Topics for today

- Architecture of TTS systems
- Festival's Utterance structure:
  - utterances, relations, items and features
- Festival's module structure:
  - breakdown of TTS processes

TTS architecture

- Large systems need structure
- TTS Utterances:
  - representation of words, syllables, phones, etc.
- TTS processes:
  - Lexical lookup, duration prediction,
  - waveform generation

TTS architecture

- Try to make things modular:
  - but there will be dependencies
- Allow swapping of modules:
  - testing different technique in *same* environment
- Don't build-in language specifics:
  - no fixed phoneset
  - allow things to be dynamic
- Have a scripting language:
  - You can't guess all the necessary params
  - So allow the user to control things

Utterance architectures (1)

String model:

– A single string replaced with lower level items

- Tokens
  - *Feb 25*
- Words
  - *february twenty fifth*
- Phones
  - *f eh b r ax r iy t w eh n t iy f ih f th*

Simple, but lose information about higher levels

Utterance architectures (2)

Table model:

– multi-leveled table model

Feb							25									
february							twenty							fifth		
1			0		0	0	1				0		1			
f	eh	b	r	ax	er	iy	t	w	eh	n	t	iy	f	ih	f	th

– no tree structures

– one hierarchy

– no explicit connections between levels

Utterance architectures (3)

Hetrogeneous Relation Graphs:

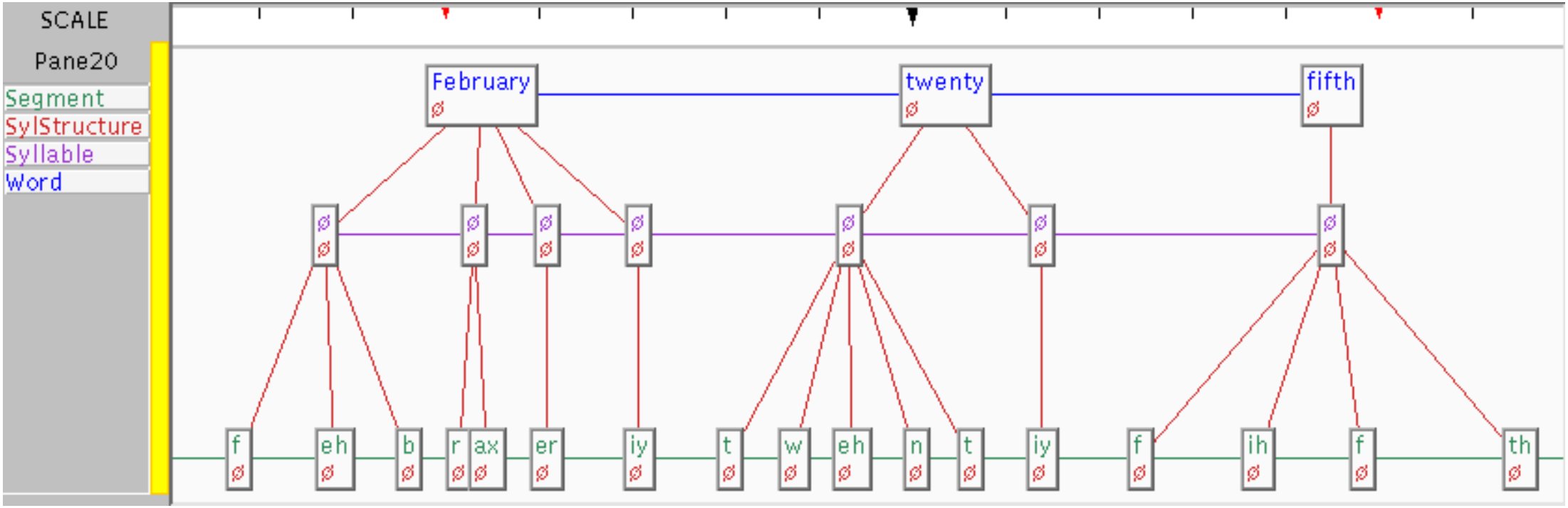
Utterances consist of a set of **items**.

Each **item** is related by one or more **relations**.

Each **item** contains a set of **features**.

Relations define lists, trees or lattices of **items**.

Hetrogeneous Relation Graphs



Items and features

Accessing information in an utterance.

