sustainable, economic, long-term development of resources and components.**

***Keywords*–Advanced Knowledge Discovery; Universal Decimal Classification; Conceptual Knowledge; Dynamical Visualisation and Computation; Cognostics.**

I. INTRODUCTION

Many methods have been created for deploying computing and processing with knowledge discovery and dynamical visualisation. However, conceptual knowledge and cognostics supporting the creation of fully functional application components has not been been considered explicitely. The target in this implementation is multi-disciplinary information with examples from geoscientific and natural sciences referring to universal knowledge and reaching into many disciplines. The secondary data utilised here can also include spatial information.

Within the last decades the value of the content, the "value of data", has steadily increased and with this the demand for flexible and efficient discovery processes for creating results from requests on data sources. This paper presents the extended research based on the creation of knowledge-supported dynamical visualisation and computation, the results of which were published and presented at the GEOProcessing conference in February 2015 in Lisbon [1]. Applying the conceptual knowledge and cognostics in this context, this paper is especially focussing on support for data-centric approaches.

This research shows details of the latest case studies and discusses the up-to-date experiences from the implementation of the dynamical components and their integration with knowledge resources' structures and workflows. The case studies especially consider the levels inside application components, which can be created based on universal knowledge resources and cognostics. The studies also discuss the conceptual support for generators and some resulting features.

This paper is organised as follows. Section II introduces with the state-of-the-art and motivation for this research. Sections III and IV summarise the foundations and challenges with cognostic components, Section V introduces the methodological bases, Section VI presents the previous research being a fundament for this work. Sections VII and VIII present the fundamental implementations, esp. integration referring to knowledge and dynamics, discussing the foundations, architecture, framework, integration, and dynamical visualisation and computation. Section IX discusses selected parts of the implementation and resulting components and Section X presents examples of dynamical cognostic processing in context with knowledge and cognostics. These sections show the details of the implementation and the resulting components, from geo sets, computation to index selection and some views from the resulting visualisations. Sections XI to XIII evaluate the main results, potential and summarise the lessons learned, conclusions and future work.

II. STATE-OF-THE-ART AND MOTIVATION

The creation of long-term knowledge resources and utilisation methods is one of the most pressing goals in information science as the masses of data and the loss of knowledge in society are steadily increasing in all areas. Existing projects employ segment-like spectra of disciplines in their focus. Examples are large digital libraries and projects like the Europeana [2] and the World Digital Library (WDL) [3]. For most data, source and resulting data, it is reasonable to assume a data value at least higher than the funding value [4], which motivates for increased efforts.

As existing projects, e.g., which are only concentrating on bibliographic means, do not focus on such integration, use different and mostly isolated classifications and schemes for different areas and specific purposes. For example, there is a small number of general classifications, which are mostly used in library context. Although such classifications are used in many thousands of institutions worldwide this is neither a general use case or application scenario nor a significant share of the overall knowledge. They are missing to provide facilities for arbitrary kinds of objects, e.g., factual data and trans-disciplinary context in information science and natural sciences. Therefore, the handling of knowledge issues at a cognostic level is not reflected by processes for creation of software components. Besides these major gaps in research, shortcomings result regarding data quality, data-centric solutions, required long-term aspects, and functionality of application components.

In contrast to that, the state of the art for documentation of universal, conceptual knowledge is the Universal Decimal Classification (UDC) [5], which is one of the very few classifications providing a universal classification [6], [7]. Besides public interfaces, the implementations of the known application scenarios are not publicly available in common. Anyhow, all known scenarios have in common that they deploy only a small subset of available classifications and in the vast majority the classification process is not automated. It is necessary to develop logical structures in order to govern the existing big data today and in future, especially in volume, variability, and velocity. This is necessary in order to keep the information addressable and maintain the quality of data on long-term.

Beyond the focus of the mentioned segment-like projects the knowledge resources and concepts discussed and implemented in this research focus on the trans-disciplinary integration of arbitrary different segments and disciplines and a universal usability based on factual data and criteria. The documentation and context also integrates and refers to content and context, e.g., conceptual, procedural, and metacognitive knowledge and allows for a huge range of possible scenarios. This is a driving force to extend the use of classification in trans- and multi-disciplinary context and transfer the experiences from deploying a classification for long-term documentation and application.

III. FOUNDATIONS OF COGNOSTIC COMPONENTS

The term cognostics is related to the Latin verb cognoscere (con 'with', gnoscere 'know, recognise'). This is in itself a cognate of the Greek verb *γιγνωσκω* (gignósko), meaning 'I know, I perceive' (noun: gnósis, 'knowledge') referring to 'recognize', 'conceptualize'. The archaic paradigm of many aspects of fields of human activities is, e.g., a complementary trias of animistics, empirics, and cognostics. Most cognostic content followed prehistorical and early historical times, in the later stages of development. Cognostic fundaments have been discussed in detail by classical ancient Greek philosophers. "Cognition" as a modern term at least dates back to the 15th century, used for "awareness" and "thinking".

Cognition is the set of all mental abilities and processes. Cognition is therefore related to knowledge, decision making [8], [9], problem solving, human-computer interaction and many more. Cognitive processes use existing knowledge and generate new knowledge.

In result, the implementation of cognostic views can be complex, not only because of application components but especially because of the knowledge-centric base, which has to be created. A lot of following researchers have picked-up the term, e.g., in context with diagnostics guided by computers [10], [11], in an early phase of data exploratory analysis and without developing a base for the knowledge itself.

The term cognostics has been more widely used with developments in information science since the nineteen-nineties. In Geocognostics refers not only to dynamical components but to different views and how to achieve this, e.g., how to integrate political and social-cultural differences, which are examples of major aspects to be considered.

The cognitive aspects of human-computer interaction are multifold, especially in the context of geographic information systems [12]. As one contribution to complex information systems, on the one hand, the accuracy of spatial databases is an important factor [13] but on the other hand it is important that researchers and users can create cognitive collages and spatial mental models [14]. Besides that, the integration of psychological aspects of spatial information [15] as well as the consideration of cultural aspects [16] has become significant for several decades. This has led to the concepts of cognitive geographic information systems [17] and the idea of geocognostics [18]. These fundamental concepts have led to implementations considering cognostics with dynamical features [19] and collaboration frameworks [20], resulting in modular cognostic component concepts [21] and knowledge based approaches and implementations [22], e.g., the new concept of object carousels.

IV. CHALLENGES WITH KNOWLEDGE AND COGNOSTICS

The insufficient care for knowledge has shown to have impact on scientific work [23] and most achievements have to be created over and over again [24] as well as on industrial developments and automation [25], [26], [27], [28], [29], [30].

Data collections can provide any huge amount of information, directly and in consequence of applied workflows. The more unstructured the data collections are the more interpretation of the data are possible. Automated processes can then easily lead to a much higher rate of misinterpretation.

Examples of misinterpretation [31] and unclean data [32], which can regulary result when not integrating high quality knowledge resources have led to suggestions and recommendations that raw data might take enormous efforts to clean, reformat, and consolidate but is very well worth. In spite of the quantity of data [33] bigger does not mean better. For many cases big data has been claimed a 'big misnomer' [34].

The quality of data cannot be neglected especially when creating sustainable structures, long-term documentations and solutions. Some analysis considers data size being important on the one hand, e.g., volume of data. On the other hand, small volumes of data can have a large significance, examples are the following:

- Non-standard mean data like outliers can be significant for working with problems and data.
- Rare data events or attributes can be the interesting ones.
- Rare discrete values or classes.
- Missing values can lead to sparsely observed observation space.

Therefore, the target is a) to minimise the continuous rework and provide long-term features in order to document all parts of the creational steps and results and b) to integrate knowledge and cognostic features, which is a core purpose of the knowledge resources. Besides benefits, complex "all-in" folders, like in election context do show up with challenges [35], which requires alternatives.

