

Ubiquitous Sensing for National Security **extracted from LA-UR-06-8783**

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16 November 2006, edited 31 October 2007

What is ubiquitous sensing?: The Threat Reduction mission of Los Alamos National Laboratory is to reduce global threats, especially weapons of mass destruction; the key technical challenge for this mission is what the military would call global situational awareness, as applied to the problem of weapons of mass destruction. These threats include infectious bioagents and nuclear terrorism. At the heart of the technical challenge is anticipating, sensing, processing, and organizing information. If we succeed at the nuclear and biological threats, we will succeed at other national security challenges such as radiological dispersal devices (“dirty bombs”). The Threat Reduction challenge is best summarized:

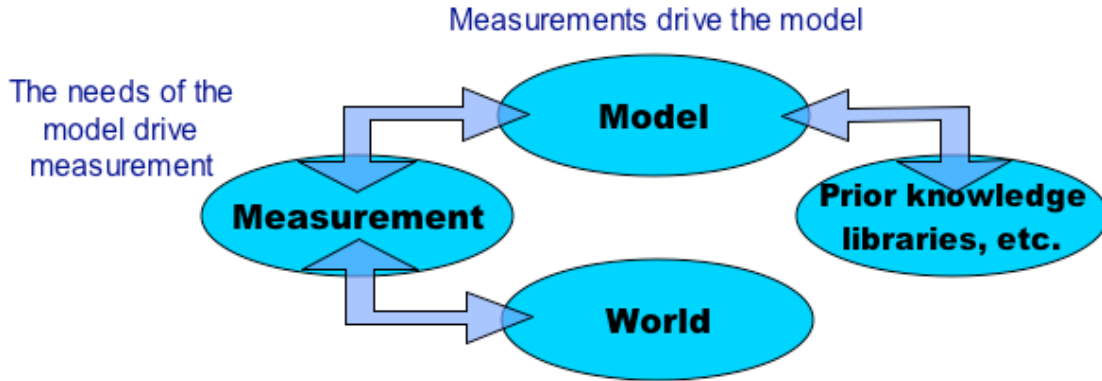
“Sense and anticipate nuclear and biological threats at a global scale in real time.”

Our challenge has also been dubbed “ubiquitous sensing.” Key aspects of ubiquitous sensing include:

- Ubiquitous sensing is the continuous improvement of our ability to detect subtle and ephemeral threats over large areas. Sensed data then becomes knowledge by populating and updating models.
- Ubiquitous sensing is made possible by the invention, improvement, and integration of technology.
- Ubiquitous sensing becomes relevant only if it provides information that can impact the end-user’s decision process.

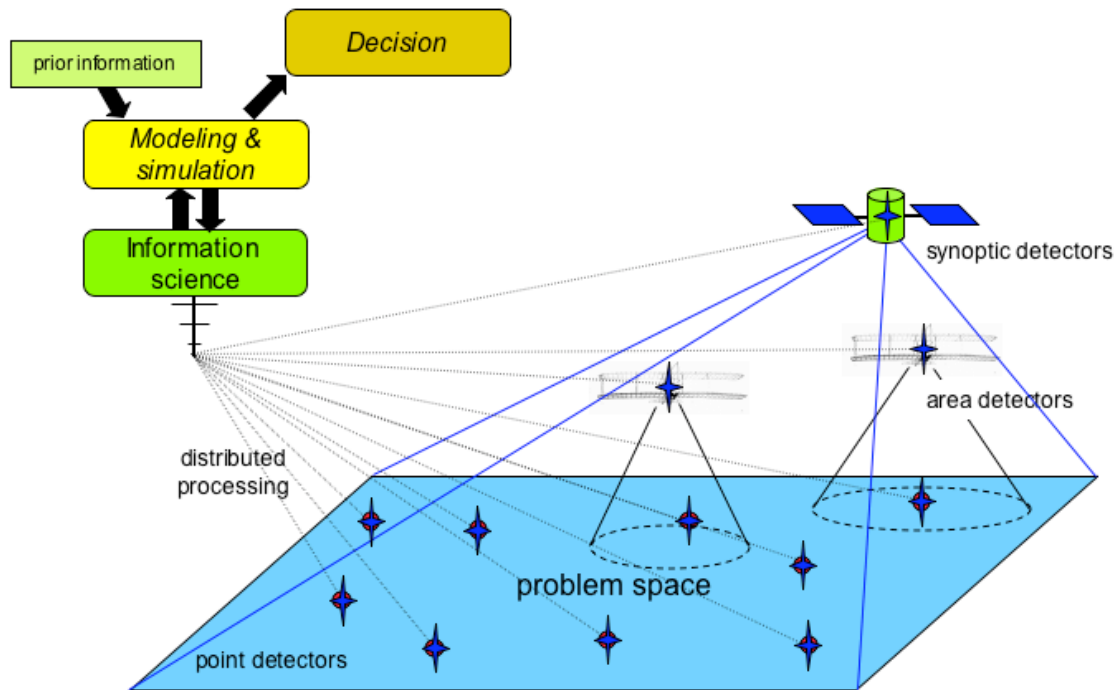
The heart of the challenge: The key to sensing and anticipating nuclear and biological threats is the connection between model and measurement, as sketched in the figure below. The model provides context to measurement, and serves as the locus that integrates the information that comes in via measurement with that available from prior knowledge.

