An Ontology-Driven Web Portal for Spatial Decision Support

Naicong Li

Philip Murphy

Redlands Institute, University of Redlands

Ontolog Virtual Workshop

Semantics in Geospatial and Other Architectures: Design and Implementation

May 7, 2013

Definition of spatial decision support

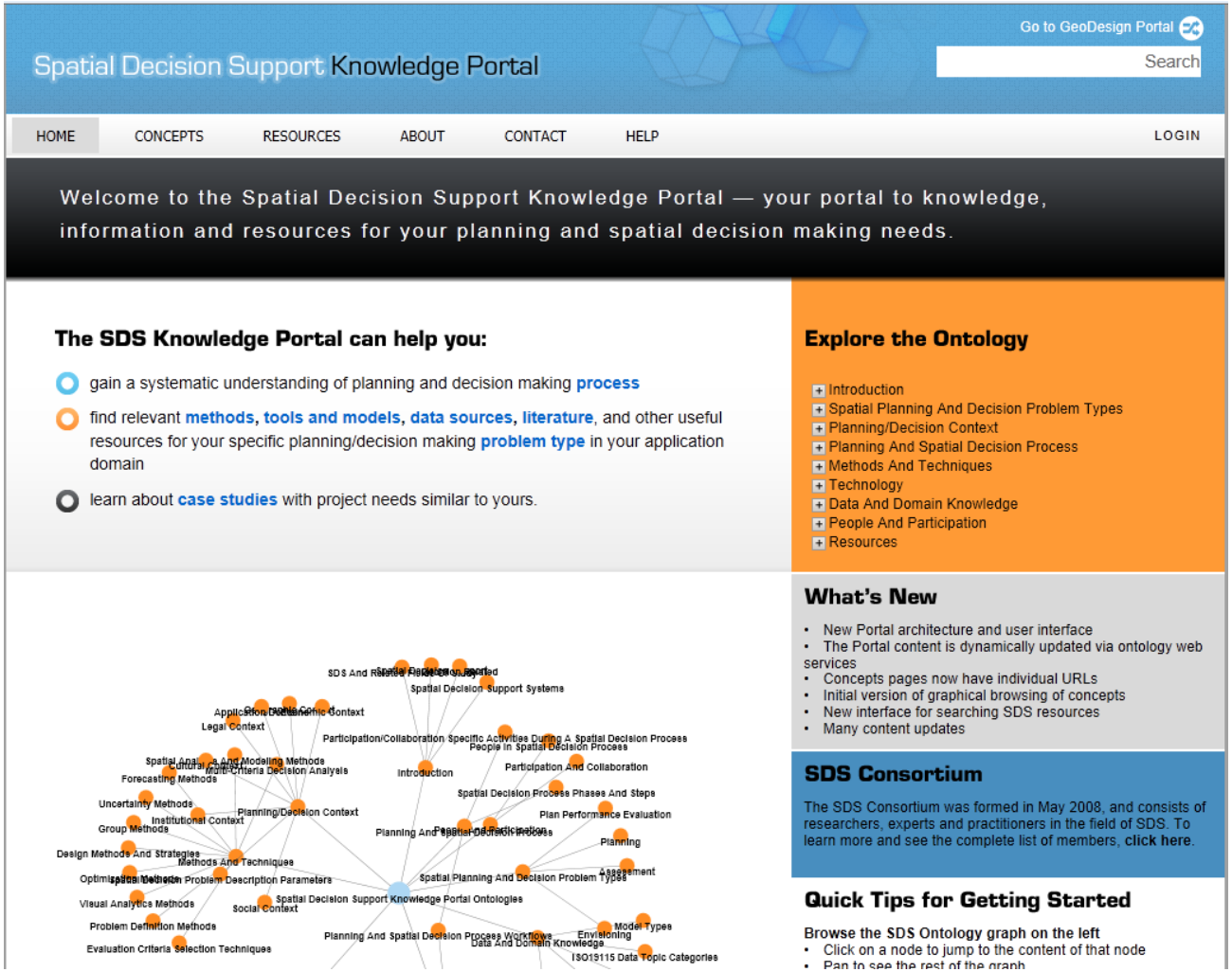
Spatial decision support is the computational or informational assistance for making better informed decisions about problems with a geographic or spatial component. This support assists with the development, evaluation and selection of proper policies, plans, scenarios, projects, interventions, or solution strategies.

The SDS Consortium, 2008

Need for formalizing the knowledge in SDS

- Registration, automatic discovery and access of SDS resources (e.g. workflow templates, methods and algorithms, models and tools, data, cases studies)
- Encourage modular, reusable models and tools development
- Facilitate interoperability among models and tools
- Automatic workflow composition and orchestration
- Provide framework for science-based social decision making, integrating workflow with human and machine steps, methods, tools
- Provide a common vocabulary for the user community
- Facilitate learning in SDS

