Progress in Natural Language and Knowledge Representation

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(presented by Eduard Hovy)

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Even VHUMANs mature…

- **MRE and SASO: We have built a very sophisticated VHUMAN:**
  - Most innovative design and most complex internal structure in the research literature
  - Powerful capabilities of each module plus rich internal interconnections provide system's flexible and reactive behavior
- **But: the system has been experimental and exploratory**

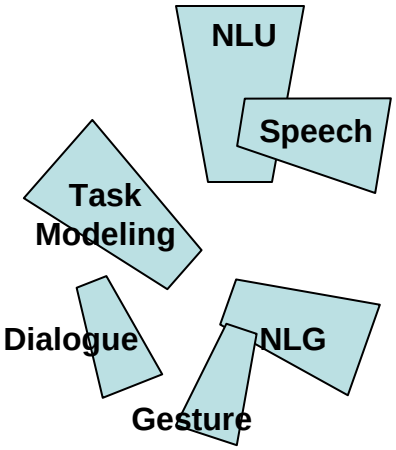
- **Recently, our work has started to mature…**
  - We want to be able to **extend** the system (e.g., add new agents) **rapidly**
  - We want to **create new scenarios** easily
  - We would like to **enable other people** to build scenarios
  - Many of our **modules** are beginning to be **used in other projects**

- **This is typical R&D evolution: idea → pilot → prototype → re-use → distribution**

- **So… We are re-engineering and centralizing much of the infrastructure to make cross-module growth and changes easy and consistent**

Current state of affairs

- **Problem: A Babel inside the system:**
  - *N* major modules … each performing a different function
  - BUT each has its own different internal representation terms and modeling style
  - Why?
    - We started with some advanced legacy systems — building everything fresh would have taken too long
    - Each module is pushing the state of the art in its own research field — there's no reason their representations and methods should correspond



- **This makes it a LOT of work to extend functionality that crosses modules:**
  - For example, you can add new words to NLU, but that doesn't mean that NLG knows the words!

- **Desiderata for 'one-shot extensibility'**
  - Should be easy to build new knowledge
  - New additions should be made consistent, also with existing knowledge
  - Knowledge should be compositional: new knowledge should plug into older knowledge
  - Knowledge should be used by all modules in the same ways