V. METHODOLOGICAL BASES: LOGICAL STRUCTURES

To work on that goal requires to define information units and to care for depositing an appropriate segmentation in sub-units. The information units require links to the related units, e.g., superunits. The challenges are to define these structures and units for data used in different disciplinary context, in one discipline, as well as in multi-disciplinary context. These logical structures are the basic precondition for the development of functioning algorithms, which can access the units and whose application can be perfected in a next self-learning step. The tries of using unstructured data result in the fact that data volumes, variabilities, and volumes devaluate the resulting values of requests. Any isolated technological approaches to the big data challenge have shown not to be constructive. A sustainable approach has to consider the data and structure itself.

- The first step is the preconditional definition of a logical, commonly valid structure for the data.
- The second step is the planning for the applications based on the logical structures in step one.
- The third step is the creation of algorithms regarding the data and data retrieval, interfaces, and workflows based on steps one and two. The fourth step is the planning of the implementation. This includes data format, platforms, and applications.

Further, the creation, development, and operation of the content and components require to consider and define the essential plans, especially:

- Plans for extending structures.
- Preparations for all required interfaces for the newly extended structures should be done.
- Plans for self-learning components.
- Plans for container formats and utilisation.
- Plans for sustainable handling of data lifecycles, data formats, and system resources.

The early stage of planning requires a concept catalogue. So far, the activities are commonly in a pre-planning stage. The next step includes case studies on structures, algorithms, and collaborational issues (efficiency, economical cycle).

VI. FUNDAMENT FOR THIS WORK

Long-term knowledge resources can be created and used for universal documentation and re-use of content. The re-use includes discovery, as well as gathering new results and creating new applications. The knowledge resources [36] can refer to any kind of resources, e.g., to natural sciences resources or historical geographic resources [37]. Basics of knowledge organisation [38] and multi-lingual lexical linked data [39] have been discussed for various disciplines and shown the huge potential and value of the knowledge. This also shows the benefits of linking with universal classifications, especially with consequently numerical notations, which can be easily and most flexibly and efficiently used with modern applications components. Further, on the one hand, information services benefit from a comprehensive and holistic model for evaluation [40] and on the other hand, they align with the benefits for a quality management of information services [41].

The paper presents a new implementation for creating knowledge-supported dynamical visualisation and computation, which have not been integrated before for that purpose. Therefore, a major goal of the application case studies is creating dynamical program components and algorithms based on knowledge resources. The different previous projects and case studies have already shown that the combination of knowledge resources with integrated conceptual knowledge references can be used for the creation of dynamical applications.

The dynamical visualisation and computation based on knowledge resources does have numberless applications. Some prominent examples with the research presented here are knowledge discovery, visualising result matrices from workflows or search processes, and creating objects and extending knowledge resources. The framework presented here is a high level framework interconnecting several frameworks for complex system architecture, multi-column operation, and long-term creation for main resources. Therefore, the required approach is considered to be necessarily most complex from knowledge and implementation point of view.

Following the Geo Exploration and Information case studies [42] based on the actmap framework [43] a number of developments for the deployment of High End Computing resources and technologies with integrated systems are still state of the art. In addition, including the structural and conceptual knowledge based on the knowledge resources, research has been done for a different special database framework, which is as well autonomous and can be used for the creation of standalone dynamical and portable application components. The components can be integrated with the existing frameworks, as well as they can be used as standalone interactive applications.

VII. IMPLEMENTATION: INTEGRATION AND KNOWLEDGE

A. Content and context

The implementation shows the context-sensitive dynamical components based on the knowledge resources. The knowledge resources provide the structure and integrate the factual knowledge, the references, including the references for the object classification views required for the dynamic utilisation, ensuring integration [44] and sustainability [45].

Previous case studies have shown that any suitable cartographic visualisation can be used for the presentation of the results, for example, with the Generic Mapping Tools [46] (e.g., filtering, trend fitting, gridding, views, and projections) or creating exports and imports with various products.

Most available cartographic visualisation products are too specialised in order to handle advanced knowledge workflows on the one hand and dynamical results on cognitive context on the other hand. In the presented case where the application should concentrate on the intention of presenting a special result in an abstract way we require special and flexible facilities for dynamical sketch drawings. The more, in the special case the cognitive background forbids to concentrate on detailed cartographic visualisation or mixing with modern ways of geographic conventions. Historical names, locations, and context are not adequately represented by existing modern frameworks.

Regarding both requirements for this study are fully complied by the flexibility of the implementation. The knowledge resources themselves are not restrictive regarding the use of other components for other purposes.

B. *Implementation foundations*

The implementation for dynamical visualisation and computation is based on the framework for the architecture for documentation and development of advanced scientific computing and multi-disciplinary knowledge [47]. The architecture implemented for an economical long-term strategy is based on different development blocks. Figure 1 shows the three main columns: Application resources, knowledge resources, and originary resources.

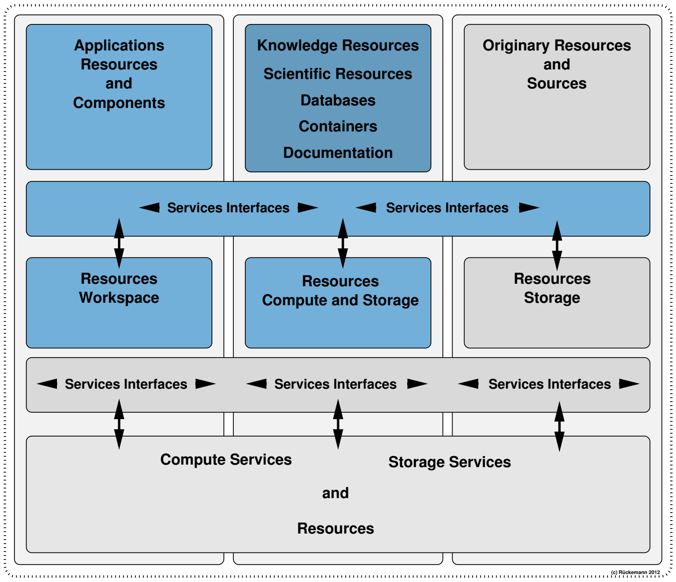


Figure 1. Architecture: Columns of practical dimensions. The knowledge resources are the central component within the long-term architecture.

The central block in the “Collaboration house” framework architecture [48], are the knowledge resources, scientific resources, databases, containers, and documentation (e.g., LX [36], databases, containers, list resources). These can be based on and refer to the originary resources and sources (photos, scientific data, literature).

The knowledge resources are used as a universal component for compute and storage workflows. Application resources and components (Active Source, Active Map, local applications) are implementations for analysing, utilising, and processing data and making the information and knowledge accessible. The related information, all data, and algorithm objects presented are copyright the author of this paper, LX Foundation Scientific Resources [36], all rights reserved. The LX structure and the classification references based on UDC [5], especially mentioning the well structured editions [49] and the multi-lingual features [6], are essential means for the processing workflows and evaluation of the knowledge objects and containers. Both provide strong multi-disciplinary and multi-lingual support.

The three blocks are supported by services’ interfaces. The interfaces interact with the physical resources, in the local workspace, in the compute and storage resources the knowledge resources are situated, and in the storage resources for the originary resources.

All of these do allow for advanced scientific computing and data processing, as well as the access of compute and storage resources via services interfaces. The resources’ needs depend on the application scenarios to be implemented for user groups.

C. *Cognostics and related data*

The content-supported cognostics support a plethora of knowledge object sources, information, and data features. An excerpt of examples of these features used in the case studies implemented here are:

- name,
- keywords,
- conceptual knowledge and classification,
- text,
- link references,
- dates,
- languages,
- translations,
- transliterations,
- map locations and GPS,
- various types of comparisons and context references,
- researchers’ views,
- comments,
- object specific material, classification, documentation, parameters, files, workflow descriptions, programs, . . .