Solution – ontology driven SDS Knowledge Portal

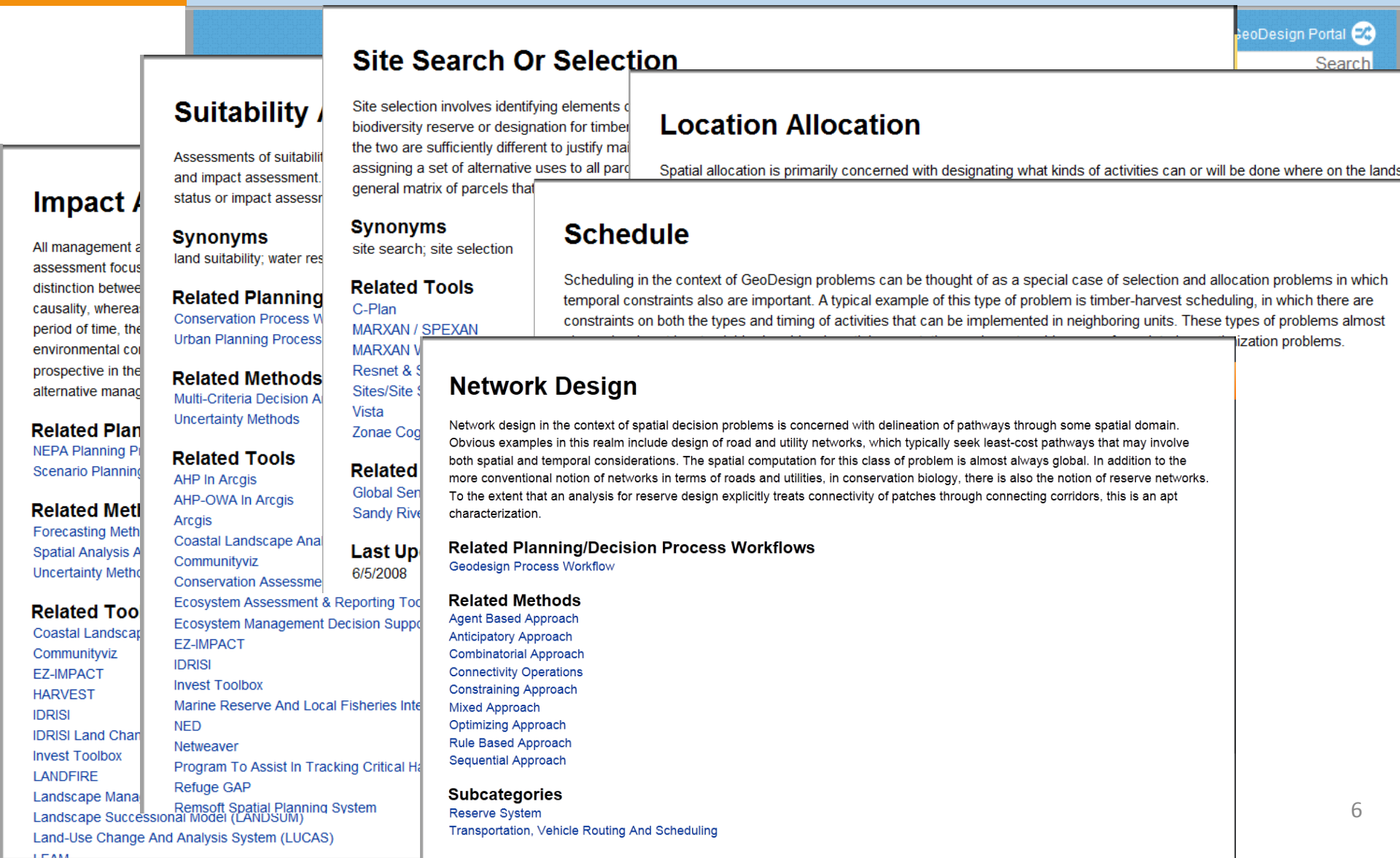


http://www.spatial.redlands.edu/sds/

Content of the SDS ontology

- Planning/decision problem types
- Planning process workflows and steps
- Strategies, methods and techniques that are commonly associated with different workflow steps
- Models and tools supporting spatial planning
- Data sources supporting spatial planning
- Spatial planning/decision support case studies
- Related concepts supporting the descriptions of the above

Spatial planning and decision problem types



Spatial planning workflows

Adaptive Natural Resource Plan

A prototypical process flow for adaptive natural resource managem
well the p
adaptive.
process.

CMP Open Standards F

The CMP
framework
bringing to
to help pra
guidance r

The Open
context; 2)
results, an
steps or st
complex b

Source
CMP (200
content/up

For Dec
Alternative
Impact Ass
Reserve S
Status Ass
Suitability

For App
Biodiversit
Fish And W
Threatene

Process
1. Concep
2. Plan Ac

Scenario Plannin

Scenario planning is a process that
framework for developing a shared v
environmental, land use, etc.) that a