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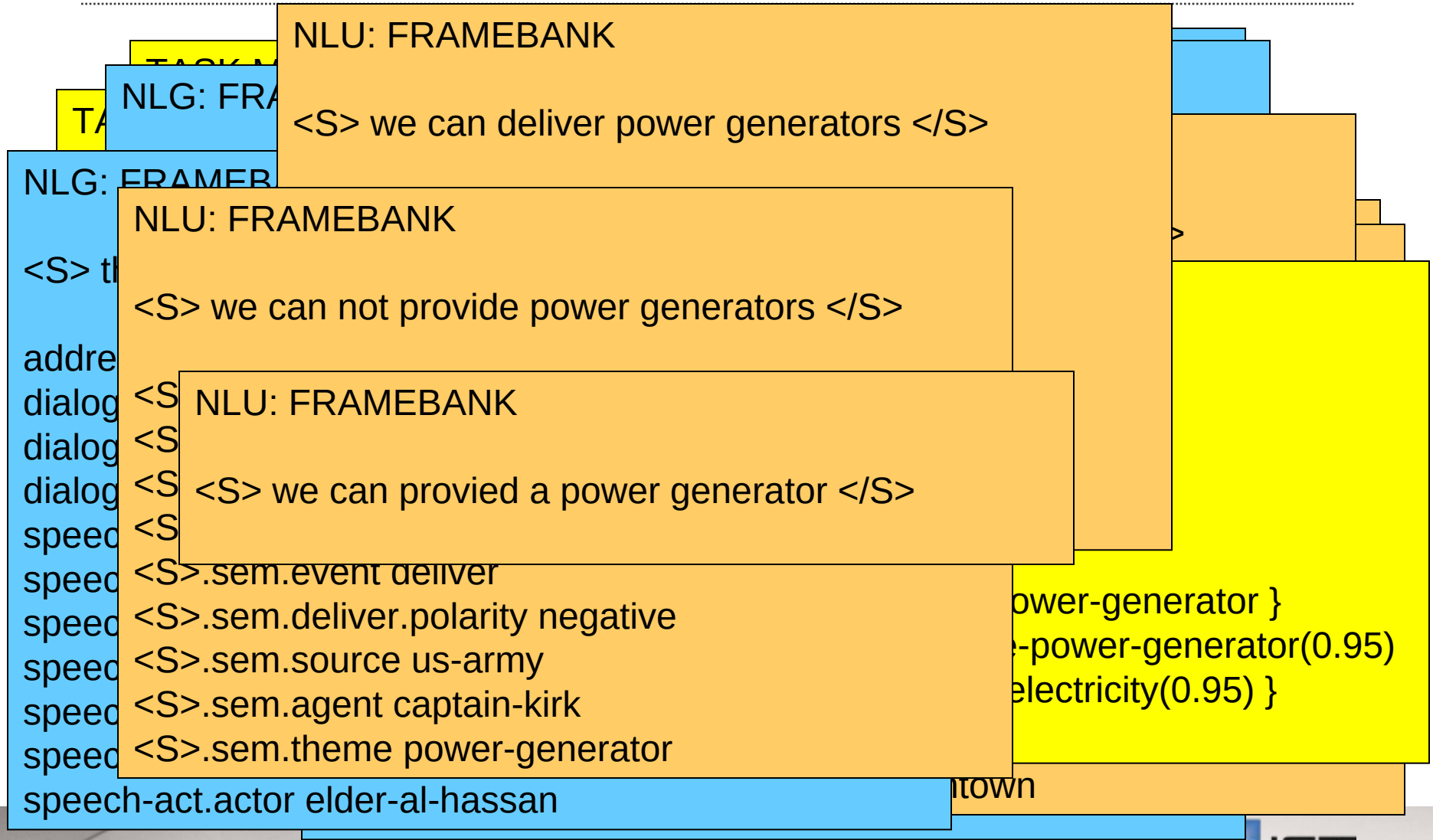
Example: Extending the system

- **Want to add new line of negotiation:**
  - EXISTING: Doctor can negotiate for delivery of medical supplies downtown
  - NEW: Want Elder to negotiate delivery of power generator downtown
  - So: Elder needs to know
    - Task model module: Define “deliver” action, its preconditions, effects, dependencies on other entities:
      - Operating the clinic downtown requires power
      - Having power downtown would be a good thing
      - Precondition for power is a power generator
      - There isn’t one today, so it has to be obtained and delivered
      - etc.
    - NLU and NLG and Speech modules:
      - Lexicons: Words for “power generator”, “deliver”, “need”, etc.
      - Grammars: Patterns and phases using these words that can accommodate the negotiation
      - Semantics: Representation frames that represent these concepts
- **Currently this is hard to do: even though the Doctor knows all this, the Elder doesn’t, and his various modules must *each* be extended**

Example: Adding new knowledge (old method)



Example: Adding knowledge for NLU

- **Of course we create tools and interfaces to speed up system extension**
- **Still, it can be a lot of work to add the knowledge needed for NLU:**
  - Define the words
  - Define the representation frame elements
  - Link them together
  - Ensure that they integrate with everything else

QuickTime™ and a
H.264 decompressor
are needed to see this picture.

Today: Extending NLG, using auto-generation

- **Evolved specialized procedure to facilitate extensions:**
  - Builder adds knowledge for one new phrase
  - System automatically creates variations, using grammar
- **For NLG, sequence is:**
  - Want to say “power generator”
  - Generator can’t produce sentence
  - Addition interface: provide needed knowledge (yes, it’s ugly!)
  - Back to NLG: now produces sentence
  - …AND: its auto-extension produces six more variations for free!
  - BUT: this is not yet centralized, not exported to NLU…

Extending NLG: Before addition

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Extending NLG: Making addition

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Extending NLG: After addition