All the data provided for an application, e.g., from knowledge objects in collections or containers, including textual and non-textual data, scientific data, mathematical data, technical data as well as comments can be analysed by the workflows and application components.

The visualisation components can use all the cognostic attributes in order to further exploit the information for the respective application targets. In addition, with the multi-disciplinary long-term features and structures the knowledge resources provide the means for a sustainable integrated research data management [50].

This is significant in combination with integrated realia and digital resources, for example, in digital museums projects [51]. An example for creating components usable with complex environments is an agent-based modeling and simulation in archaeology [52]. This is especially interesting for High End Computing environments, in the given examples, for example, for archaeological simulations [53].

In the presented scenarios implemented with this research, the new resources overcome the insufficient documentation, the structural and long-term deficits. Therefore, the integration benefits from the combination of structured and unstructured data.

A lot of unstructured data is provided on the Internet. For some scenarios this source might provide the largest percentage of unstructured data, regulary integrated in the workflows, e.g., with knowledge discovery processes. Regarding non knowledge resources based sources the propertisation (or 'Proprietarisierung' and 'proprietarisation' in German and French a bit more concisely reflecting the stricter and essential Latin 'proprius', meaning 'own, individual, special, particular, characteristic' and dissociating from 'proper' and 'property') is not only a threat for the free Web [54], [55], [56] but also for the workflows, which can be based on unstructured data and free and open access data, at least to a flexible extend. The situation may lead to challenges with application scenarios, which contain a large percentage of references to unstructured data on the free net as well as with workflows, which require or benefit from such data.

With unstructured Big Data, which is most of the overall amount of data available, there is also a lot of bias [57]. With high end solutions and resources, e.g., with High Performance Computing, there is an increasing demand for techniques supporting fault tolerance [58]. For High End Computing solutions this can be achieved by modular structures and documentation.

One of the important features of algorithms and structures supporting these applications is the ability to cope with failures in information and applied knowledge [59]. With the facilities of the knowledge resources for precision and fuzzyness the components can cover a flexible range of cognostic coverage.

VIII. IMPLEMENTATION: INTEGRATION AND DYNAMICS

A. Integration and computation

The context of the application components is fully integrated with the knowledge resources and dynamical components [60]. The screenshot (Figure 2) illustrates some features. Shown examples illustrate features of Active Source, computed and filtered views, LX information, and aerial site photographs, e.g., from Google Maps.

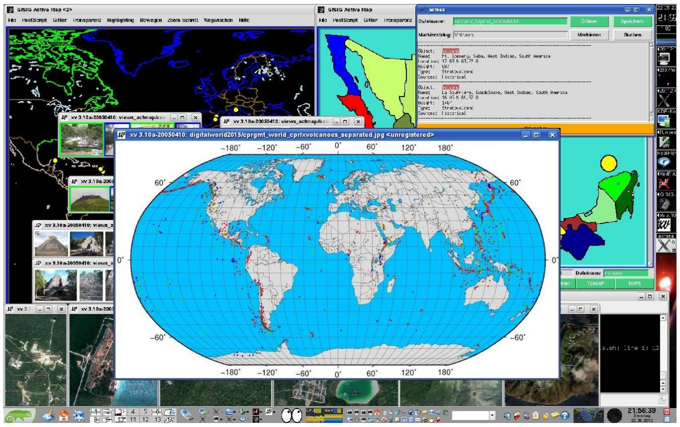


Figure 2. Dynamical use of information systems and scientific computing with multi-disciplinary and universal knowledge resources [48].

Many general aspects of dynamical use of information systems and scientific computing have been analysed with the collaboration house case studies.

B. Implemented content and application dynamics

The main groups of challenges are resulting from the content and from the applications.

- Content side: From content side, the knowledge resources provide the central repository and infrastructure ('Knowledge as a Service') for discovery and component creation.
- Application side: From application side, the dynamical components can deploy the resources to any extent and in any step of workflows.

Any part of the components and features can be assembled from the knowledge resources' workflows. As an example, the site context and factual data components, the database and the graphical user interface components including event definition and management can be dynamically created via transform routines and `concatenate` operations.

C. Dynamical visualisation and computation implementation

A number of different visualisation tools and frameworks have been analysed in the latest case studies. The results presented here were mostly realised with Tcl/Tk [61] for the dynamical visualisations, Fortran and C based programs for required algorithms, Message Passing Interface (MPI) [62], and Perl for dynamical scripting.

Many components have been developed for the actmap framework [43] and successfully used and verified in context with existing scenarios. Besides the actmap framework additional possibilities of creating application programming interfaces and graphical user interfaces for dynamical visualisation of knowledge matrices have to be analysed.

As a simple example for a dynamical, portable, and standalone component an application like Tclworld has been considered [63]. The application is built on a very portable Tool

Command Language (TCL) base integrating programming, database, and user interfaces.

The database application programming interface [64] is very simple, portable, and extendable. The database graphical user interface [65] can be used within the same application and is based on a rapid prototyping concept. Both interface models allow dynamical control and extension of any features regarding the application, as well as for the content.

IX. IMPLEMENTATION AND RESULTING COMPONENTS

The knowledge resources are very flexibly supporting documentation and handling of knowledge content and context. The features include cognostics as well as dynamical application support.

Key to the flexibility is that any knowledge object can carry as much documentation as required. It is the task of the application workflow to make use of the available information to the extend needed and to develop or create complementary information. Creating knowledge-supported dynamical components starts at the application to knowledge resources' interface level. The conventional components and processes have been described and discussed in practice in detail in previous research, regarding Active Map Software [43], case studies [42], and knowledge integration for classification and computation [44].

For the visualisation and computation using the matrix objects with spatial and georeferenced context, a new application instance "lxworlddynamic" has been created based on the knowledge resources and interfaces. This component re-using the Tclworld interfaces is the required extension complementary to the actmap framework components. All parts of the component shall

- support dynamical and cognostic features,
- integrate with the knowledge resources and existing components, e.g., georeferenced objects,
- be usable interactively,
- have access to the content, e.g., index selection,
- facilitate a standalone application assembly, and
- allow a flexible configuration of all aspects of the applications' visualisation and computation, including cognostic support.

Especially, the component requires a site handler database, has to refer to sets of georeferenced objects, a level handler for selecting levels of detail, to create groups of matrix objects, to support for an individualised configuration, to facilitate index selections on the generated matrix elements, to visualise the matrix elements and context graphically, and has to provide associated data textually and numerically.

Therefore, the implementations done for this study concentrate on creating dynamical, generated, cognostic components. Explicitly, the focus was not on georeferencing standards or cartographic issues or precision. Any of such features can be developed by third parties being interested in supporting their individual scenarios.

A. *Knowledge resources and geo sets*

The integrated information systems can generate result matrices based on the available components and workflows. The result matrix generators can be configured to deliver any kind of result matrix. One base for the implementation is the generation of georeferences data resulting from requests. The listing (Figure 3) shows an example of a result matrix, an excerpt of the generated site handler database.

```
{LX Site 20.687652 -88.567674} site 20.687652 88.567674
{LX Site 20.682658 -88.570147} site 20.682658 88.570147
{LX Site 20.682859 -88.568548} site 20.682859 88.568548
{LX Site 21.210859 -86.80352} site 21.210859 86.80352
{LX Site 21.097633 -86.796799} site 21.097633 86.796799
{LX Site 21.157199 -86.834736} site 21.157199 86.834736
{LX Site 21.157199 -86.834736} site 21.157199 86.834736
{LX Site 21.094751 -86.812248} site 21.094751 86.812248
{LX Site 41.377968 2.17804} site 41.377968 -2.17804
{LX Site 41.375842 2.177696} site 41.375842 -2.177696
{LX Site 38.676439 -0.198618} site 38.676439 0.198618
{LX Site 38.677683 -0.198103} site 38.677683 0.198103
{LX Site 21.234502 -86.740494} site 21.234502 86.740494
{LX Site 21.184412 -86.807528} site 21.184412 86.807528
{LX Site 16.043421 -61.663857} site 16.043421 61.663857
{LX Site 16.043153 -61.663374} site 16.043153 61.663374
{LX Site 17.633225 -63.236961} site 17.633225 63.236961
{LX Site 17.633225 -63.236961} site 17.633225 63.236961
{LX Site 51.151786 10.415039} site 51.151786 -10.415039
{LX Site 20.214301 -87.429103} site 20.214301 87.429103
{LX Site 20.493276 -87.735701} site 20.493276 87.735701
{LX Site 20.494663 -87.720294} site 20.494663 87.720294
{LX Site 20.494761 -87.720138} site 20.494761 87.720138
{LX Site 40.821961 14.428868} site 40.821961 -14.428868
{LX Site 20.365228 -87.452545} site 20.365228 87.452545
{LX Site 20.365228 -87.452545} site 20.365228 87.452545
```

Figure 3. Excerpt of generated site handler database (lxworlddynamic).

