Ontology of Evidence

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OIC 2008
December 3, 2008

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In the olden days…

- We built stovepipes
  - Stand-alone systems
  - Used by a single organization for a single purpose
  - Specialized formats for inputs and outputs
  - Idiosyncratic database schema
  - Key assumptions documented on paper or not at all
  - Labor-intensive manual transformation of outputs for use by another stovepipe

A Whole New World…

The Net Centric World-to-Be:

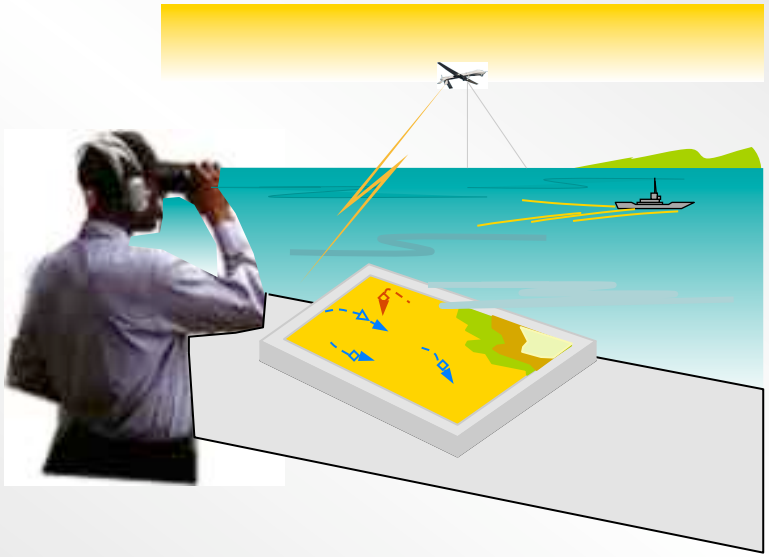
- Autonomous software agents interoperate seamlessly
- Collective behavior emerges to address information needs
- Each agent has timely access to mission-critical information
- Agents are not overloaded with unnecessary information
- Information is properly synchronized and up-to-date
- Multi-level security permits needed access while preventing non-authorized use

Semantic technology is an essential enabler!

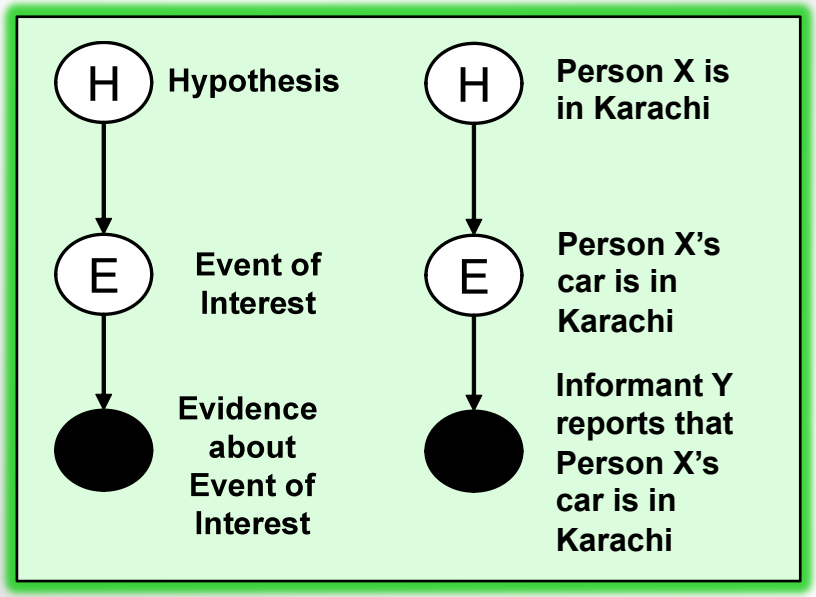
http://www.emporia.edu/earthsci/student/graves1/project.html

What Information to Exchange?