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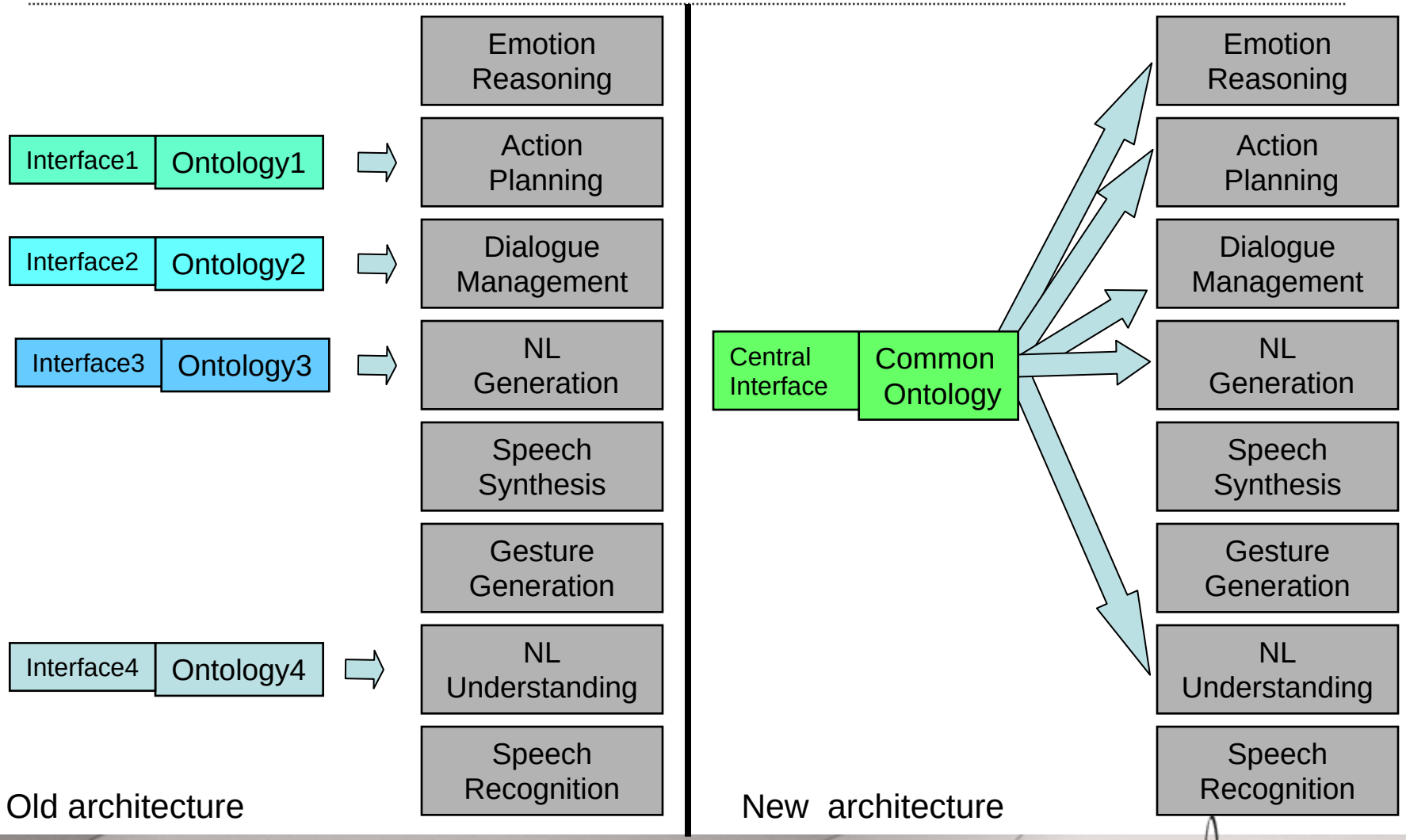