business conditions and better man

The hallmark of scenario planning is
that might be considered demograph
possibilities for each variable helps
future.
Scenario planning creates guiding p
Stakeholders, including the public, c
future vision that provides a framew
scenarios and discussing their poss
discuss trade-offs, and make better

Scenario planning is a flexible appro
quality of life, urban form, transporta
geographic scales (including at the
critical component in using the techn

Scenario planning may involve aspe
to create sometime surprising future
to formalize, such as novel insights
used in conjunction with scenario pl
be demonstrated. In these cases wh
sometimes referred to as structural

More recently in geospatial domain,

Urban Planning Process

Urban pla
urbanized
created th
ideals bas

Changes
process.
decisions
grassroot
planning.

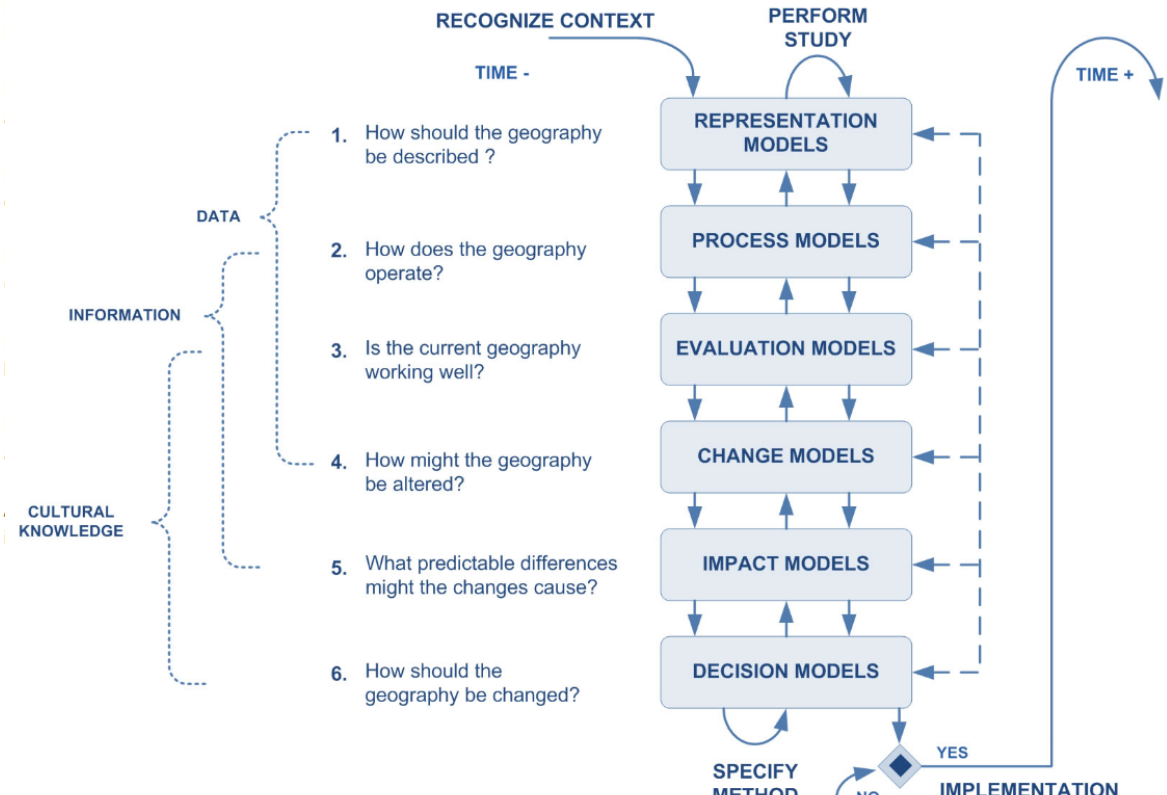
Proces
Phase 1 -
Phase 2 -
Phase 3 -
Phase 4 -
Phase 5 -
Phase 6 -
Phase 7 -
Phase 8 -
Phase 9 -

For Ge
Alternative
Plan Evalu
Status As
Suitability

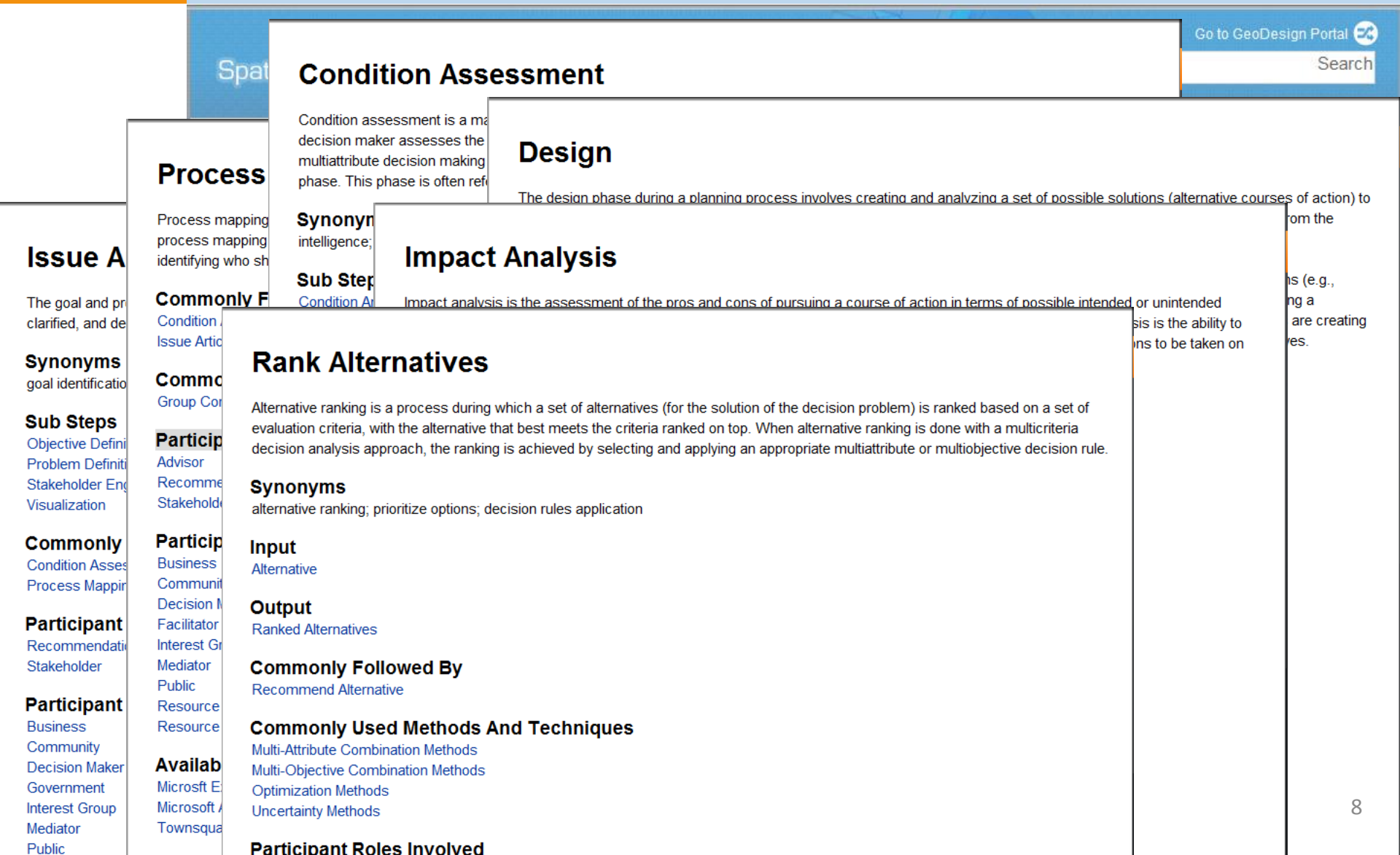
The Ap
Addres
Health Ca
Historic P
Land Use
Public Util
Transport
Urban Pla
Zoning

