Uta Priss
Simon Polovina
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Conceptual Structures: Knowledge Architectures for Smart Applications

15th International Conference on Conceptual Structures, ICCS 2007
Sheffield, UK, July 2007, Proceedings

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Preface

This volume contains the proceedings of the 15th International Conference on Conceptual Structures (ICCS 2007), which is an annual event that, for the first time, was hosted in the UK. Conceptual structures focus on the representation and analysis of concepts, events, actions and objects with applications in research, software engineering, manufacturing and business. The conference brings together researchers in computer science, information technology, artificial intelligence, philosophy and a variety of applied disciplines to explore novel ways that information technologies can be leveraged to assist human reasoning and interaction for tangible business or social benefits. Conceptual structures can be used to augment human intelligence by facilitating knowledge integration, decision making, the creation of intelligent software systems and the exploration of implicit structures.

The theme for this year's conference was "Conceptual Structures: Knowledge Architectures for Smart Applications." Knowledge architectures give rise to smart applications that allow enterprises to share meaning across their interconnected computing resources and to realize transactions that would otherwise remain as lost business opportunities. Conceptual structures and smart applications integrate the creativity of individuals and organizations with the productivity of computers for a meaningful digital future. A focus of ICCS 2007 was on papers that apply conceptual structures in business and technological settings. Other submitted papers covered research in conceptual structures, which is supported by mathematical and computational theory, including formal concept analysis, algorithm design and graph theory, and a variety of software tools.

The conference had a rigorous refereeing process. All papers were reviewed by one Editorial Board member and two Program Committee members. About 50% of the submitted papers were accepted as full papers to be presented at the conference. A few additional papers were accepted as short or position papers. In addition, four invited papers and one introductory paper by Simon Polovina are included in this proceedings volume.

We wish to express our thanks to all the authors of submitted papers, to the members of the Editorial Board and Program Committee, to the Workshop and Tutorial Chair, B. Akhgar, the Industry Chair, J. Schiffel, and the Sponsorship Chair, D. Corbett, and to our sponsors!

July 2007

Uta Priss
Simon Polovina
Richard Hill

Organization

The International Conference on Conceptual Structures (ICCS) is the annual conference and principal research forum in the theory and practice of conceptual structures. The conference has been held since 1993 in various locations: Universitè Laval (Quebec City, 1993), University of Maryland (1994), University of California (Santa Cruz, 1995), Sydney (1996), University of Washington (Seattle, 1997), Montpellier (1998), Virginia Tech (Blacksburg, 1999), Technische Universität Darmstadt (2000), Stanford University (2001), Borovets (Bulgaria, 2002), Technische Universität Dresden (2003), University of Alabama (Huntsville, 2004), Universität Kassel (2005) and Aalborg University (Denmark, 2006).

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An Introduction to Conceptual Graphs

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Abstract. This paper provides a lucid introduction to Conceptual Graphs (CG), a powerful knowledge representation and inference environment that exhibits the familiar object-oriented features of contemporary enterprise and web applications. An illustrative business case study is used to convey how CG adds value to data, including inference for new knowledge. It enables newcomers to conceptual structures to engage with this exciting field and to realise "Conceptual Structures: Knowledge Architectures for Smart Applications", the theme of the 15th Annual International Conference on Conceptual Structures (ICCS 2007, www.iccs2007.info).

1 Introduction

Conceptual Graphs (CG, www.conceptualgraphs.org) provide a powerful knowledge representation and inference environment, whilst exhibiting the familiar object-oriented and database features of contemporary enterprise and web applications. CG capture nuances in natural language whilst being able to be implemented in computer software. CG were devised by Sowa from philosophical, psychological, linguistic, and artificial intelligence foundations in a principled way [8, 9]. Hence CG are particularly attractive as they are built upon such a strong theoretical and wide-ranging base.

There is an active CG community, evidenced by the annual International Conferences on Conceptual Structures (ICCS, www.iccs.info), now in its 15th year (ICCS 2007, www.iccs2007.info), not to mention the annual CG workshops beforehand (www.conceptualstructures.org/confs.htm). There is also the CG discussion list (cg@conceptualgraphs.org). Its participants happily support newcomers to CG e.g. in answering queries; www.conceptualgraphs.org provides information on how to join this list, as well as a comprehensive catalogue of software CG tools.

CG is core to the ISO Common Logic standard (http://cl.tamu.edu/)[1]. The CG community has furthermore grown to embody a wider notion of Conceptual Structures (CS, www.conceptualstructures.org, and the title of Sowa's seminal 1984 text [9]). This is typified by the large scale and valued contributions that Formal Concepts Analysis (FCA, www.upriss.org.uk/fca) brings to ICCS each year [4].

[1] Assigned to WG2 (Metadata) under SC32 (Data Interchange) of ISO/IEC JTC1.

U. Priss, S. Polovina, and R. Hill (Eds.): ICCS 2007, LNAI 4604, pp. 1–14, 2007.

A strong case therefore exists for bringing an awareness of CG to an even wider community. Through an illustrative business case study, the following explication of CG[2] aims to achieve this objective so that many more researchers and industry professionals can realise the benefits of CG and, as the theme of ICCS 2004 highlighted, put them to work [10].

2 Concepts and Relations

CG are based upon the following general form:

This may be read as: "*The* relation *of a* Concept-1 *is a* Concept-2". The direction of the arrows assists the direction of the reading. If the arrows were pointing the other way, then the reading would be the same except that Concept-1 and Concept-2 would exchange places (i.e. "*The* relation *of* Concept-2 *is a* Concept-1").

