Diagramming notations form an integral part of the “language” of IT practice and have done since the earliest beginnings of the field. They are used at all levels of IT practice, from strategic planning down to integrated circuit design. It is hard to think of any area of IT practice where diagramming notations don’t play a central role: for example, UML in software engineering, BPMN in business process management, PERT charts in project management. They play a particularly critical role in communicating with business stakeholders (end users and customers) because of their ability to present complex ideas in a simple way.

Currently, IT diagramming notations are designed in a way that has more in common with black magic than reasoned thought. Symbols are defined without any explanation as to why they were chosen or the alternatives considered: the reasons for choosing particular symbols are generally shrouded in mystery. There is also a lack of explicit principles for designing diagramming notations, with the result that notation designers have to fall back on intuition and common sense, which is unreliable: the effects of graphic design choices are often counterintuitive and our instincts can lead us wildly astray.

As a result, most IT diagramming notations violate some of the most basic principles about how the human visual system works and often act as a barrier rather than an aid to communication, especially with business stakeholders. Also, by using only a limited repertoire of graphical techniques, they fail to exploit the potential power of diagrams. Some of the most powerful graphical techniques (e.g., spatial location, colour) are rarely, if ever, used in IT diagramming notations.

Diagramming notations play a central role in all engineering and design disciplines, but currently we lack sound principles for designing them.

The goal of this tutorial is to establish a scientific basis for diagramming notation design: to help it progress from an art into a science. It defines a set of principles for designing cogni-
tively effective diagramming notations: notations that are optimised for processing by the human mind. Importantly, the design principles are evidence-based: they are not based on common sense, experience or opinion but on theory and empirical evidence about how our visual systems work. Together they provide a scientific basis for constructing diagramming notations, which has previously been lacking in the IT field.

The principles have been successfully used to evaluate and improve several modelling notations as well as design notations from first principles. They have recently been proposed as an international standard for designing diagramming notations across engineering disciplines, so could have implications beyond the IT field.

The tutorial challenges some longstanding assumptions about how diagramming notations should be designed and how they have been since the earliest beginnings of the IT field. It identifies serious design flaws in some of the leading notations used in IT practice (e.g. UML, BPMN), together with some simple and practical ways of improving them. It also defines a way of measuring the effectiveness of diagramming notations and for testing them prior to their release (analogous to user acceptance testing for software systems).

### Learning objectives

At the end of the tutorial, participants will be able to:

- Design diagramming notations in a systematic, evidence-based manner.
- Justify choice of symbols with reference to known principles about how our visual systems work.
- Conduct studies to evaluate the usability and effectiveness of notations.

### Presenter background

Daniel Moody is a Director of Ozemantics, a Sydney-based information management consultancy firm. He is recognised as one of Australia’s leading experts in data modelling and information management and has an international reputation in these fields. He holds a doctorate in Information Systems from the University of Melbourne and has held senior positions in some of Australia’s leading corporations and consultancy firms. He has conducted consulting assignments in 12 different countries, covering a broad range of industries. He has also published over 100 scientific papers, been a keynote speaker 9 times and chaired several international conferences. He was the inaugural President of the Australian Data Management Association (DAMA), former Vice-President on the DAMA International Board and is listed in Who’s Who in Science and Engineering. He has lived in 8 different countries, speaks fluent English and can say “hello”, “thank you” and “cheers” in at least 10 different languages.

### Structure and content

The structure of the tutorial is summarised in the mind map below:
1. **What is a “good” diagramming notation?**

This looks at how diagramming notations are used in IT practice and why. It defines what a “good” diagramming notation is (the design goal) and how to measure this.

2. **The Art of Diagramming Notation Design: Current Practice**

This looks at current practice in designing IT diagramming notations. It analyses some of the leading diagramming notations used in the IT field and practices of the leading notation designers (i.e. what the experts do). The conclusion is that radical change is needed to current design practices to produce effective diagramming notations.

3. **The Theory of Diagramming Notation Design: How Diagramming Notations Communicate**

This explains how and why diagramming notations communicate, with reference to theories of communication, graphic design, visual perception and cognition. Only by understanding how diagramming notations communicate can we improve their ability to communicate. The theory also enables us to explain and predict why some diagramming notations are more effective than others.