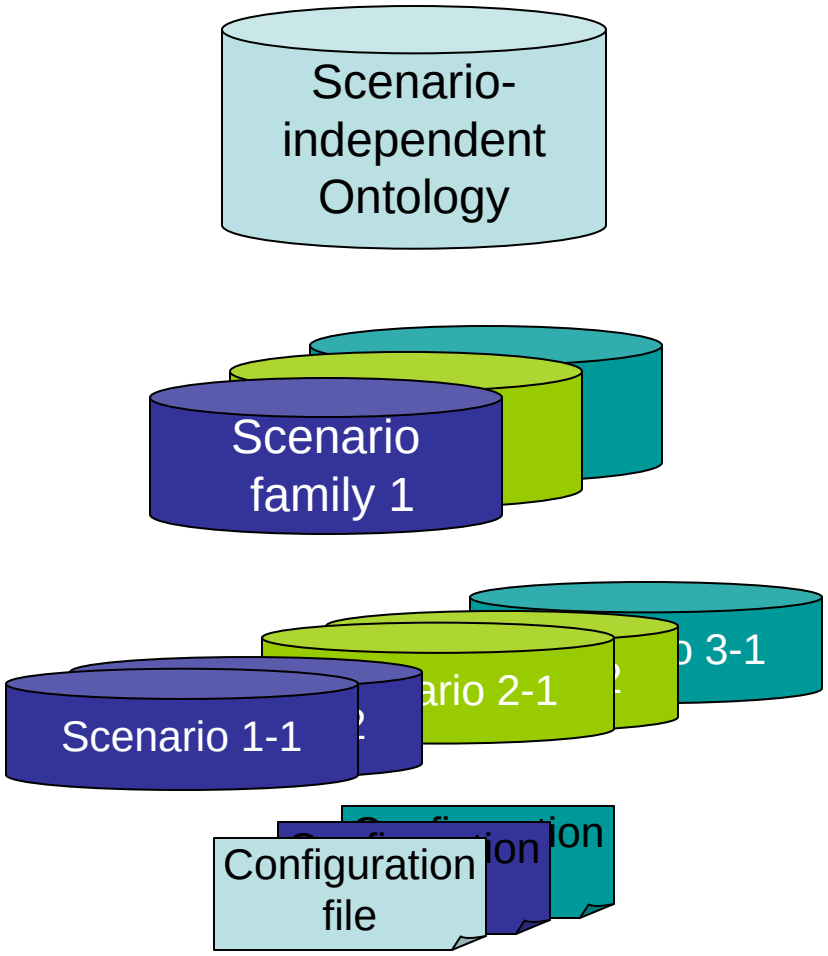
Where are we going? A centralized framework

