

## Communication Breakdown

Verbmobil, a coalition of German university and industry research labs, is on the cutting edge of speech-to-speech research. This chart shows the primary method of Verbmobil's translation system, which can handle conversations about travel and meeting arrangements. The system also uses three other techniques: an example-based system, a statistical probability approach, and a model based on determining the type of "dialog act": scheduling a meeting, canceling a meeting, and so on.

- Matt Steinglass ([mattsteinglass@csi.com](mailto:mattsteinglass@csi.com))

**"Has he got a meeting with Bill in, uh, Hamburg on May fifteenth?"**

### Speech Recognition Modules

**Acoustic Probability Module** Runs the digital waveform through a vast compilation of speech samples to identify the most likely phoneme strings.

**Phonetic Recognition Module** Suggests words by simply guessing at their pronunciation, assigning a probability to each phoneme matchup. Because no two speakers or utterances are exactly alike, the computer can never be 100 percent sure. Filters out nonsense phonemes, like "uh."

### Phonetic Guesses

"Is he got a meeting with Bill in Hamburg on May 15?"

Score: 86

"Has he got a meeting with Bill in Hamburg on May 50?"

Score: 58

"Izzy god a meaty wood built-in hamburger maybe fist teeth?"

Score: 46

"Has he got a meeting with Bill in Hamburg on May 15?"

Score: 35

**Language-Model Module** Tests word-order probability, which measures the likelihood of particular word sequences. The sequence "Is he got," for example, becomes a lot less likely.

### Sentence Guesses

"Has he got a meeting with Bill in Hamburg on May 50?"

Score: 95

Has he got a meeting with Bill in Hamburg on May 15?"

Score: 64

"Is he got a meeting with Bill in Hamburg on May 15?"

Score: 20

"Izzy god a meaty wood built-in hamburger maybe fist teeth?"

Score: 2

**Prosodic Analysis Module** Recognizes rising and falling tones and asks, "Is this sentence a question or a statement? Is there an emphasis on a certain word?" It also hears pauses that segment phrases, enabling it to distinguish, for example, between "Ed said Sue did it" and "Ed, said Sue, did it."

**Syntactic/Semantic Analysis Module** Takes the most probable sentence guess so far - "Has he got a meeting with Bill in Hamburg on May 50?" - and, using four analytical strategies, tries to determine its meaning. Performs the same analyses on the next-most-probable sentence guesses.

**Head-Driven Phrase Structure Grammar:** Arranges the sentence into a structure of heads and subheads. The subject, "He," is the overall head; the object, "meeting," is a subhead; "with Bill," which modifies "meeting," is a sub-subhead; and so on.

**Chunk Analysis:** Divides the sentence into phrases and clauses, determines verb tense, and finds the grammatical relationships between these components.

**Statistical Parser:** Compares hypothetical sentence diagrams for the sentence to a bank of already familiar diagrams of other sentences.

**Semantic Construction:** Using a 10,000-word dictionary optimized for travel speech, the system determines the appropriate meanings for words - so that, for instance, Hamburg is understood as a place.

**Dialog Semantics Module** Combines these different interpretations into one expression in Verbmobil Interface Terms, a language-neutral representation of the sentence's meaning and structure.

**Dialog and Context Evaluation Module** Keeps track of what's happened in the conversation so far. It asks, "Who does 'he' refer to?" It also knows certain things about the real world - chiefly things having to do with travel and meetings. In this case, it knows there's no such thing as May 50. So it switches to the next best sentence guess: "Has he got a meeting with Bill in Hamburg on May 15?"

**German Module** Pulls up the corresponding German words for the Verbmobil Interface Terms.

**Sentence Generation Module** Rearranges the words into a German sentence structure, conjugates verbs, and declines nouns and adjectives.

**Speech Synthesis Module** Reads out the sentence with emphasis on the proper words by consulting content information as well as a phoneme database.

**"Hat er eine Besprechung mit Bill am fünfzehnten Mai in Hamburg?"**