4. **The Science of Diagramming Notation Design: Principles for Effective Diagramming Notations**

This is the main practical content of the tutorial, and describes 9 principles for producing effective diagramming notations:

- **Principle of Semiotic Clarity:** there should be a one to one correspondence between concepts and graphical symbols
- **Principle of Perceptual Discriminability:** symbols should be clearly distinguishable from one another
- **Principle of Semantic Transparency:** use symbols whose appearance suggests their meaning
- **Principle of Complexity Management:** include explicit mechanisms for dealing with complexity
- **Principle of Cognitive Integration:** include explicit mechanisms for integrating separate diagrams together
- **Principle of Visual Expressiveness:** use the full range of visual variables (fully utilise the graphic design space)
- **Principle of Dual Coding:** use text to reinforce and complement graphics
- **Principle of Graphic Economy:** the number of graphical symbols should be cognitively manageable
- **Principle of Cognitive Fit:** use different visual representations for different tasks and audiences (visual horses for cognitive courses)
- **Trade-offs and synergies:** understanding interactions among principles

5. **Conclusion: A Manifesto for Diagramming Notation Design**

This reviews and summarises all the material covered and concludes with a “manifesto” for designing effective diagramming notations.

### Intended audience

The tutorial is aimed at:

- Notation designers (e.g. members of OMG taskforces involved in designing or revising diagramming notations): it defines practical guidelines for constructing effective diagramming notations and improving existing ones.
- Tool vendors: it provides the basis for providing enhanced tool support for diagramming notations, incorporating advanced graphical capabilities.

### Previous presentations

This tutorial has previously been presented at some of the most prestigious conferences in the IT field and has received rave reviews from participants (90-100% ratings for both content and presentation quality). These include:

- International Conference on Model Driven Engineering Languages & Systems (MODELS: formerly called the UML conference)
- IEEE International Conferences on Requirements Engineering (RE)
- International Conference on Business Process Management (BPM)
- International Conference on Software Engineering (ICSE)
- IEEE Symposium on Visual Languages and Human Centric Computing (VL/HCC)
- International Conference on Advanced Information Systems Engineering (CAiSE).
- International Conference on Conceptual Modelling (ER)
- Australian Software Engineering Conference (ASWEC)
The “Physics” of Notations
Towards a Scientific Basis for Designing Visual Notations in Requirements Engineering

Visual language is one of the oldest forms of knowledge representation
Language for the eye

Visual notations form an integral part of the language of IT practice

Unselfconscious design culture
★ Instinct, imitation, tradition
★ Inability to explain designs
★ Lack of variety


There must be another way...
“Here is Winnie-the-Pooh coming downstairs, bump, bump, bump on the back of his head. It is, as far as he knows, the only way of coming downstairs, but sometimes he feels that there really is another way, if only he could stop bumping for a moment to think of it...”

The Design Space (encoding side): The Symbol System of Graphics


Perceptual Distortion

The Physics of Notations: A Theory for Visual Notation Design
Scientific basis for evaluating, comparing, improving, and designing visual notations

1. Principle of Semiotic Clarity

Onomatopoeia: form → content

Semiotic Clarity Analysis Summary (UML)

Perceptual discriminability in action

“The Magical Number Seven, Plus or Minus Two”

Visual Distance

Cognitive Integration Theory


Source: Miller, G. A. (1956). The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information. The Psychological Review, 63, 81-97.

5/6: Principles for Visual Notation Design

Visual expressiveness

- Information carrying variables
- Free variables (degrees of visual freedom)
- Non-graphical
- Visual Saturation

Visual Expressiveness of UML

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Dual Coding

- Graphics and text should not be enemies

Representation medium (or production method)

The Graphic Design Space

- Horizontal Position (x)
- Vertical Position (y)
- Shape
- Orientation
- Size
- Texture
- Colour
- Brightness

Notational Darwinism

- Somewhere, something went terribly wrong

Colourising diagrams

A Manifesto for Designing Effective Visual Notations