Steinitz's Framework

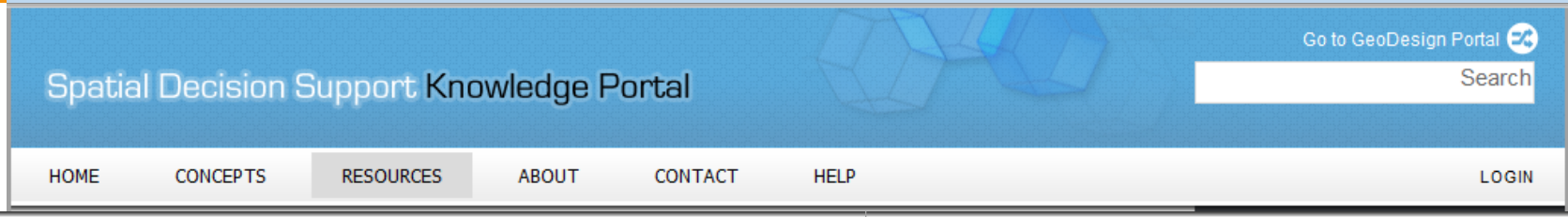
Steinitz's framework is a conceptual framework proposed by Carl Steinitz (1990) to describe six levels of inquiry during a spatial decisio
process; each level is associated with a type (phase) of modeling with GIS to form a comprehensive expression of a decision support
strategy for landscape planning and design:



Steps in a spatial planning workflow



Methods, techniques, algorithms



Multi-Criteria Decision Analysis

Methods f
decisions
(MCDM).
incommer
two broad
Both MAD
categories
required d
the corres
problem e
uncertainl
decision a
assume a
criteria va

Abbrev
MCDA

Synony
multi-crite

For Dec
Alternative
Suitability

Implem
Conservat
Criterium
DEFINITE
EZ-IMPAC
Impact A

Analytical Hierarchy Process

The Ana
psycholo
provides
those ele
decision
decision
element
estimate
makers
makers
importan
evaluatio
problem
element
making t
numbers
courses

Abbre
AHP

Used I
Conditio
Constrai
Evaluatio
Impact A

Pairwise Comparison

The pairwis
involves pai
as output. S
(reciprocal)
weights con

Used Fo
Specify Crit

Number
n(n - 1)/2

Respons
Ratio Scale

Underlyi
statistical/he

Trustwo
High

Precisio
Quite Precis

Value/Utility Func

The utility func
both the conc
the nature of t
approach). Th
the utility funct
function (Keer
attribute, and
a convenient
inherently prol

The value and
decisions req
The individual
in the decisior
probabilistic, a

For Decisi
Balance Bene
Maximize Ben

Criterior

Multicriteria Decis
information about
derivation of weig
evaluation criterio
the criterion in the

Synonyms
weights assessm

Used For De
Specify Criterion

Implemented
Conservation Ass

Rati

The ratir
100 can

Used
Specify

Numb
n

Respo
Interval

Under
none

Trustv
High

Geneti

A genetic algo
problems. Ge
chromosome
problem evolv
are also poss
generation, th
population (ba
population is t
generations h
a maximum n

For Decisi
Balance Bene
Maximize Ben
Minimize Nega

Used For Decision Pro
Alternative Generation
Alternative Screening
Rank Alternatives

Heuris

In computer s
problem in ma
not be proven
method to find

For Decisi
Balance Bene
Maximize Ben
Minimize Nega

Used For I
Alternative Ge
Alternative Scr
Rank Alternati

Subcatego
Metropolis Has
Simulated Ann

Source Of
http://en.wikipe

Weighted Linear Combination

Weighted linear combination is the most often used technique for tackling spatial m
procedure based on the concept of a weighted average. The decision maker direct
attribute. A total score is then obtained for each alternative by multiplying the impor
value given to the alternative on that attribute, and summing the products over all a
the alternatives, the alternative with the highest overall score is chosen. The GIS-ba
steps:

1. Define the set of evaluation criteria (map layers) and the set fo feasible alternati
2. Standardize each criterion map layer.
3. Define the criterion weights; that is, a weight of relative importance is directly as
4. Construct the weighted standardized map layers; that is, multiply standardized r
5. Generate the overall score for each alternative using the add overlay operation o
6. Rank the alternatives according to the overall performance scores; the alternati

The weighted linear combination method can be operationalized using any GIS sys
techniques allow the evaluation criterion map layers (input maps) to be aggregated
The method can be implemented in both raster and vector GIS environments.