- **A single central ontology of terms:**
  - Standardizes all the terms used by all modules
  - Makes explicit most of the detailed knowledge currently held by experts
- **A single content-building/checking interface (Protégé, from Stanford):**
  - Provides a single point of entry of all necessary info, all related
  - Supports a scripted series of content-building steps, during which the interface requests different related kinds of info (as needed for each module)
- **Automated internal consistency checking**
- **Automated content enhancer/exporter functions:**
  - Automatically inherits required info from ontology and fleshes out new input material
  - Automatically converts fleshed-out input into formats used by various modules

Old and new architecture



New ontology organization



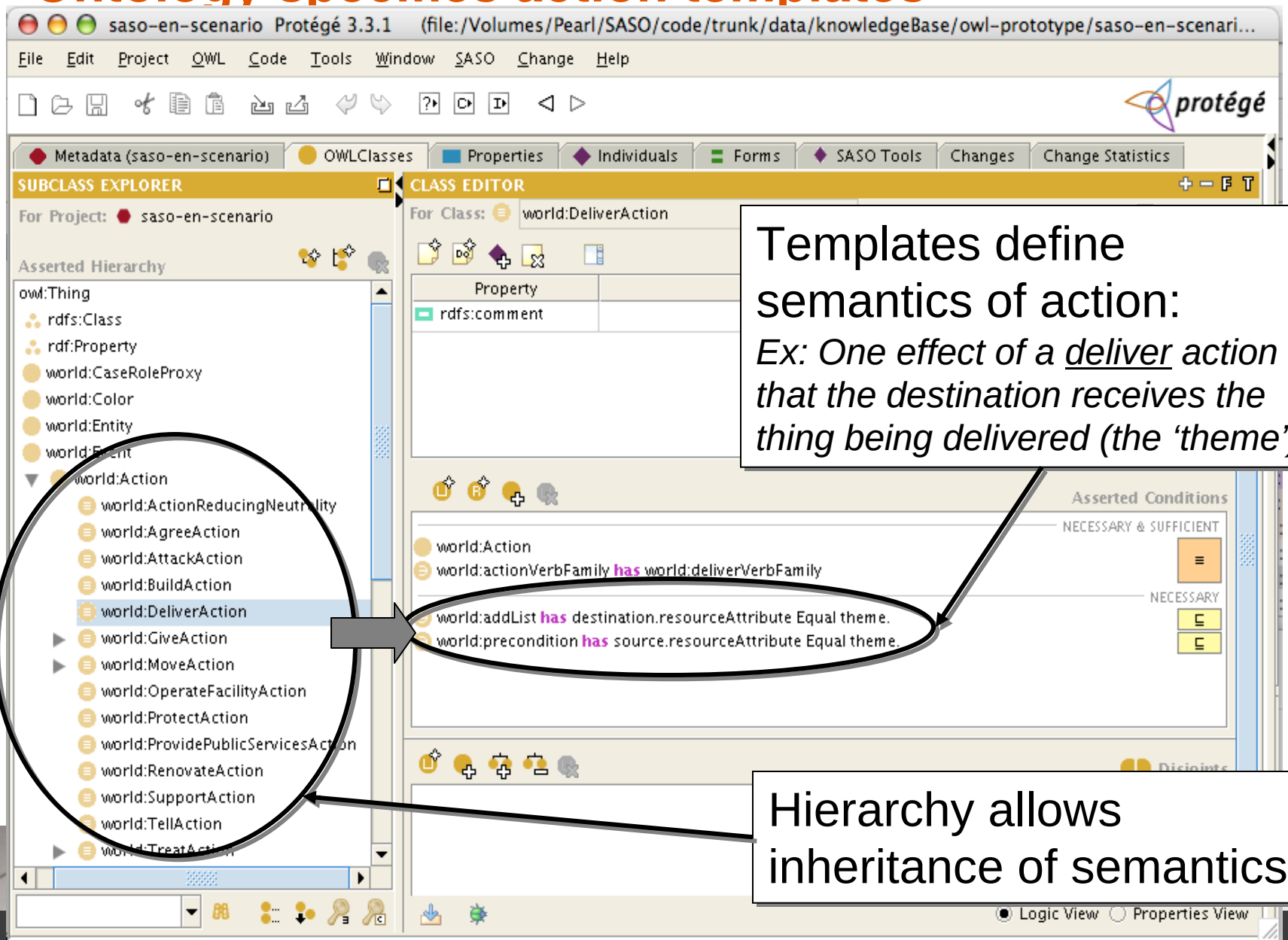
- General world knowledge
  - (generic actions, objects…)
- Linguistic structures
- Generic dialogue items

- Scenario actor classes
- Scenario action templates
  - (generic preconds, effects...)
- Propositions for scenario