The database is the result of a request summarising results on objects referring to a defined context, in this case references between archaeological and geological objects.

The framework provides a number of features like level handlers and sets of object georeferences. The listing (Figure 4) shows an excerpt of the generated site level handler.

```
foreach i {
  { ... }
  { ... }
  ...
} {+ $i level 2}
```

Figure 4. Excerpt of generated site level handler (lxworlddynamic).

The level handler manages the site handler database, which can also be generated and updated dynamically. Appropriate entries are managed by the geo::set. The listing (Figure 5) shows an excerpt of the generated geo set.

```
geo::Set {
  { ... } site ... ...
  { ... } site ... ...
  ...
}
```

Figure 5. Excerpt of generated geo::set (lxworlddynamic).

Groups of objects, e.g., associated archaeological, geological, meteorite, and volcanological sites, as well as subgroups like pottery and stones, can be dynamically associated and handled in the generated component. The listing (Figure 6) shows an excerpt of the generated database matrix.

```
 + {Archaeological site} : {A selected site with findings
    of human activity, complementary to a
    {Geological site} .
    These sites have been dynamically created
    from a request to the LX knowledge resources ... .
    These sites have been ... .
    }

 + {Geological site} : {A selected site with geological
    findings, e.g., a {Volcanological site} or a
    {Meteorite site} , complementary to an
    {Archaeological site} .
    This site has been ...}

 + {Metorite site} : {A selected site with meteorite
    findings, e.g., meteorite crater, a special
    {Geological site} .
    This site has been ...}

 + {Volcanological site} : {A selected site with
    volcanological findings, e.g., volcanological
    findings like a volcano or fumarole, a special
    {Geological site} .
    This site has been ...}

 + Pottery    : {Archaeological site} major.countries {
  Italy France Spain Greece}

 + Stone      : {Geological site} major.countries {Italy
  France Spain Greece}
```

Figure 6. Excerpt of generated database matrix (lxworlddynamic).

Here, the matrix includes site and object types for the respective matrix with excerpts of descriptions and linked references.

B. Index selection and configuration

When a representation of matrix objects in dynamical spatial cartographic context is possible then selected objects can be integrated either from the matrix elements or from the context elements and references (Figure 7).

```
foreach i [geo::Names] {
   if {[lindex $geo::db($i) 0]=="city"} {
       "LX_World_database" $i : {city} loc [lrange $
        geo::db($i) 1 end] }
   if {[lindex $geo::db($i) 0]=="mount"} {
       "LX_World_database" $i : {mount} loc [lrange $
        geo::db($i) 1 end] }
   if {[lindex $geo::db($i) 0]=="site"} {
       "LX_World_database" $i : {site} loc [lrange $
        geo::db($i) 1 end] }
   if {[lindex $geo::db($i) 0]=="lake"} {
       "LX_World_database" $i : {lake} loc [lrange $
        geo::db($i) 1 end] }
   if {[lindex $geo::db($i) 0]=="road"} {
       "LX_World_database" $i : {road} loc [lrange $
        geo::db($i) 1 end] }
   if {[lindex $geo::db($i) 0]=="rail"} {
       "LX_World_database" $i : {rail} loc [lrange $
        geo::db($i) 1 end] }
   if {[lindex $geo::db($i) 0]=="river"} {
       "LX_World_database" $i : {river} loc [lrange $
        geo::db($i) 1 end] }
   if {[lindex $geo::db($i) 0]=="grid"} {
       "LX_World_database" $i : {grid} loc [lrange $
        geo::db($i) 1 end] }
}
```

Figure 7. Excerpt of generated index selection (lxworlddynamic).

The listing shows an excerpt of the generated index selection. Matrix elements are, e.g., sites. Context elements and references are, e.g., cities, mounts, lakes, roads, rails, rivers, and grids. Any part of the dynamically generated components can be individualised depending on context-sensitive attributes and workflow configuration. The listing (Figure 8) shows an example for the generated on-the-fly-symbol used for “sites”.

```
set bitmaps(site) [image create bitmap -data [strimj::xbm
  "
....#....
...###...
..#...#..
.#.###.#.
##.###.##
.#.###.#.
..#...#..
...###...
....#...."] -foreground darkviolet]
```

Figure 8. Excerpt of generated on-the-fly symbol for sites (lxworlddynamic).

Different symbols can be integrated for different sites or for different groups. The objects with their symbols are only visible if the defined level, which is handled by the level handler, is active in the interactive view.

C. Dynamical visualisation and computation

The following image (Figure 9) shows a screenshot of a resulting dynamical visualisation of items in the result matrix, in this case the resulting archaeological context sites. The generated application utilises all the features so far described with the implementation.

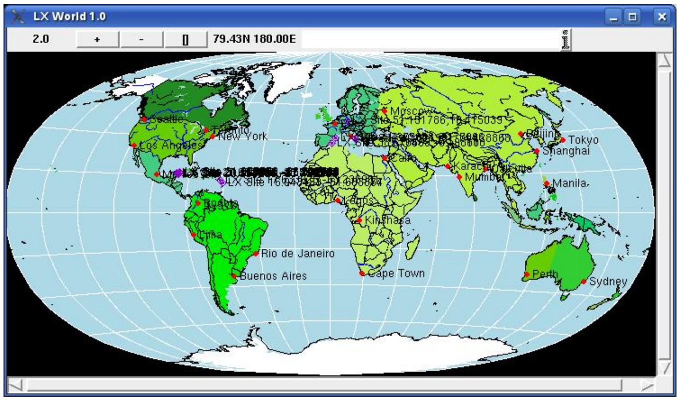


Figure 9. Archaeological context sites in interactive, dynamically generated spatial application (lxworlddynamic).

The screenshot illustrates the dynamical visualisation of the matrix elements for the context of the respective results. With the workflow a spatial context has been chosen for the matrix, creating the components. The spatial application component has been assembled by the workflow, integrating the object item references from the result matrix and secondary information from the referring knowledge resources objects with a dynamical and interactive view of the matrix.

Figure 10 shows a screenshot of a resulting dynamical zoom visualisation of matrix results and secondary information on geological and archaeological context sites. The partially shown superpositioning effect of the respective zoom is still visible in order to show the results, which can be separated in different cognitive views, different zooms, and event sensitive actions. The implementor can do anything with this feature he is interested in, e.g., use the interactive features for label stacks and level effects, being sensitive for single results or result group. Workflow sensitive cartographic material objects (e.g., cities, land, sea, countries, border lines, grid lines) are shown for orientation and context and support cognitive feature display. The shown zoom value and the scroll bars indicate the level of detail. The screenshot illustrates the matrix elements and their references within the knowledge resources.