A model, whether explicit or implicit, is always the foundation of any information integration effort. Formalizing and quantifying the model is necessary to move beyond the limitations of mental models inherent in human thought. Moreover, the optimization of the measurement-model interplay depends, critically, on finding the right sensor for the needs of the model, and conversely, the right model for the capabilities of the sensor.



The heart of ubiquitous sensing lies in the connection between model and measurement.

Integrating multiple models and multiple sensors into a functional network that operates in real or near-real time is the key challenge, as shown schematically in the figure below:



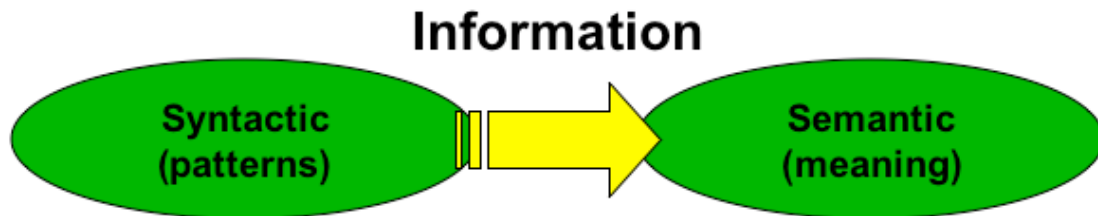
Schematic of the flow from the physical/socio/technical world, through information, to model and decision.

The missing links needed to instantiate the vision illustrated above include sensors that can be placed in sufficient numbers to yield decisive results in real time, sensor cueing and placement that responds to model needs, information integration that is driven semantically (i.e., by contextual meaning, rather than merely by structure), and multi-scale, multi-resolution, multi-formalism models.

More detailed challenges: Significant research and development challenges are found in the sensor, information, and modeling & simulation domains.

Sensors: At the top level, sensors need to be small, fast, specific, affordable, autonomous, and easily interfaced within a system. These sensors must permit integration into a network, rather than being limited to standalone operation.

Information: On the information front, we need to integrate data from disparate sources such as text, images, signals, and nuclear measurement. Such heterogeneous data integration requires analysis of data beyond the syntactic level, *i.e.* driven largely by the internal structure of the data. We must work at the semantic level, where we are driven by the meaning of the data in a broader context, as suggested by the graphic below:



To take its next steps, information integration must move from the syntactic to the semantic.

Acknowledgements: We would like to credit the following leaders of the Ubiquitous Sensing component of the Los Alamos Grand Challenges workshop, October 2006: plenary speakers James Theiler and Jim Smith, and discussion group chairs Basil Swanson, Jeff Bloch, Eleanor Dixon, Cynthia Mahan, Ed McKigney, Nick Hengartner, Ed McKerrow, Cliff Joslyn, David Izraelevitz, and Dave Forslund.