- Intelligence analysts draw conclusions from *evidence*
- Evidential reasoning must account for uncertainties:
  - Noise in sensors
  - Incorrect, incomplete, deceptive human intelligence
  - Lack of understanding of cause and effect mechanisms in the world
- We must exchange more than reports & conclusions:
  - Sources
  - Context
  - Pedigree
  - Credibility



Some Key Attributes of Evidence



Relevance

- *How does the evidence bear on H?*
  - *Direct*
  - *Circumstantial*
  - *Indirect (ancillary)*

Credibility

- *How trustworthy or believable is the evidence?*
  - *Tangible*
  - *Testimonial*
  - *Authoritative records*

Weight

- *How strong is the relationship between the evidence and H?*

(Schum, 1994)

Some Entity Types

- Sources and their characteristics
  - Sensors
  - Human agents
  - Forensic artifacts
- Environmental and contextual factors
- Hypothesis sets
  - Binary
  - Categorical
  - Ordinal
  - Numeric (discrete, continuous)
- Reports

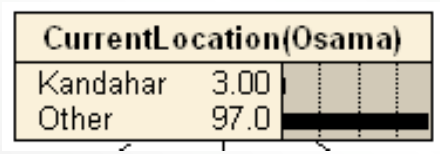
Some Attributes of Credibility

- Tangible evidence (e.g., image)
  - Authenticity of report
  - Sensitivity of sensor
  - Specificity of sensor
  - Reliability of sensor
- Testimonial evidence (e.g., informant report)
  - Veracity of source
  - Objectivity of source
  - Competence of source with regard to reported event

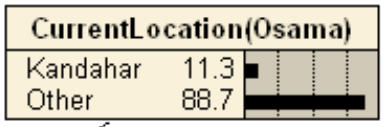
Probability and Ontology

- Probability is a well-established representation for evidential weight
  - Represent statistical regularities in domain
  - Combine statistical information with expert knowledge
  - Draw powerful inferences under uncertainty
- Probabilistic semantics supports interoperability
  - More than just numbers!
  - Much of the value of probabilistic representation is structural