Abbreviation
WLC

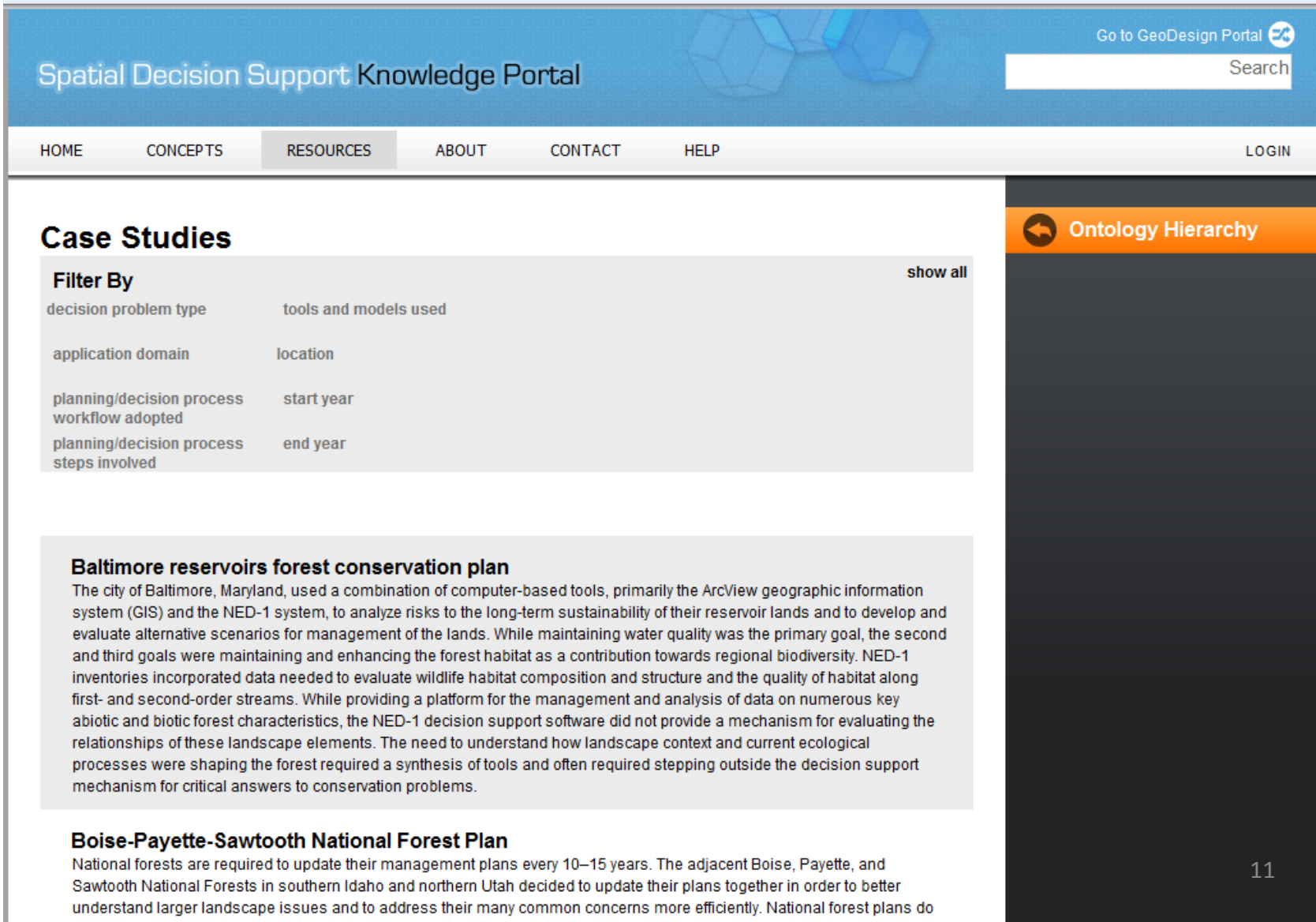
Synonyms
weighted summation; boolean overlay; simple additive weighting method; SAW; sc

Used For Decision Process Phases/Steps
Condition Analysis And Assessment
Impact Analysis
Rank Alternatives

Input

Software models, tools, services

Case studies



Browsing on SDS Knowledge Portal

Site Search Or Selection

Site selection involves identifying elements of the l… biodiversity reserve or designation for timber harve… the two are sufficiently different to justify maintainin… assigning a set of alternative uses to all parcels in… general matrix of parcels that are optimal for some…

Synonyms
site search; site selection

Related Tools
C-Plan
MARXAN / SPEXAN
MARXAN With Zones
Resnet & Surrogacy
Sites/Site Selection Module (SSM)
Vista
Zonae Cogito

Related Case Studies
Global Sensitivity Analysis, GIS And Multi-Criteria E…
Sandy River Basin Anchor Habitats Project

Last Updated
6/5/2008

Contributor
Keith Reynolds

Graphical Ontology Browser

Expand All | Collapse All | filter hierarchy

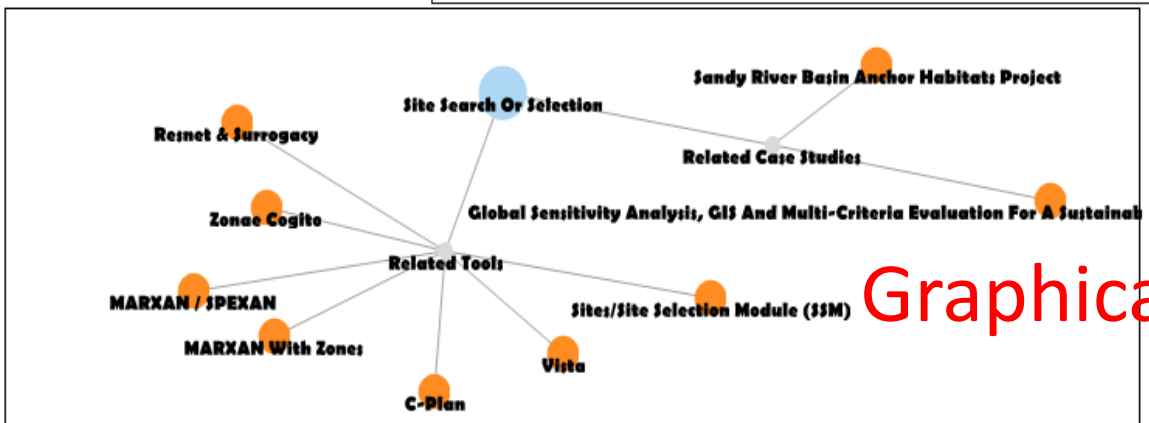
Ontology Hierarchy

There are currently no assigned tags
add a tag

- Introduction
- Spatial Planning And Decision Problem Types
  - Envisioning
  - Assessment
  - Planning
    - Alternative Evaluation
    - Network Design
    - Plan Evaluation
    - Schedule
    - Select Or Allocate
      - Location Allocation
      - Resources Allocation
      - *Site Search Or Selection*
  - Plan Performance Evaluation
- Planning/Decision Context
- Planning And Spatial Decision Process
- Methods And Techniques
- Technology
- Data And Domain Knowledge
- People And Participation
- Resources

← Follow the ontology hierarchy

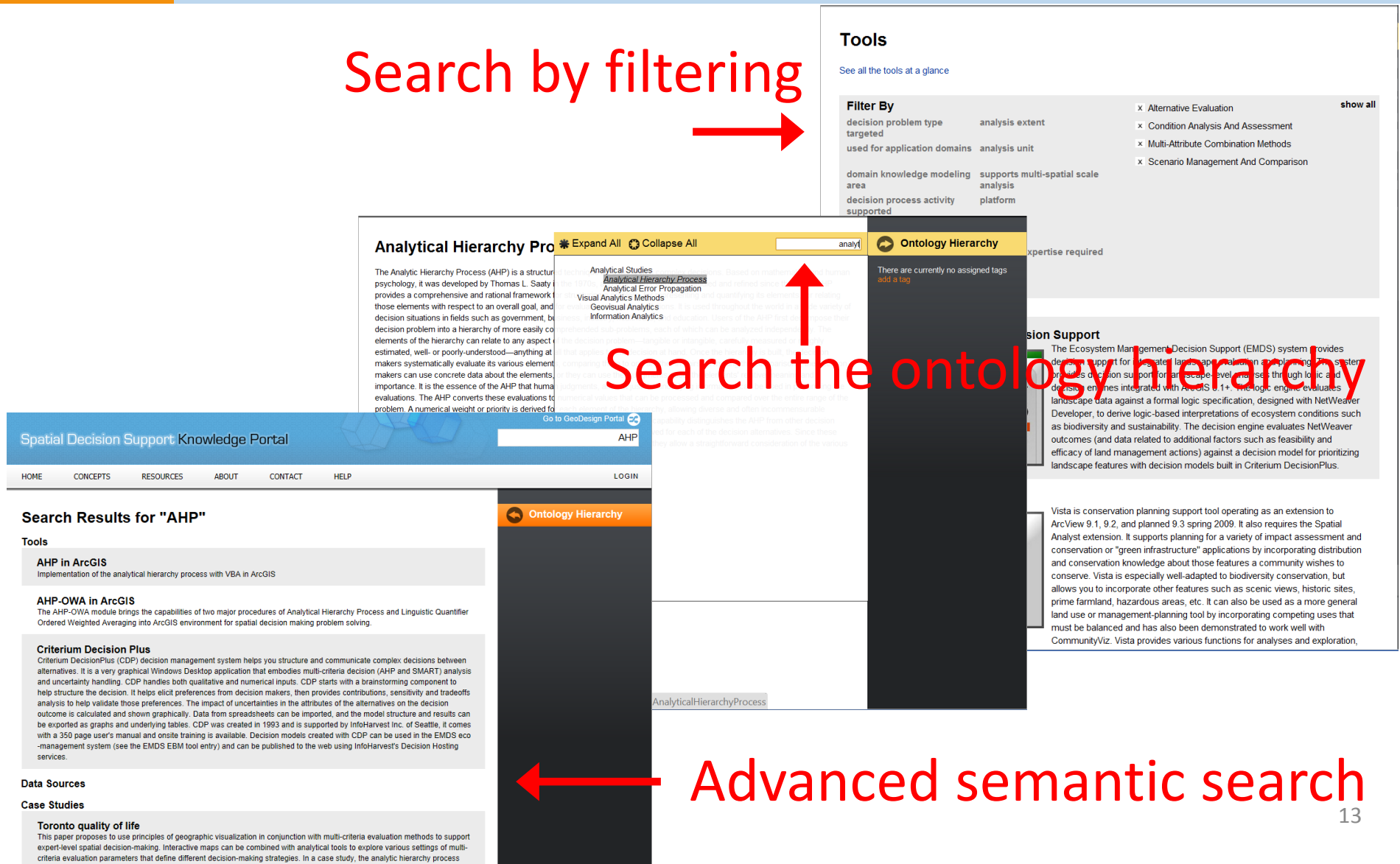
↑ Follow the relation links from concept to concept