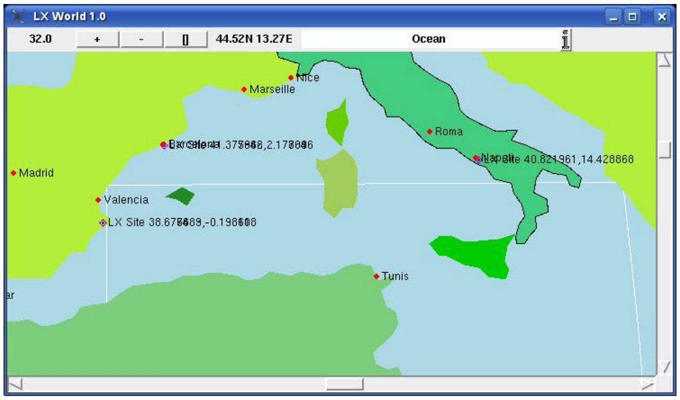


Figure 10. Zoom archaeological and geological sites and context, integrated in interactive, dynamically generated spatial application (lxworlddynamic).

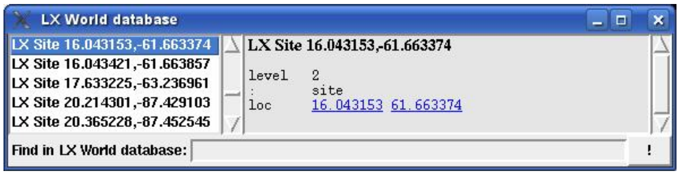
In this example, an active context-sensitive window component is delivering the secondary information. This component is actively communicating with the other components. The site entity data regarding levels and objects referred from the matrix elements is dynamically available (Figure 11).

```
LX Site 16.043153,-61.663374

level    2
:        site
loc      16.043153 61.663374
```

Figure 11. Example of a single site entity data extract (lxworlddynamic).

Here the matrix elements are referring to the attributes of the knowledge resources' objects, e.g., sites and cities. In this example, the displayed data excerpt includes the level, the type, and the location of the respective site. Figure 12 shows a screenshot of the corresponding dynamical site database.



LX Site 16.043153,-61.663374
LX Site 16.043421,-61.663857
LX Site 17.633225,-63.236961
LX Site 20.214301,-87.429103
LX Site 20.365228,-87.452545

LX Site 16.043153,-61.663374

```
level    2
:        site
loc      16.043153 61.663374
```

Find in LX World database:

Figure 12. Site database, secondary information (lxworlddynamic).

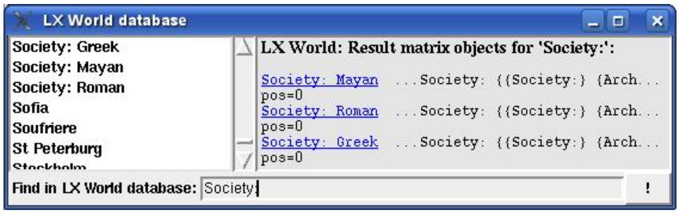
The site database can be accessed by integrated or external applications' components, e.g., for searches, references or for generating further result matrices. The screenshot illustrates the matrix elements and their references within the knowledge resources. In this example, an active context-sensitive window is delivering the secondary information.

X. DYNAMICAL COGNOSTIC PROCESSING

Some of the knowledge object data is processed and filtered for cognostic context and shown in application components, e.g., as secondary data in dynamical windows, e.g., in the LX World database windows.

A. *Knowledge levels and cognostics*

A resulting selection can, for example, be used for interactive discovery processes in the dynamically generated result matrix. The next passages are based on a result matrix of objects from the context of natural sciences and archaeology. The result matrix elements were dynamically processed and added to the interactive application component. The standard entries had not to be removed as from the processing workflow they are not interlinked and as they demonstrate the coexistence of non-linked objects. The data is based on the knowledge resources and the lxworlddynamic components. The workflow illustrates the secondary information from the dynamically extendable database being used for cognostic based improvement of an intermediate result matrix. In this case, the goal is to look for archaeological sites with associations to more than two societies or cultures as they might be called. The following example (Figure 13) shows a search window searching "Society" context in the intermediate result matrix in the intermediate historical result matrix.



Society: Greek
Society: Mayan
Society: Roman
Sofia
Soufriere
St Peterburg

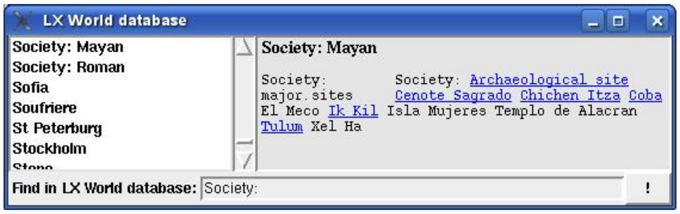
LX World: Result matrix objects for 'Society:':

```
Society: Mayan   ...Society: {{Society:} {Arch...
pos=0
Society: Roman   ...Society: {{Society:} {Arch...
pos=0
Society: Greek   ...Society: {{Society:} {Arch...
pos=0
```

Find in LX World database: Society:

Figure 13. Secondary information on "Society" (lxworlddynamic).

The secondary search window contains the results from within the result matrix, Mayan, Roman, and Greek society. They are dynamically interlinked with deeper respective information. The following example (Figure 14) shows the referenced information for "Mayan society" in the context of the result matrix.



Society: Mayan
Society: Roman
Sofia
Soufriere
St Peterburg
Stockholm

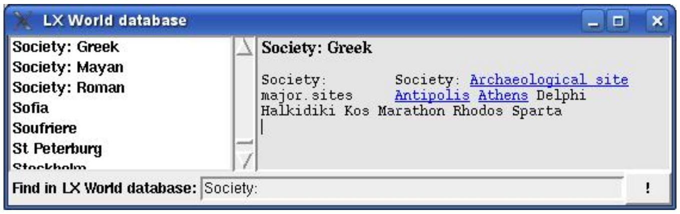
Society: Mayan

```
Society:           Society: Archaeological site
major.sites        Cenote Sagrado Chichen Itza Coba
El Meco Ik Kil Isla Mujeres Templo de Alacran
Tulum Xel Ha
```

Find in LX World database: Society:

Figure 14. Dynamically linked information on "Mayan society" (lxworlddynamic).

The following example (Figure 15) shows the referenced information for “Greek society” in the result matrix’ context.



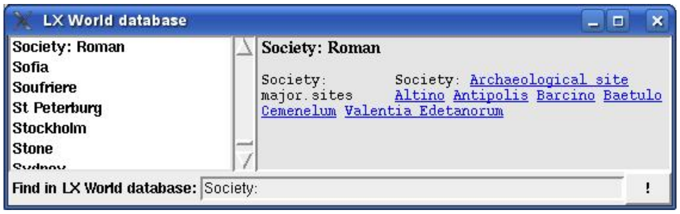
Society: Greek

```
Society:        Society: Archaeological site
major.sites     Antipolis Athens Delphi
Halkidiki Kos Marathon Rhodos Sparta
```

Find in LX World database: Society:

Figure 15. Dynamically linked information on “Greek society” (lxworlddynamic).

The following example (Figure 16) shows the referenced information for “Roman society” in the result matrix’ context.



Society: Roman

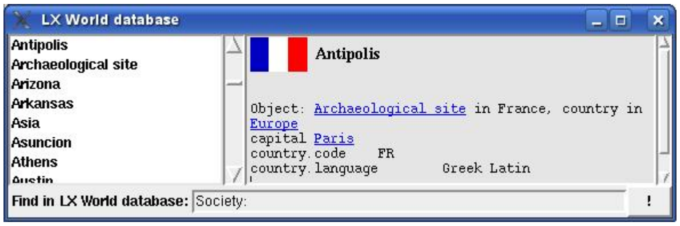
```
Society:        Society: Archaeological site
major.sites     Altino Antipolis Barcino Baetulo
Cemenelum Valentia Edetanorum
```

Find in LX World database: Society:

Figure 16. Dynamically linked information on “Roman society” (lxworlddynamic).

Whereas the first entry does not carry a dynamical reference to a common location, both entries Greek and Roman link to a location object “Antipolis”.