As an alternative to the above 'display' form[3], the graphs may be written in the following 'linear' text-based form:

```
[Concept_1] -> (relation) -> [Concept_2].
```

The full stop '.' signals the end of a particular graph. Consider the following example:

```
[Funding_Request] -> (initiator) -> [Employee].
```

This example will form a part of an illustrative case study about requests for funding new business projects in the fictitious enterprise 'P-H Co.'. The example graph reads as "The initiator of a funding request is an employee". This may create readings that may sound long-winded or ungrammatical, but is a useful mnemonic aid in constructing and interpreting any graph. It is easier to state "An employee initiates a funding request".

Concepts can have *referents*, which refers to a particular instance, or individual, of that concept[4]. For example consider the concept:

```
[Employee: Simon].
```

This reads as "The employee known as Simon". The referent is a *conformity* to the *type label* in a concept. This example shows that Simon conforms to the type label 'Employee'.

---

[2] That also draws on an earlier introduction to CG in 1992 [7].

[3] The display form CG throughout this paper were produced using the *CharGer* software (http://charger.sourceforge.net/), one the many useful CG software tools that are catalogued at www.conceptualgraphs.org.

[4] There are other kinds of referents, such as plural ('sets' of) referents (which are rather like collections in object-orientated classes, and scalars ('measures') [8, 9]. In passing, as well as Concepts and Relations in CG there are Actors (which incidentally are not to be confused with UML Actors! [6]) Delugach is a proponent for the use of CG Actors [3].

A concept that appears without an individual referent has a *generic* referent. Such 'generic concepts' should be denoted as `[Type_Label: *]`. Writing `[Type_Label]` is merely a convenient shorthand.

Generic concepts may take up an individual referent. A unique identifier can be used to make a concept distinct. Thereby the generic concept `[Funding_Request]` might become `[Funding_Request: #1234]` with respect to `[Employee: Simon]`. This would yield:

```
[Funding_Request: #1234] -> (initiator) -> [Employee: Simon].
```

If there are two or more employees with the name Simon we would need to make them distinct from one another e.g. `[Employee: Simon#122014]`.

3 The Type Hierarchy

In CG, type labels belong to a type hierarchy. Thereby:

`Manager < Employee.` ("A manager is an employee")

This means Manager is a more specialised type of the type Employee i.e. Manager is a *subtype* of Employee. Alternatively, this can be stated as Employee is a *supertype* of Manager. (Subtypes and supertypes are analogous to subclasses and superclasses in object-orientation, thus a subtype inherits the characteristics of its supertypes.) Similarly, the remainder of the hierarchy may be:

```
Employee < Person.
Person < Animal.
Animal < Entity.
Entity < T.
Funding-Request < Request.
Request < Act.
Act < Event.
Act < T.
```

Sowa provides a conceptual catalog that includes a representative set of hierarchical concepts, as well as relations [9]. It also shows the context in which a type label should be used. For example an Act is an Event with an Animate agent:

```
[Act] -> (agent) -> [Animate].
```

The type denoted as 'T' means the universal supertype. It has no supertypes and is therefore the most general type.

A subtype can have more than one immediate supertype. For example, consider the concept `[Animal]`, which has a more detailed set of supertypes than indicated above. This concept has a type label Animal which may be defined as [9]:

```
Animal < Animate, Mobile_Entity, Physical_Object, ¬Machine.
Animate < Entity.
Mobile_Entity < Entity.
Physical_Object < Entity.
```

An animal therefore inherits the characteristics of being animate, a mobile-entity, and a physical object, but it is not a machine (¬ means 'not').

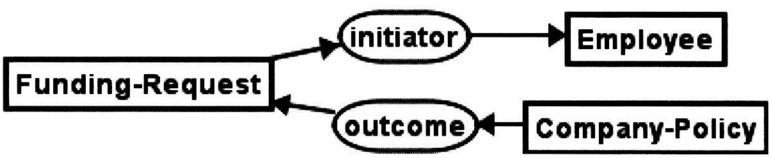
4 Projection

Projection in CG extends the notion of projection in SQL in database systems [1, 8, 9]. It is used in conjunction with specialised graphs. A CG becomes more specialised when one or more of the following happens:

a) more concepts, types and relations are added to it to narrow the scope further, e.g. an employee initiates a funding request that is the outcome of a company policy (as opposed to the earlier where it is only shown that an employee initiates a funding request) i.e.:

```
[Funding_Request] -
 (initiator) -> [Employee]
 (outcome) <- [Company_Policy].
```

This larger graph illustrates the use of hyphen '-', which allows the relations of a concept (being Funding-Request in this case) to be listed on subsequent lines. In the visual display form of CG this is not needed as the following equivalent CG shows:



b) it acquires non-generic referents, e.g. `[Employee]` becomes `[Employee: Simon]`, or
c) subtypes are substituted for (super)types e.g. replacing `[Employee]` with `[Manager]`

The following example illustrates a combination of these:

```
[Funding-request] -
 (initiator) -> [Manager: Susan]
 (outcome) <- [Company-Policy: #CP76321].
```

Therefore each specialised graph may have a more general graph from which it was derived. Likewise a general graph can have a number of specialised variants. Thus *projection* is where we take a graph and try to see if another graph is a generalisation of it. It there is such a fit we have determined that the graph is indeed a specialised variant, and that the other graph is indeed a generalisation of it. We can then state that the general graph 'projects' into the specialised one.