← Graphical browsing

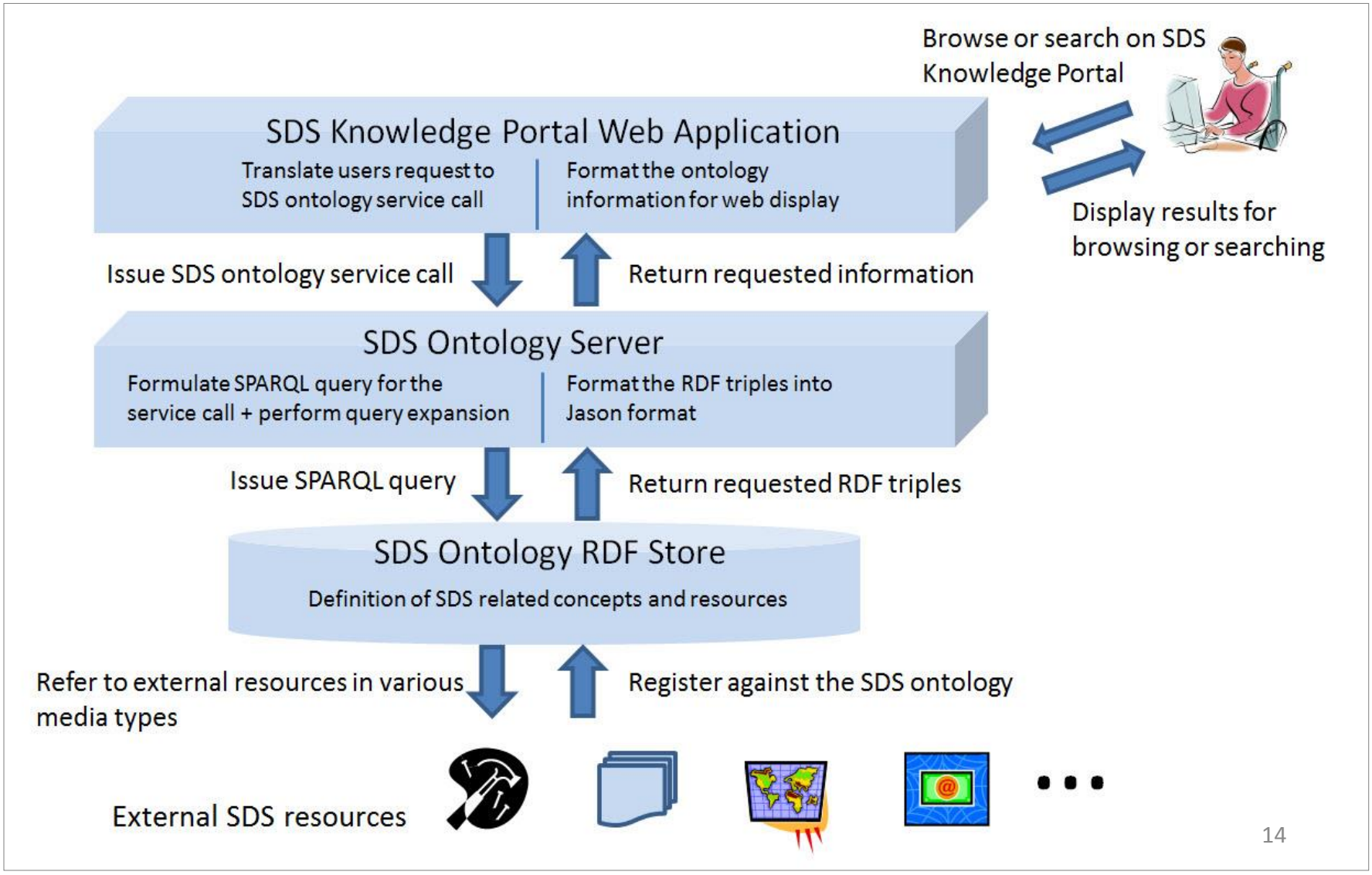
Searching on SDS Knowledge Portal

Search by filtering

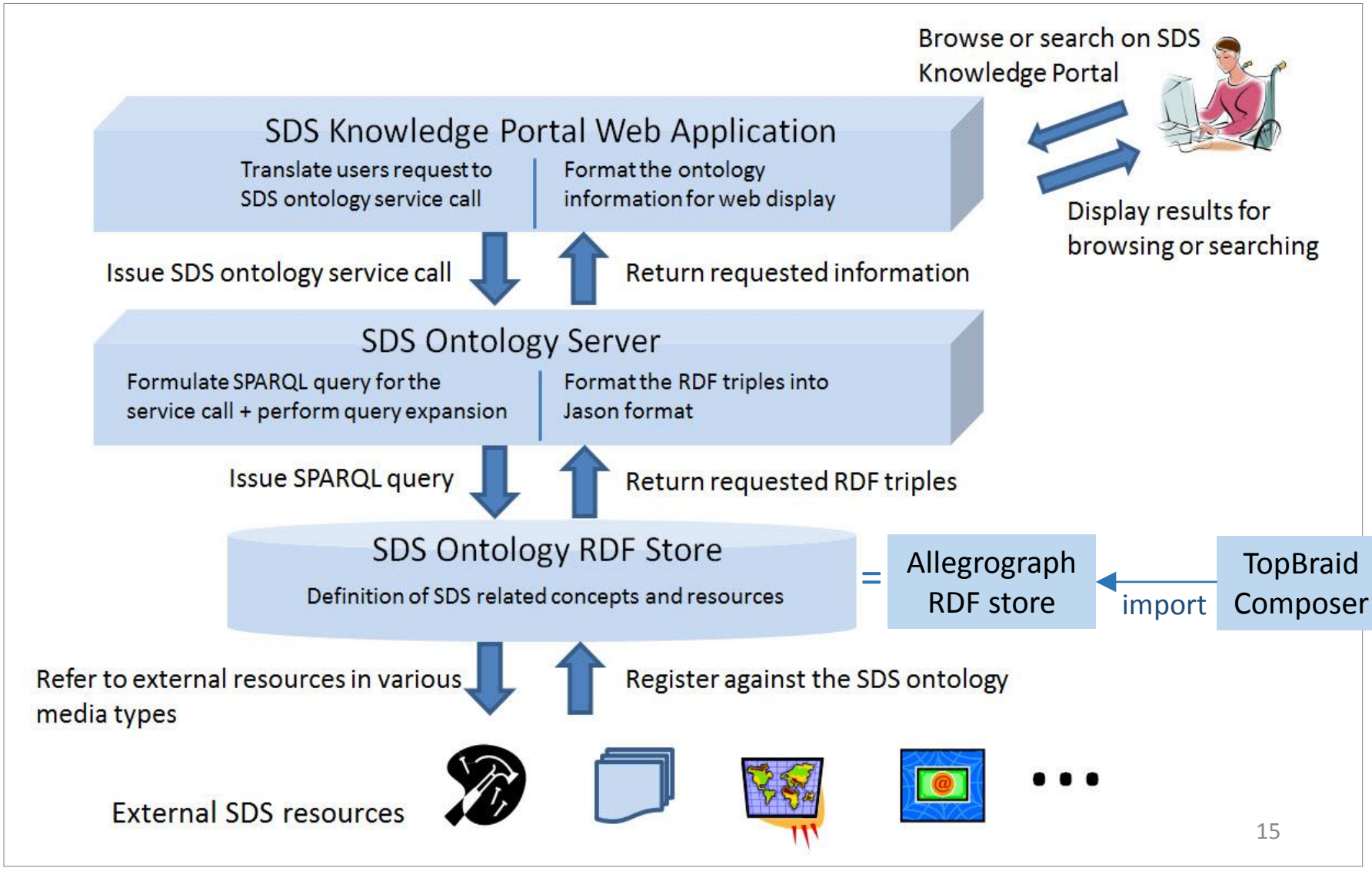


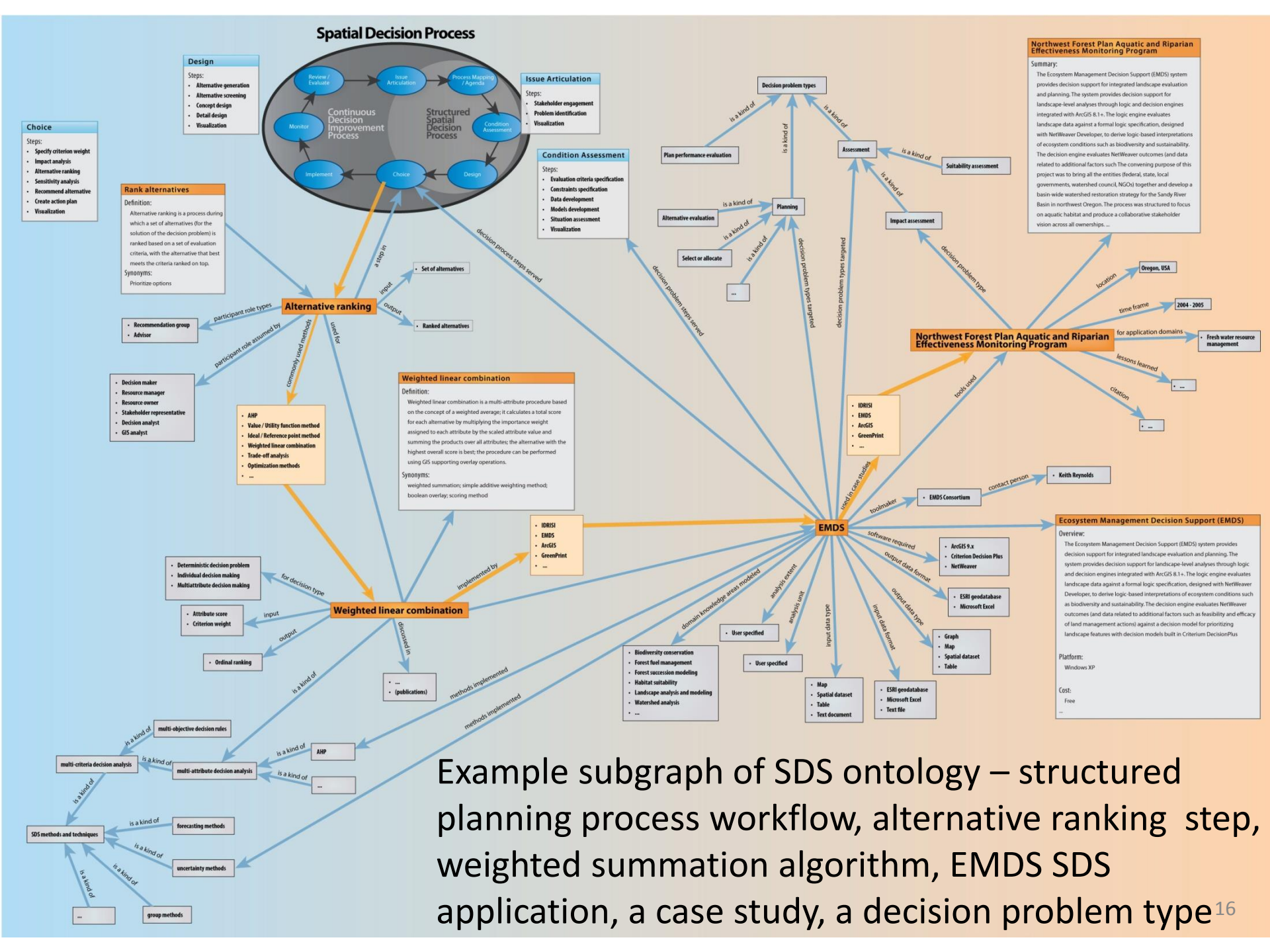
Advanced semantic search

Architecture of the SDS Knowledge Portal



Architecture of the SDS Knowledge Portal





Example subgraph of SDS ontology – structured planning process workflow, alternative ranking step, weighted summation algorithm, EMDS SDS application, a case study, a decision problem type

Design considerations of the SDS ontology

- Modularity -- more than 40 sub ontologies (in OWL)