The following example (Figure 17) shows the referenced information for “Antipolis” in the context of the result matrix.



Antipolis

```
Object: Archaeological site in France, country in
Europe
capital Paris
country.code    FR
country.language        Greek Latin
```

Find in LX World database: Society:

Figure 17. Dynamically linked information on “Antipolis” linked as well from “Greek Society” and “Roman society” (lxworlddynamic).

When the discovery goes into the elements’ context, then the attributes refer to many details of the context. Figure 18 shows an excerpt of an referenced Antipolis object entry with UDC classified knowledge objects.

```
Antipolis [Archaeology, Geophysics, Remote Sensing]:
          Greek city, later Roman city, Southern France.
          Modern location name Antibes, between Nice and
           Cannes, France.
          Predecessor of the city of Antibes, France.
          %%IML: UDC:711(38)(37)=12=14=13
```

Figure 18. Content-supported cognostics: Knowledge object “Antipolis” (LX resources).

This not only refers to the antique Greece and to the antique Rome and to both cultural ‘areas’ but also to a related predecessor name of the city. Table I shows the referred conceptual knowledge.

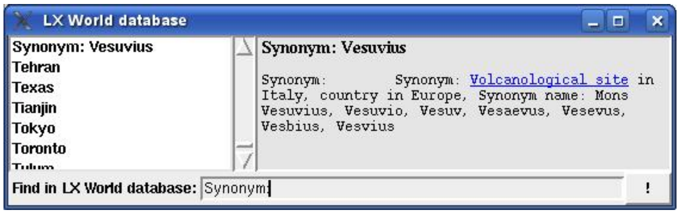
Table I. Universal Decimal Classification location and language (knowledge resources, excerpt, English version).

UDC Code	*Description*
UDC:(37)	Italia. Ancient Rome and Italy
UDC:(38)	Ancient Greece
UDC:=12	Italic languages
UDC:=13	Romance languages
UDC:=14	Greek (Hellenic)

As used in the objects’ excerpt, the classification presents a view, which includes a cognostic meaning with its selection and sort order. In this case, only appropriate elements from the compiled result matrix are linked automatically when relevant for the application scenario.

B. Synonyms and cognostics

The following example (Figure 19) shows a search window searching in the intermediate result matrix for the synonyms of Vesuvius.



Synonym: Vesuvius

```
Synonym:        Synonym: Volcanological site in
Italy, country in Europe, Synonym name: Mons
Vesuvius, Vesuvio, Vesuv, Vesaevus, Vesevus,
Vesbius, Vesvius
```

Find in LX World database: Synonym

Figure 19. Dynamically linked information on “Vesuvius” synonyms (lxworlddynamic).

The excerpt result matrix provides quite a number of Vesuvius synonyms. Any further discovery can exploit this context for views and cognostics, either proceeding with the discovery in-width or in-depth.

Figure 20 shows an excerpt of an referenced Vesuvius object entry with UDC classified knowledge objects.

```
Vesuvius [Vulcanology, Geology, Archaeology]:
          (lat.) Mons Vesuvius.
          (ital.) Vesuvio.
          (deutsch.) Vesuv.
          Volcano, Gulf of Naples, Italy.
          Complex volcano (compound volcano).
          Stratovolcano, large cone (Gran Cono).
          Volcano Type: Somma volcano,
          VNUM: 0101-02=,
          Summit Elevation: 1281\UD{m}.
          The volcanic activity in the region is observed
           by the Oservatorio
          Vesuviano. The Vesuvius area has been declared a
           national park on
          \isodate{1995}{06}{05}. The most known antique
           settlements at the
          Vesuvius are Pompeji and Herculaneum.
          Syn.: Vesaevus, Vesevus, Vesbius, Vesvius
          s. volcano, super volcano, compound volcano
          s. also Pompeji, Herculaneum, seismology
          compare La Soufrière, Mt. Scenery, Soufriere
          %%IML: UDC:[911.2+55]:[57+930.85]:[902]"63"
           (4+23+24)=12=14
          %%IML: GoogleMapsLocation: http://maps.google.de
           /maps?hl=de&gl=de&vpsrc=0&ie=UTF8&ll
           =40.821961,14.428868&spn=0.018804,0.028238&t=h&
           z=15
```

Figure 20. Content-supported cognostics: Knowledge object “Vesuvius” (LX resources).

Besides all the other information in this excerpt, the names of the object in different languages and the explicitely declared synonyms were choosen to be handled equally when dynamically generating the “Synonym:” data for the lxworlddynamic database as shown in Figure 19. Due to the reference to the objects in the knowledge resources it will also be possible to use the information separately again for further cognostic purposes, e.g., when creating a language specific search interface.

It is important to mention that with the excerpts of classification shown the conceptual knowledge consistency is supported by editions, which may be used exclusively but also in combination. Table II excerpts the classification (UDC) references used for objects as implemented with the knowledge resources references for the example above.

Table II. Universal Decimal Classification “Vesuvius” (knowledge resources, excerpt, English version).

UDC Code	*Description*
UDC:55	Earth Sciences. Geological sciences
UDC:57	Biological sciences in general
UDC:930.85	History of civilization. Cultural history
UDC:902	Archaeology
UDC:”63”	Archaeological, prehistoric, protohistoric periods . . .
UDC:(4)	Europe
UDC:(23)	Above sea level. Surface relief. Above ground . . .
UDC:(24)	Below sea level. Underground. Subterranean
UDC:=12	Italic languages
UDC:=14	Greek (Hellenic)

Whereas any of the application components are limited by default –not only those in the examples above– the resources containing the knowledge provide much higher flexibility, which includes “universal” conceptual knowledge features. In consequence, only individual representations and views of the objects can be shown.

C. Cognostic levels and dynamical visualisation

Classification has been considered as a research tool for several decades now [66]. When getting into non-disciplinary classification [67] or the more into integrated knowledge processing then the UDC can support even complex context. Today, many sites using a classification will considered UDC to be the top end of the existing multi-lingual universal classifications [68]. In detail, regarding some disciplines’ classification the reliability of classification is an issue, e.g., with diagnostic classification [69]. In other cases, e.g., with text classification a non-parametric statistical method can help to provide solutions [70]. The recherche in heterogeneous data resources is a special challenge [71], which can be supported by referencing between classifications and imaging between classifications.

This means besides UDC, regarding universal, multi-disciplinary knowledge, natural sciences, and mathematics, e.g., the Physics and Astronomy Classification Scheme (PACS) [72], the Mathematics Subject Classification (MSC) [73], the U.S. Geological Survey (USGS) library classification system [74], and the North American Industry Classification System (NAICS) [75] are and were widely in use and might need to be considered.

With the research on knowledge resources and dynamical components basic work for intermediate classification has been done [76], which can extend the knowledge context and interlinks specialised resources into universal conceptual knowledge. Handling details or respectively the content and context of “objects” includes challenging tasks. Using an universal classification can support the cognostic aspects in many ways. For example, on the one hand, the granularity must be as high as possible but on the other hand it should still be easy to group certain selections. Therefore, the documentation requires means, which combine precise and fuzzy methods at the same time. This results in challenges from creating documentation down to using the content in any way. Today advanced cognitive geoscientific information system components can integrate higher levels of cognostic information. All the aspects can be documented and provided applying a universal classification. Mapping cognostic details with levels of details can, e.g., be aligned with the depth of the classification.

All the objects, like map objects and their attributes are part of the environment, including the city markers. These entries are defined for creating a specific environment.

In this example, from the second view level on the generated entries are shown. These entries are objects from the group of result matrix elements. The context and attributes of these objects can be generated according to the cognostic context and purpose. For example, the labels, colours, appearance of the objects, the dynamical features and so on can be modified by the author for creating the respective view accordingly. In the above examples cognostics contributes especially from the

- Object level (e.g., documentation context),
- Workflow level (e.g., result matrix generation),
- Application level (e.g., component implementation),
- Interactive level (e.g., dynamical context).