- Specific actors, locations, etc.
- Sentences for scenario

- Actor positions, attitudes, etc.
- Simulation initialization

Ontology specifies action templates

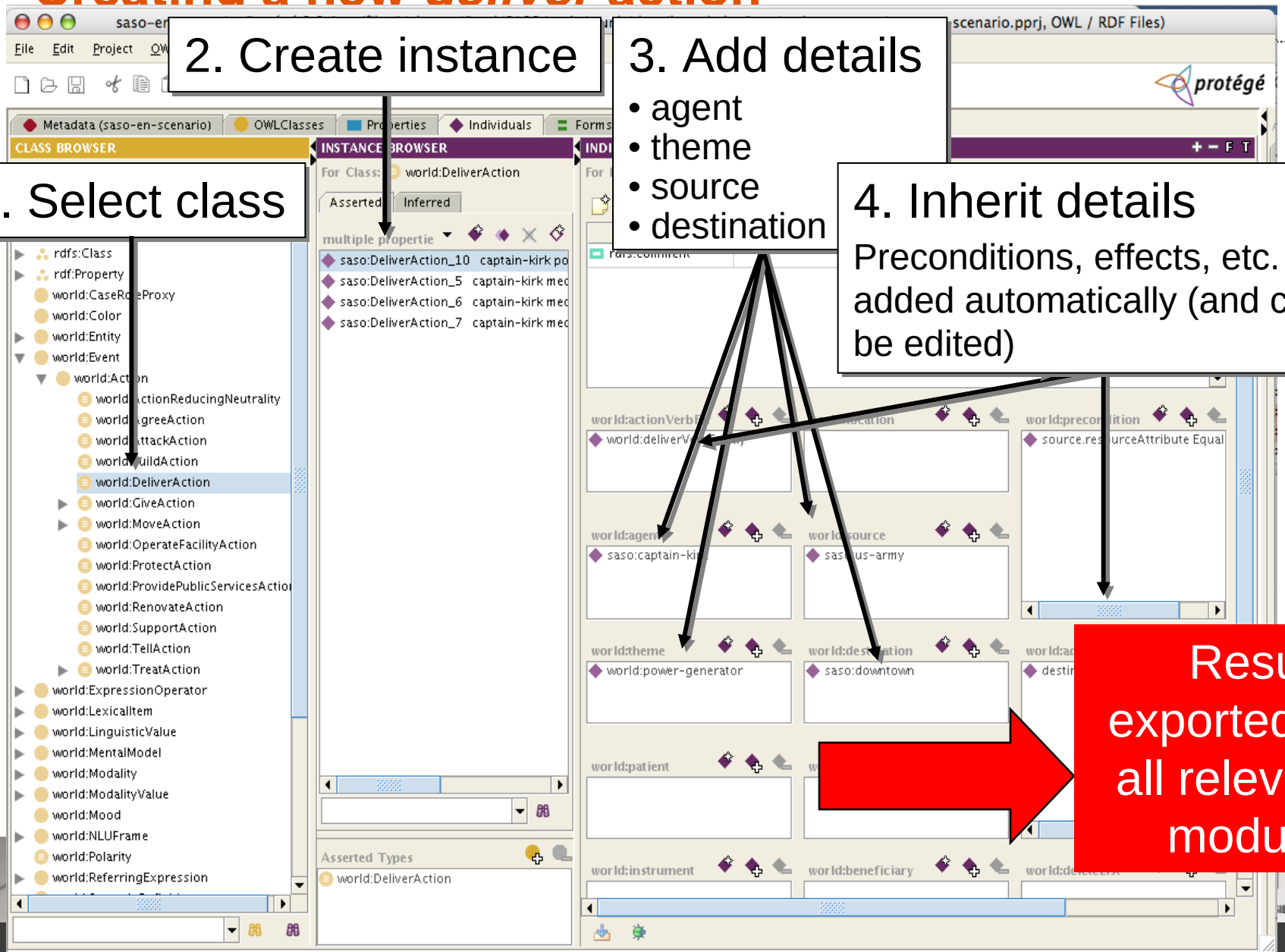


Templates define semantics of action:

Ex: One effect of a deliver action is that the destination receives the thing being delivered (the 'theme')

Hierarchy allows inheritance of semantics

Creating a new *deliver* action



Templates simplify adding *deliver*

Old method

Create new Deliver action instance
Specify agent = “CaptainKirk”
Specify theme = “power-generator”
Specify source = “us-army”
Specify destination = “downtown”

Create state “downtown-has-power-generator”
Create task model “downtown-has-power-generator”

Specify belief
Specify initial-value
Create state “us-army-has-power-generator”
Create task model “us-army-has-power-generator”
Specify belief
Specify probability
Specify initial-value

Create new task instance
Specify ground event is the deliver action instance
Specify precondition “us-army-has-power-generator”
Specify add-effect “downtown-has-power-generator”

New centralized method

Create new Deliver action instance
Specify agent = “CaptainKirk”
Specify theme = “power-generator”
Specify source = “us-army”
Specify destination = “downtown”

Create state “downtown-has-power-generator”
Create task model state
“downtown-has-power-generator”
Specify belief