Decision problem types

Decision contexts

Decision process steps

Decision process workflows

Decision methods and techniques

Participation and collaboration

Organizations

Data models

Models and tools

Data sources

Case studies

Literature

People

Related websites

Data topics

Data attributes

Decision related

Application domains

Knowledge domains

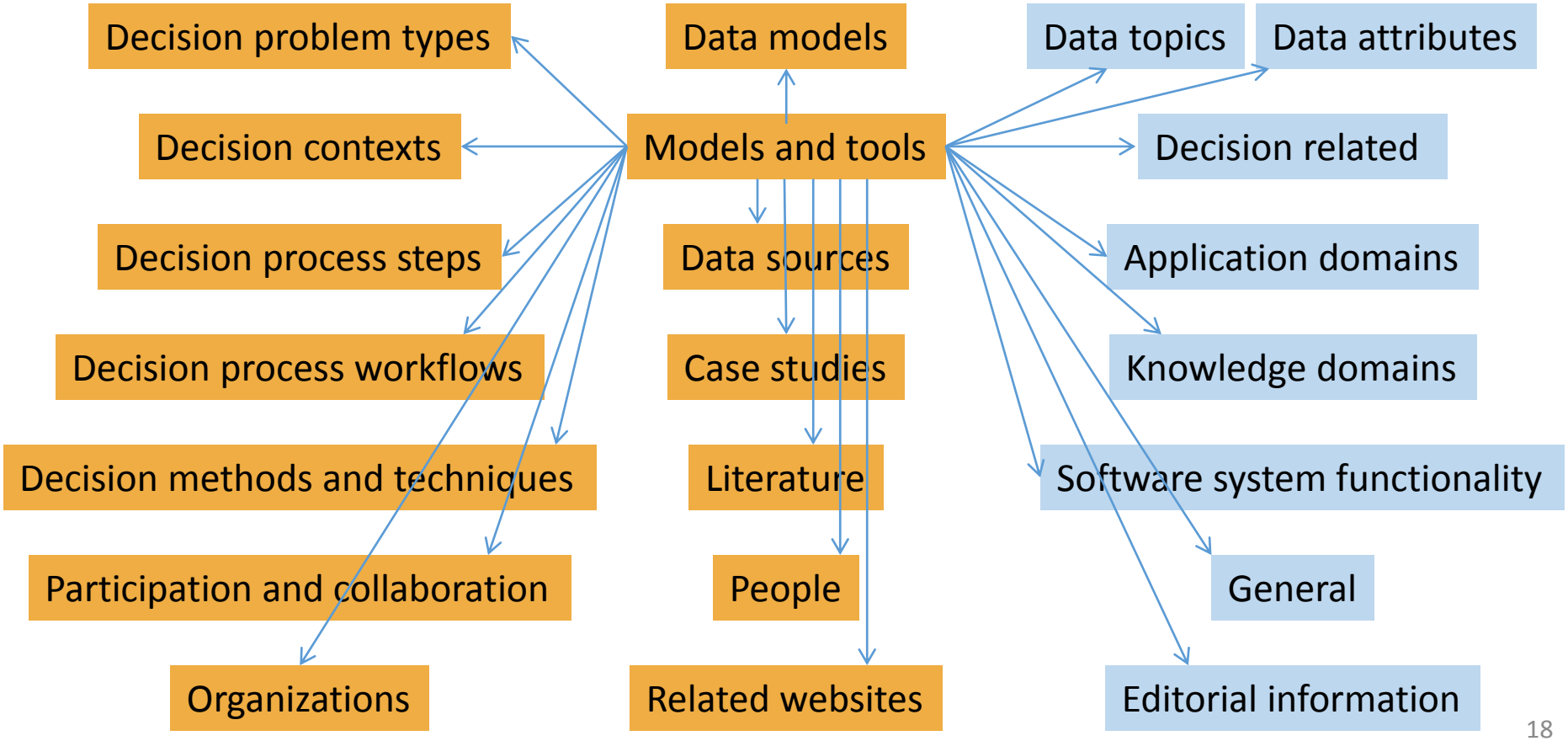
Software system functionality

General

Editorial information

Design considerations of the SDS ontology

- Modularity – allowing concepts in more specific ontologies refer to concepts in more general ontologies



Design considerations of the SDS ontology

- Modularity – Allowing easy import of well-established 3rd party ontologies

Decision problem types

Decision contexts

Decision process steps

Decision process workflows

Decision methods and techniques

Participation and collaboration

Organizations

Data models

Models and tools

Data sources

Case studies

Literature

People

Related websites

Data topics

Data attributes

Decision related

Application domains

Knowledge domains

Software system functionality

General

Editorial information

Design considerations of the SDS ontology

- Modularity – Allowing easy import of well-established 3rd party ontologies

Decision problem types

Decision contexts

Decision process steps

Decision process workflows

Decision methods and techniques

Participation and collaboration

Organizations

Data models

Models and tools

Data sources

Case studies

Literature

People

Related websites

ISO 19115

Data attributes

Decision related

Application domains

Knowledge domains

Software system functionality

General

Editorial information

Design considerations of the SDS ontology

- Degree of formalization -- Determined by user's need of search and navigation

E.g. for "models and tools":

- name
- acronym
- summary
- overview
- toolmaker
- decision problem types targeted
- decision process steps supported
- methods and techniques implemented
- used in case studies
- analysis extent
- analysis unit
- data models used
- application areas
- knowledge domains
- indicators used
- supports analysis of interdisciplinary interactions
- supports multi spatial scale analysis
- supports social negotiation
- input, output data type
- Input, output data format
- description of system components
- software required
- platform
- scientific expertise level required
- technical expertise level required
- developer support needed
- development status
- online download available
- cost
- information source

Design considerations of the SDS ontology

- Choice of relation types – based on best practice and the purpose
  - Identify a minimal set of subclasses and superclasses
  - Express other facts using non- taxonomic relations or attributes
  - Dynamically generate extra taxonomic relations out of non-taxonomic relations based on the user's browsing need

Design considerations of the SDS ontology

- Automatic generation of multiple taxonomic relations

E.g. for “models and tools”:

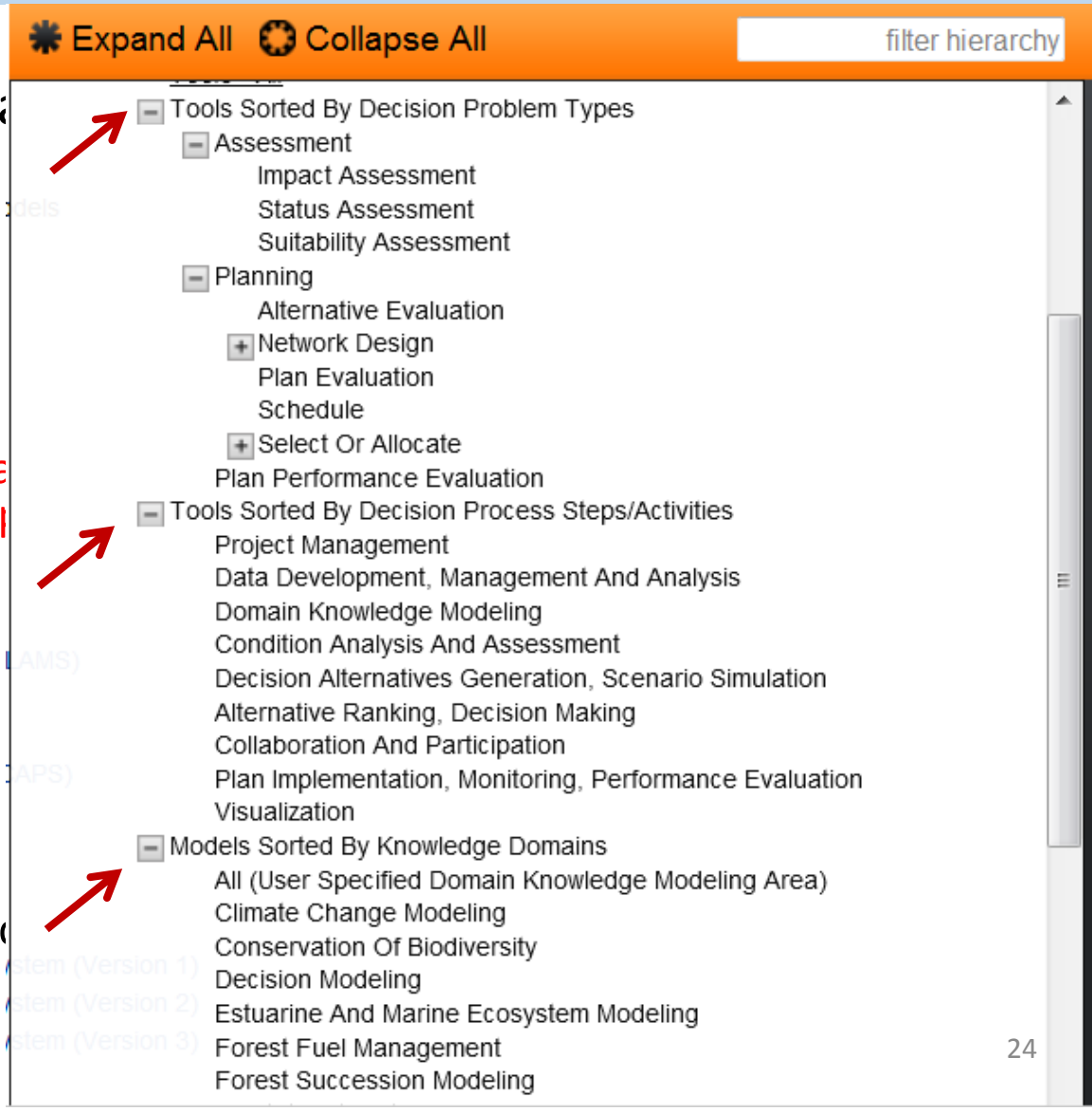
- name
- acronym
- summary
- overview
- toolmaker
- decision problem types targeted
- decision process steps supported
- methods and techniques implemented
- used in case studies
- analysis extent
- analysis unit
- data models used
- application areas
- knowledge domains
- indicators used
- supports analysis of interdisciplinary interactions
- supports multi spatial scale analysis
- supports social negotiation
- input data format
- output data type
- description of system components
- software required
- platform
- scientific expertise level required
- technical expertise level required
- developer support needed
- development status
- online download available
- cost
- information source