The following screenshot (Figure 21) shows an example for the dynamical visualisation of a result matrix containing archaeological and geological sites and context. The object data is integrated in an interactive, dynamically generated spatial application. The screenshot shows level 1, where the cognostic level of detail containing the “site” objects is defined level 2.

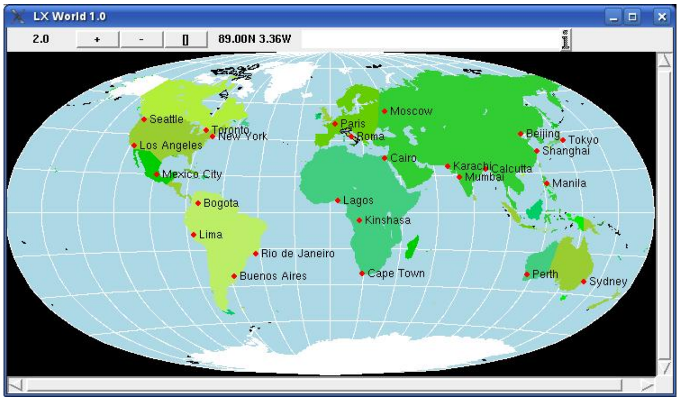


Figure 21. lxworlddynamic – archaeological and geological sites and context, integrated in interactive, dynamically generated spatial application (level 1).

Whereas in this example level 1 only contains continents, some border lines, and some larger cities level 2 also visualises the targeted objects.

D. Conceptual support for generators

The high level of required application and discovery processes leads to the fact that there must be facilities to create result matrices via many different ways when using a knowledge resources concept.

Structured long-term resources integrating complex documentation and classification and providing the required 'data features' have been developed for that purpose. Besides the large spectrum of features of the knowledge objects, the major attribute supporting cognostic reuse is conceptual knowledge.

The knowledge object can carry many attributes, e.g., references, keywords, and conceptual knowledge. In many cases this conceptual knowledge comes in the form of one or more classifications.

The classification, which has shown up being especially important for complex multi-disciplinary long-term classification with knowledge resources is the Universal Decimal Classification (UDC) [77].

UDC allows an efficient and effective processing of knowledge data and provides facilities to obtain a universal and systematical view on classified objects.

Regarding library applications only, UDC is used by more than 144,000 institutions and 130 countries [78]. Further operational areas are author-side content classifications and museum collections, e.g., with documentation of resources, library content, bibliographic purposes on publications and references, for digital and realia objects.

The tiny unsorted excerpts of knowledge resources objects only refer to main UDC-based classes, which for this part of the publication are taken from the Multilingual UDC Summary (UDCC Publication No. 088) [49] released by the UDC Consortium under the Creative Commons Attribution Share Alike 3.0 license [79] (first release 2009, subsequent update 2012).

If nothing special is mentioned the basic classification codes are used in an unaltered way. If a classification refers to a modified code in particular contributing authors have to notice and document the modifications explicitely. So in practice, the classification views with knowledge resources are references to UDC.

E. Series of cognostic views

The series of screenshots in Figure 22 depicts the sequence zoom details in levels 2 to level 5 for the archaeological and geological sites and context. The first image shows the LX sites generated from the result matrix. The second image shows the zoom of the Europe LX sites' area. The third and fourth images show a zoom and a followup zoom of the Europe selection, e.g., identifying Barcin and Vesuvius sites.

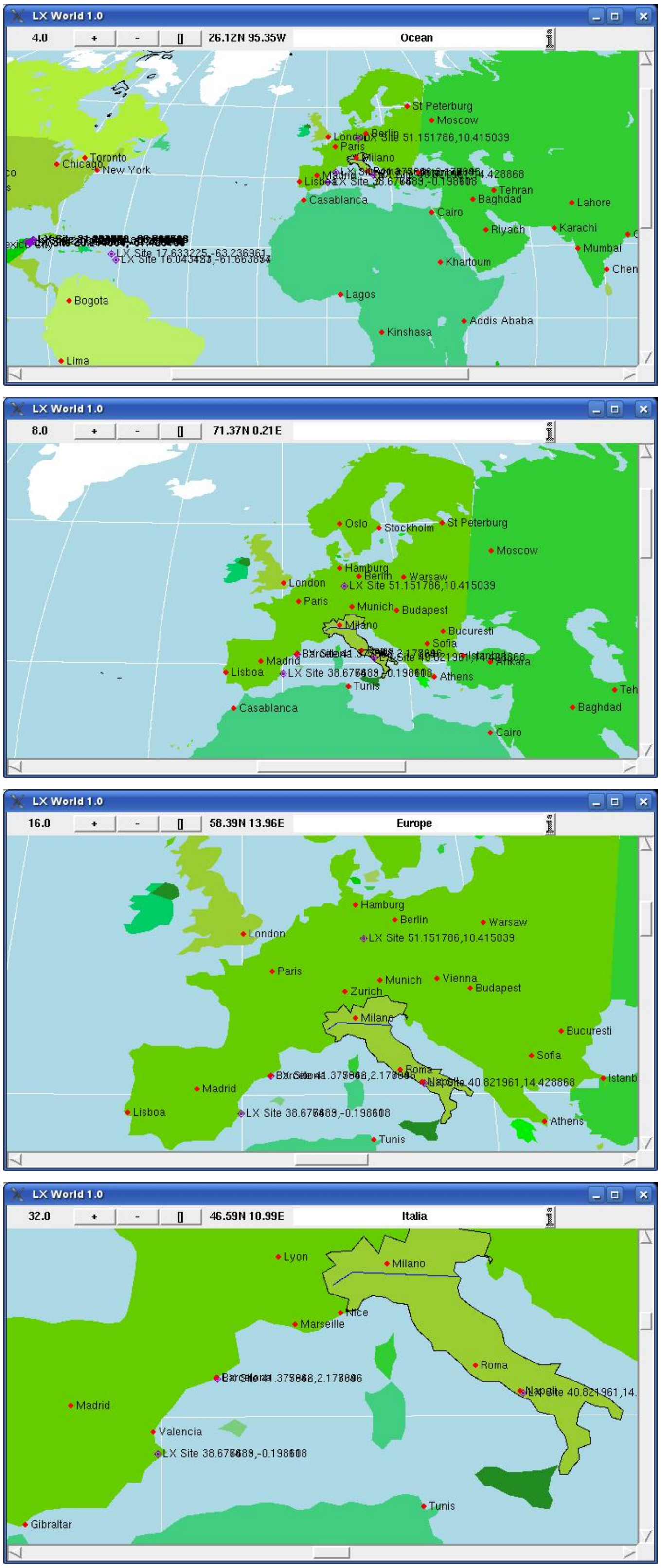


Figure 22. lxworlddynamic – archaeological and geological sites and context, integrated in interactive, dynamically generated spatial application (top to bottom: Zoom details, level 2 – 5).

F. Triggering events and interactive features

Figure 23 shows the generated search window for the result matrix site database, especially with the Vesuvius georeference data.

LX Site 38.676439,-0.198618
LX Site 38.677683,-0.198103
LX Site 40.821961,14.428868
LX Site 41.375842,2.177696
LX Site 41.377968,2.17804

LX Site 40.821961,14.428868

level 2
: site
loc 40.821961 -14.428868

Find in LX World database: 40.821961

Figure 23. lxworlddynamic – archaeological and geological sites and context, site database window (Vesuvius).

Using the "!" function triggers a "goto" for the coordinates and open a corresponding zoom window containing the selected georeferences (Figure 24).