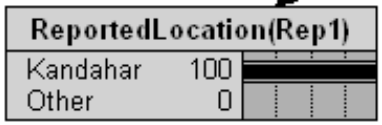
Example: Independent Reports

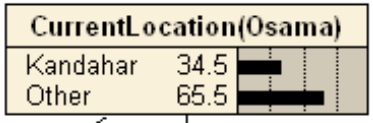


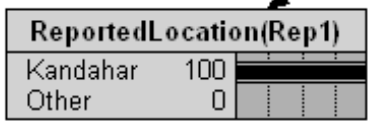
A priori



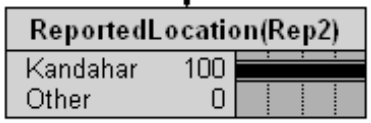
First report

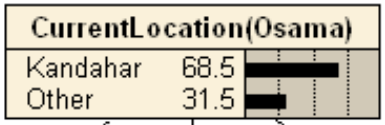


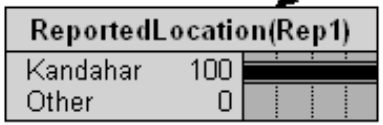


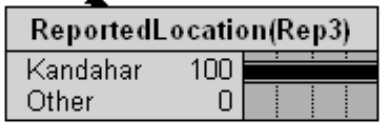


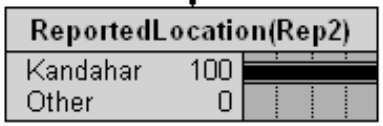
Second report







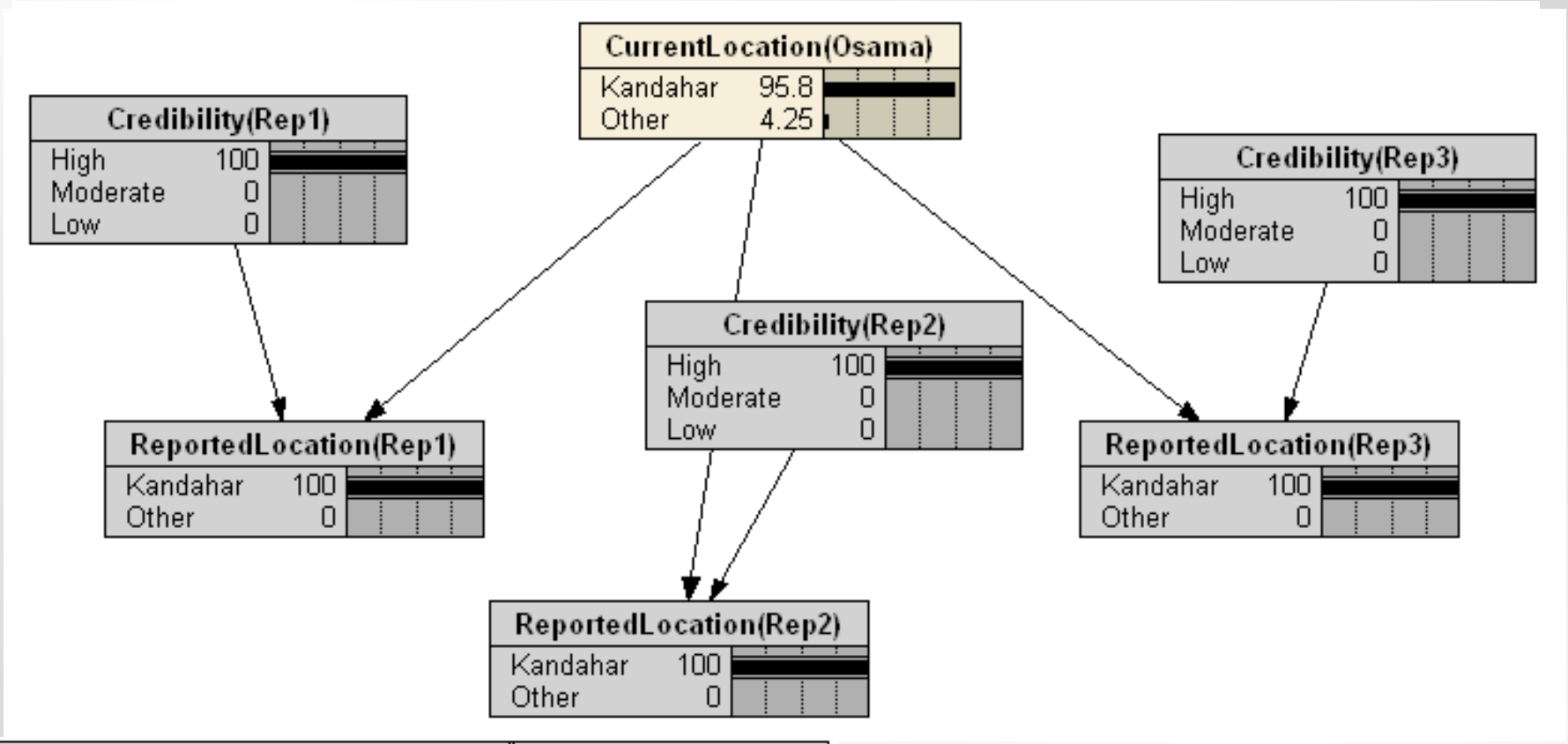




Third report

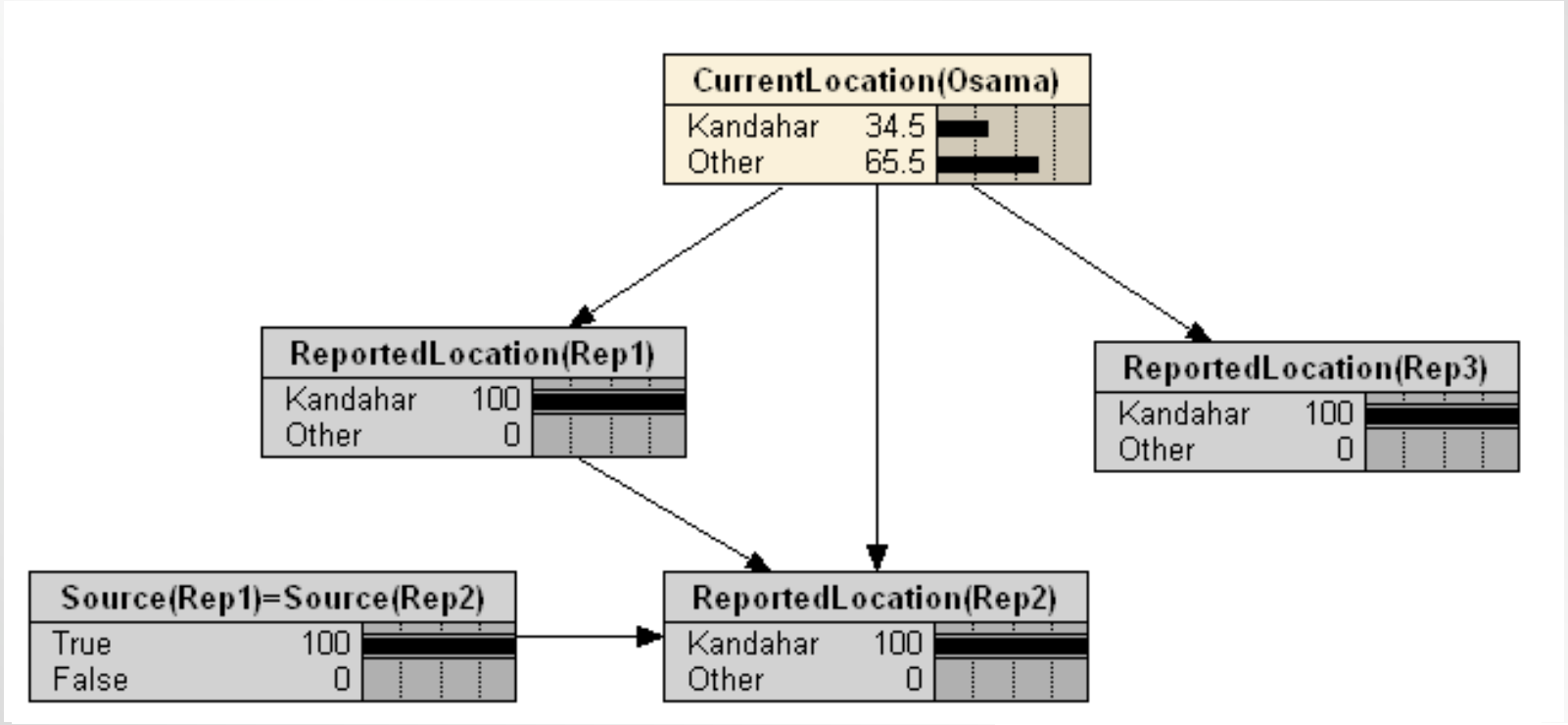
CurrentLocation(*x*) isa PhysicalLocation
ReportedLocation(*r*) isa LocationReport
Subject(*r*) = *x*