Create new task instance
Specify ground event is the deliver action instance

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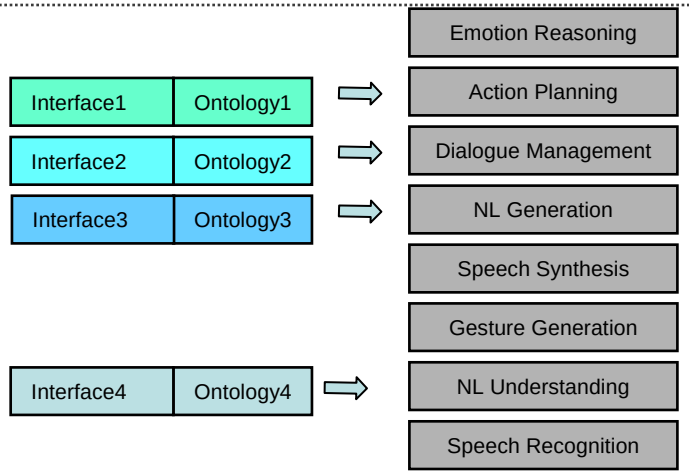
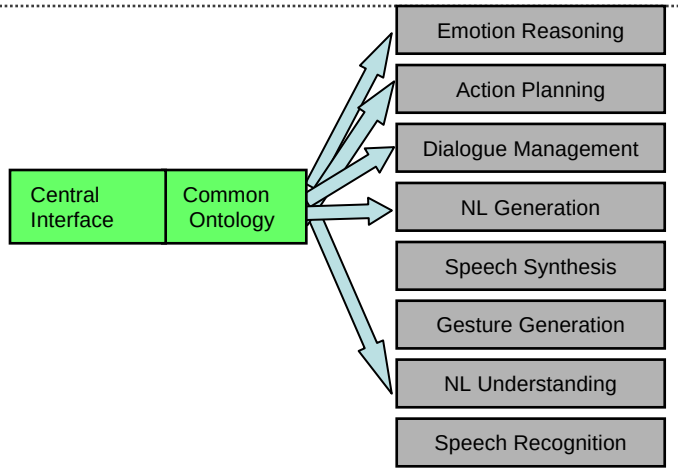
Work required: The old and the new





- **In the past: system builder**
  - identify core problem,
  - locate problem in each module,
  - design all fix/extension(s),
  - implement change(s) in each module,
  - coordinate change across modules,
  - perform extensive tests,
  - perform cross-module debugging.

- **In the future: system builder**
  - identify core problem,
  - design fix/extension,
  - implement change in central repository, letting tools perform consistency check
  - perform final tests and one-shot centralized debugging.

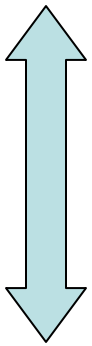
Where next?

- **We're partway through the work…**
  - Completed central standard ontology
    - Using Stanford's Protégé for content building
    - Using Protégé's interface for ontology access/browsing
    - Using OWL (Semantic Web) representation formalism
    - Used some concepts from various upper-level ontologies, such as SUMO and Omega
  - Completed exporter functions to some modules
- **To be done in coming year:**
  - Integrating other modules (incl. additional exporter functions)
  - Completing consistency and integrity testing routines
  - Completing authoring environment: Extending interfaces to support specialized authoring
  - Exploring software 'props warehouses' for new scenarios:
    - Repository of objects, standard actions, desires, plans, locations, etc.
    - Everything connected to ontology

Research contribution

- **Integrated ontology-driven extensibility facilitates:**
  - Rapid authoring of new scenarios, new capabilities, new agents
  - Reduction of error, making expert knowledge explicit, etc. --- Integration, consistency checking, etc.
  - Flexible planning and scripting of training alternatives
- **But…this work is not just plumbing!**

- **We want to enable non-CS people to author new scenarios…so we're investigating the optimal point in the tradeoff between**
  - Programming for Non-Experts:
    - Reduced, simple, scripting languages
    - BUT limited in functionality
    - Ex.: Sgt Blackwell internal details
  - Powertools for Experts:
    - High functionality
    - BUT need considerable expertise
    - Ex.: VHUMAN's TCL, Soar, and other components



Simpler, but limited

More powerful, but complex

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Thank you