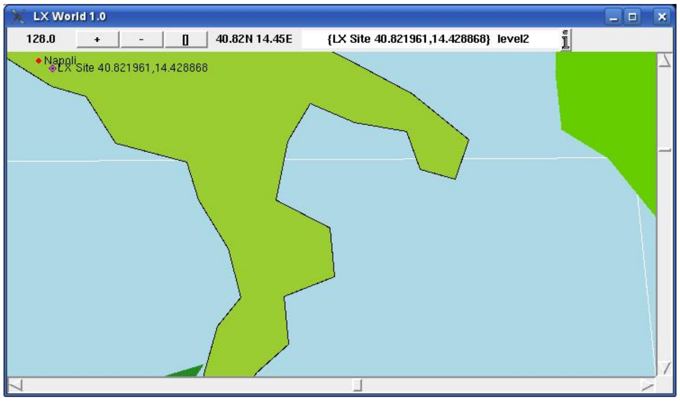


Figure 24. lxworlddynamic – archaeological and geological sites and context, "goto" (!) zoom window (Vesuvius).

The sequence of the consequent levels and interactive features shows a dynamical visualisation integrated with result matrices and components generated from universal knowledge resources. Based on this any events can be triggered that way, e.g., visualisation or computation events. This goto function is only an example for the multitude of possibilities to add code and procedures to the generated components in order to support the dynamic and cognostic features.

G. Generating referenced information code

Figure 25 shows the generated search window for the result matrix site database, especially with a country dependent graphics included with the information. The code for the component as well as for the content has been created dynamically.

Chongqing
Cimiez
Coba
Connecticut
continent

Coba

: Archaeological site in Mexico, country in America

Find in LX World database:

Figure 25. lxworlddynamic – archaeological and geological sites and context, site database window (Coba).

The listing (Figure 26) shows an excerpt of the generated database entry code for the database information windows.

```
+ Cimiez        @ flags/fr.gif : {{Archaeological site}
 in France, country in Europe} capital Paris country.
 code FR
+ Altinum       @ flags/it.gif : {{Archaeological site}
 in Italy, country in Europe} capital Rome country.code
 IT
+ Barcin        @ flags/es.gif : {{Archaeological site}
 in Spain, country in Europe} capital Madrid country.
 code ES
+ Coba          @ flags/mx.gif : {{Archaeological site}
 in Mexico, country in America}
+ Tulum         @ flags/mx.gif : {{Archaeological site}
 in Mexico, country in America}
+ Vesuvius      @ flags/it.gif : {{Volcanological site}
 in Italy, country in Europe} capital Rome country.code
 IT
+ Soufriere     @ flags/fr.gif : {{Volcanological site}
 on Guadeloupe, France, Caribbean, F.W.I.}
+ {Mt. Scenery} @ flags/nl.gif : {{Volcanological site}
 on Saba, The Netherlands, Caribbean, D.W.I.}
```

Figure 26. Excerpt of generated database entry code for the database information windows (lxworlddynamic).

The excerpt includes the references for the hypertext and flag code for parts of the result matrix elements. The database code can be used for many purposes, as codes generated like this part are capable of being directly integrated into the dynamical application components as shown above. The text is automatically linked by the framework environment in a very simple fuzzy way and can transport cognostic aspects in textual and visual context. The cognostic levels can be handled very flexible, e.g., the content and the generated database entry code in arbitrary ways. In this case, the result matrix defines objects for one level. The environment defines additional context objects for other levels.

XI. EVALUATION

Application components can be created and assembled dynamically from any workflow. Knowledge objects can be used efficiently with any dynamical components. The cognostic features for the content as well as for resulting application components can be efficiently provided by conceptual knowledge documented with advanced knowledge resources. Database interfaces can be used dynamically and efficiently with the components. Graphical User Interfaces (GUI) and Application Programming Interfaces (API) can be used most flexible on that dynamical base.

The information created from arbitrary numbers of resources' objects in this excerpt includes site labels, level information, category information, as well as the georeferences. The components can trigger any instances and events dynamically and interactively. This allows any kind of processing, computation, and visualisation, from sketch like visualisation to special cartographical mapping. All the more, the dynamical components based on the knowledge resources and the lxworlddynamic frameworks allow for the interactive, autonomous components' generation. The components have been successfully implemented on a number of operating systems (e.g., SuSE Linux, Debian, Red Hat, and Scientific Linux, as well with older and up-to-date distributions).

The knowledge and system architecture allows to seamlessly integrate with all the steps required for a sustainable implementation of the methodological bases. The case studies done over several decades of knowledge resources' creation and development and two decades of application component developments have shown that plans for extending structures, creating interfaces, self-learning components, container formats, and integration with life cycles and systems resources' operation can be assured even for long-term application.

XII. FURTHER POTENTIAL OF COMPONENTS

The development with this long-term research has led to sustainable solutions when implementing components that support splitting up the data, which is most important in order to achieve an efficient use of available resources, e.g., Input/Output or distribution onto many disks and machines. Otherwise, bulk data can be as inefficient to handle as it will not be practical to use certain methods and algorithms at all. Not all the tools, which are implemented by respective disciplines for handling data are suitable and efficient for all data, algorithms, and workflows. Parallel processing can and should be done with different tools for different purposes. Examples are commonly used tools like Hadoop, Hadoop Distributed File System (HDFS), and MapReduce with a basic Application Programmers Interface (API) for a more abstracted way of developing components for parallel processing of portions of data on a cluster system.

For critical cases it might be argued that components like MapReduce code are costly to write and difficult to troubleshoot and manage. With the same breath, tools like MapReduce are inefficient for exploring datasets. Therefore, the `Hadoop_on_a_chip` 'ecosystem' got tools that span a wide variety of needs, including providing layers of abstraction that make interacting with the data simpler.

In public presentation and marketing common understanding of containers is reduced to certain aspects, e.g., security features [80], [81]. Special container concepts have been introduced for handling Big Data, especially scientific data, e.g., the NERSC 'Shifter' at the National Energy Research Scientific Computing Center [82].

These approaches are insufficient from the content and knowledge related point of view of containers. For example, on the one hand, there is nothing general for a container when postulating that it should contain "everything". At the same level, security features have to be considered very special with specific cases of application. In addition, in most cases the advanced application scenarios trigger those secondary conditions. On the other hand, containers must not only provide computational features. The result is that up to now we neither have a commonly discussed container concept nor a set of universal features. A container is a term for a data or file format bundling the data for certain purpose and application. The features for anything more interesting will include data, documentation, references and so on. Doing so includes how the information is transferred or accessed, which includes to define the modalities for a certain scenario. When discussing containers from the content and knowledge view many scenarios if not universal application is the target, which induces a much more general understanding of containers as has been done with this research.

XIII. CONCLUSIONS

Application components have shown to benefit in many cases from dynamical processing in context with knowledge and cognostics. This research has provided details of the implementation and the resulting components, from structure, content, and context of knowledge resources and cognostic support for dynamical components, geo sets, computation to index selection and various views from the resulting visualisations.

Long-term knowledge resources are core means for providing a sustainable base for these features. The knowledge resources can refer to any kind of resources and allow to efficiently transport implementation features for long-term vitality of use cases. Over many years the implementation with different scenarios has proven to be straight forward.

It has been demonstrated that with the proposed framework and concept context-sensitive dynamical components can be successfully created on base of universal knowledge resources. It has been shown that even standalone dynamical components can be created based on the implementation of the foundations, supporting arbitrary dynamical, modular, portable, and extendable database application programming and database graphical user interfaces. The implementation can utilise workflows and algorithms for knowledge discovery and selection up to intelligent application component creation. It integrates very efficiently in workflow chains, e.g., for computation and visualisation, and is very well usable even for rapid prototyping environments.

The integration is non-invasive regarding the knowledge resources for uni-directional visualisation and computation. If the intention with an application scenario is to update information consistently then multi-directional workflows can also update objects in side knowledge resources or containers from the created components in arbitrary ways, ensuring consistency and plausibility, as well as following management and security policies. Future work will be focussed on issues and usability beyond the plain Big Data approaches, resulting from data values, creating implementations supporting data vitality. A major focus will concentrate on sustainable integration of content and context with conceptual knowledge and cognostics.

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