Credibility and Evidential Force



CurrentLocation(Osama)	Credibility(Rep1)	Kandahar	Other
Kandahar	High	90.000	10.000
Kandahar	Moderate	80.500	19.500
Kandahar	Low	70.000	30.000
Other	High	10.000	90.000
Other	Moderate	19.500	80.500
Other	Low	30.000	70.000

Example: Common Source

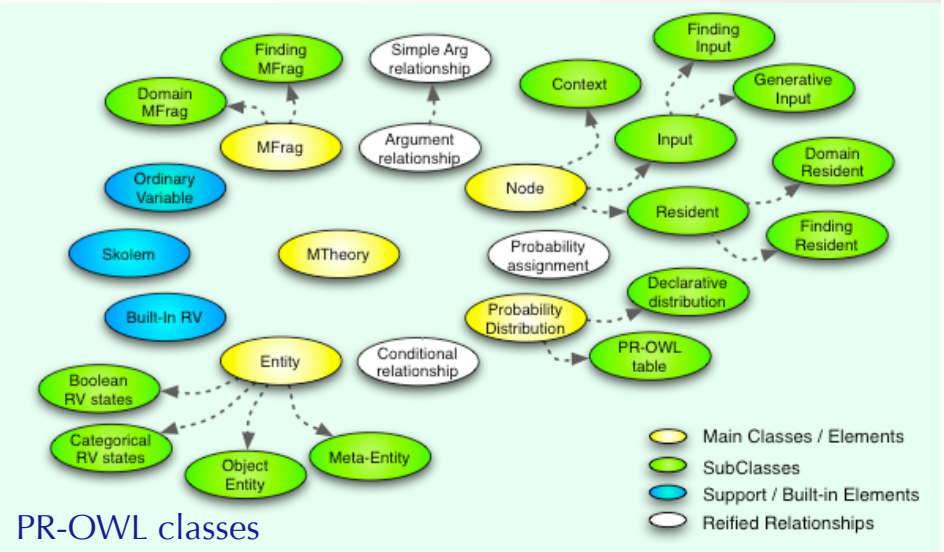


Source(...	CurrentL...	Reporte...	Kandahar	Other
True	Kandahar	Kandahar	95.000	5.000
True	Kandahar	Other	5.000	95.000
True	Other	Kandahar	95.000	5.000
True	Other	Other	5.000	95.000
False	Kandahar	Kandahar	80.500	19.500
False	Kandahar	Other	80.500	19.500
False	Other	Kandahar	19.500	80.500
False	Other	Other	19.500	80.500

PR-OWL: A Language for Expressing Probabilistic Ontologies

- Extends W3C recommended OWL ontology language
- Based on expressive probabilistic logic
- Represents probabilistic knowledge in XML-compliant format.
- Open-source, freely available solution for representing knowledge and associated uncertainty in a principled manner.
- Reasoner under development at University of Brasilia
  - Beta version released July, 2008 on SourceForge

(Costa, 2005)



PR-OWL classes

Summary

- Evidential reasoning is fundamental to intelligence analysis
- Realizing net-centric vision requires sharing credibility and pedigree as well as reports and conclusions
- Capturing semantics of evidence is necessary
- Probabilistic ontology can represent both structural and numerical aspects of evidential reasoning


Questions?