Design considerations of the SDS ontology

- Automatic genera

E.g. for "models and tools":

- name
- acronym
- summary
- overview
- toolmaker
- decision problem types ta
- decision process steps su
- methods and techniques
- used in case studies
- analysis extent
- analysis unit
- data models used
- application areas
- knowledge domains
- indicators used
- supports analysis of inter interactions

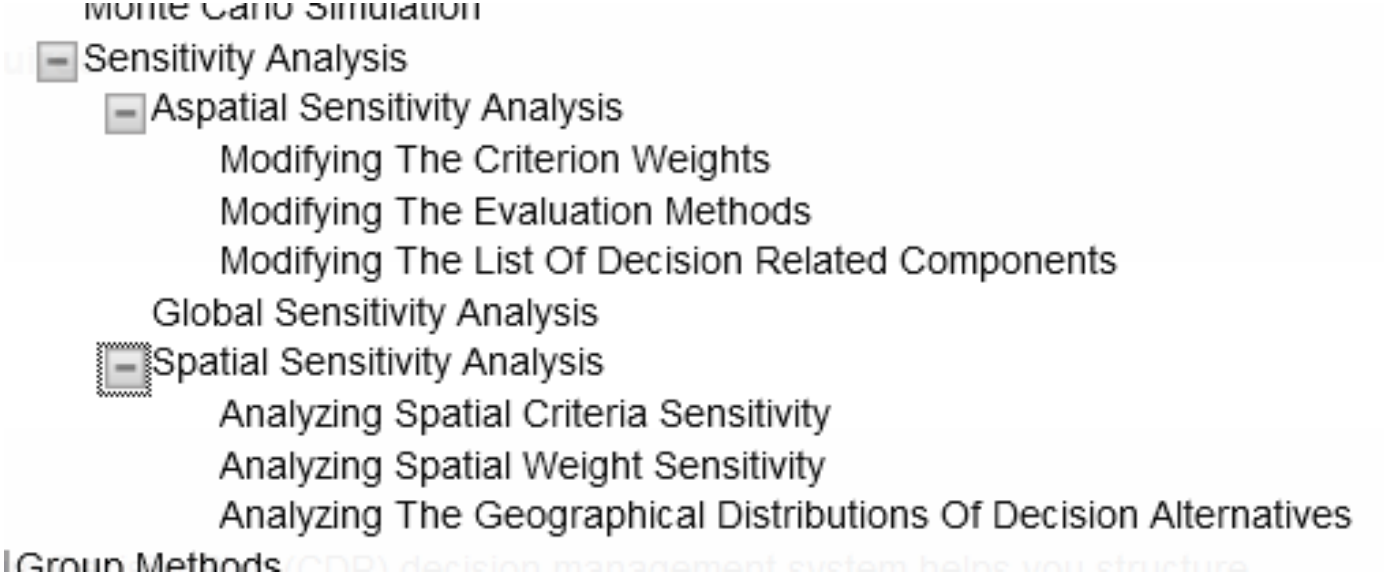


Design considerations of the SDS ontology

- Leveraging logical relations in search and navigation
  - Subsumption relation, e.g.

    Find a tool that implements sensitivity analysis:

    → return all the subclasses of sensitivity analysis



Design considerations of the SDS ontology

- Leveraging logical relations in search and navigation
  - Subsumption relation, e.g.

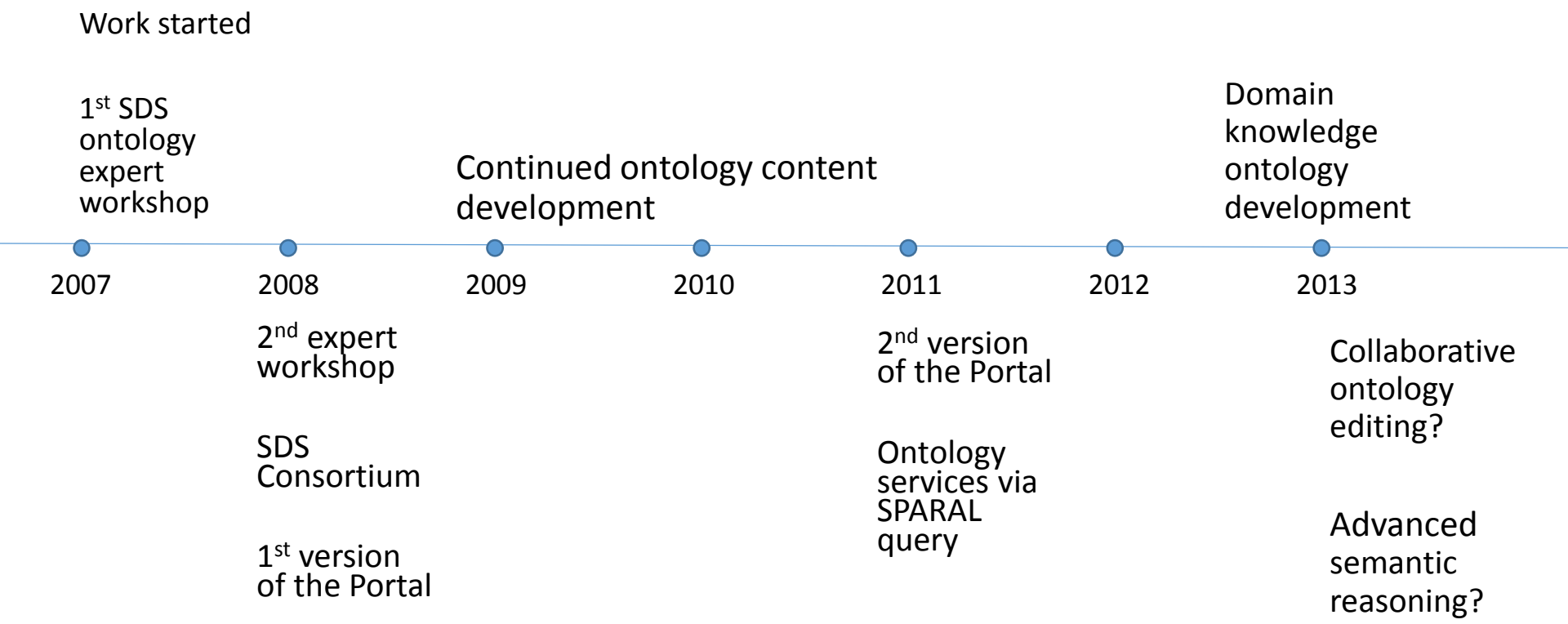
    Find a tool that implements sensitivity analysis:

    → return all the subclasses of sensitivity analysis
  - Inverse relation, e.g.

    "Tool X implements Method A"

    → "Method A is-implemented-by Tool X"
  - Transitive relation

Timeline and future work



Contact

- Naicong Li, naicong_li@spatial.redlands.edu
- Philip Murphy, philip_murphy@spatial.redlans.edu

See also:

- www.spatial.redlands.edu/sds
- Li, N., Raskin, R., Goodchild, M. and Janowicz K. (2012) An Ontology-Driven Framework and Web Portal for Spatial Decision Support. *Transactions in GIS* 16(3): 313-329.