- `(set! utt1 (SayText "The book is on the table"))`
- `(set! firstword (utt.relation.first utt1 'Word)))`
- Part of speech from word
  `(item.feat firstword "pos")`
- First syllable's stress
  `(item.feat firstword`
  `"R:SylStructure.daughter1.stress")`
- Next word's punctuation
  `(item.feat firstword "n.pos")`
- All words and pos in utterance
  `(utt.features utt1 'Word '(name pos))`

Feature access

- clean traversal of the structure allows:
  - feature-based prediction models
  - CART, linear regression, ANN etc.
- For example each item in a Segment relation dump:
  - dur name n.name p.name R:SylStructure.parent.stress ...
  - 0.15 pau dh pau 0
  - 0.08 dh ax pau 0
  - 0.09 ax dh b 0
  - 0.07 b ax oy 1
  - ...

Feature pathnames

- Item based:
  - *always* gives an answer.
  - default value 0
- `( IN-REL-MOVE | NEW-REL-MOVE ) * FEATNAME`
  - `IN-REL-MOVE` := n. p. parent. daughter. ...
  - `NEW-REL-MOVE` := R:RELATIONAME.
  - `FEATNAME` := name pos duration
  - `FEATNAME` := lisp_* ph_*

FEATNAME can also be built-in feature functions

Features and feature functions

- Apply to an items
  - *always* give an answer
- Direct features:
  - pos, name, stress
- Calculated *Feature Functions*:
  - start_duration := if (p == 0) 0 else p.end
  - duration := end - start_duration
  - num_syllables := ...
  - prev_content_word := ...
- Feature Functions :
  - C++ functions (plus registration)
  - Lisp based (slower but good for initial study)

Examples

assume `seg` is an item in the Segment relation

- `name`
  - the name of the segment
- `n.name`, `p.name`
  - names of next and previous segments (or "0")
- `R:SylStructure.parent.stress`
  - the stress marking on the syllable of *seg*
- `R:SylStructure.parent.parent.name`
  - word name
- `n.R:SylStructure.parent.parent.name`
  - word on next segment
- `R:SylStructure.parent.parent.R:Word.n.name`
  - next word

HRG databases

Not just used at synthesis time

- Utterance in speech databases:
  - converted to HRGs
  - (semi-)automatically.
- Have *same* representations as if synthesized:
  - can extract features for modelling
  - can test sub-parts of the system
  - on "natural" data.
- Can hold complex relationships

Festival relations

Different synthesizers in Festival may use different relations
"Standard" relations are

- `Text`: character string of utterance.
- `Token`: list of trees relating tokens to zero or more words. Leaves are in `Word` relation.
- `Word`: a list of words.
- `Phrase`: a list of trees over words.
- `Syntax`: a single tree over words.
- `SylStructure`: list of trees, roots are `Words`, middles are `Syllables`, leafs are `Segments`.
- `Syllable`: a list of syllables.
- `Segment`: a list of phones.

Festival relations

- `IntEvent`: a list of intonation events (accents and boundaries).
- `Intonation`: a list of trees rooted with syllables whose leafs are `IntEvents`.
- `F0`: a single F0 contour (as a track)
- `Unit`: list of diphones
- `Wave`: a single waveform.

Utterances and Modules

Each **Utterances** is declared with a **type**:

Types are declared with a list of **modules**.

Synthesis is defined in terms of the type of an utterances

```
(Utterance Text "Hello")
(Utterance Segment ((h 0.058) (@ 0.039)
           (l 0.069) (ou 0.219)))
```

```
(defUttType Word
     (Initialize utt)
     (Word utt)
     (Intonation utt)
     (Duration utt)
     (Int_Targets utt)
     (Wave_Synth utt))
```

```
(DetUttType Segment
    (Initialize utt)
    (Wave_Synth utt))
```

TTS modules

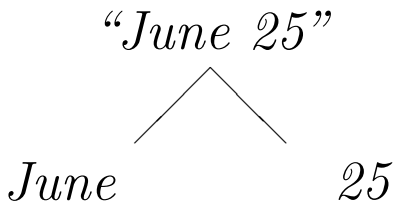
- Text: tokenize strings of chars into tokens.
- Token_POS: identify and tag homographs
- Token: convert Tokens to Words
- POS: part of speech tagger
- Phrasify: statistical phraser.
- Word: lexical lookup, builds Syls and Segs
- Pauses: adds silences
- Intonation: predicts accents and boundaries
- PostLex: post-lexical rules (swha, 's etc)
- Duration: segmental durations
- Int_Target: F0 prediction
- Wave_Synth: waveform generation
  - get_diphones, map_prosody
  - reconstruct waveform (RELPC)

modules *relations*

"June 25" **Text**

modules

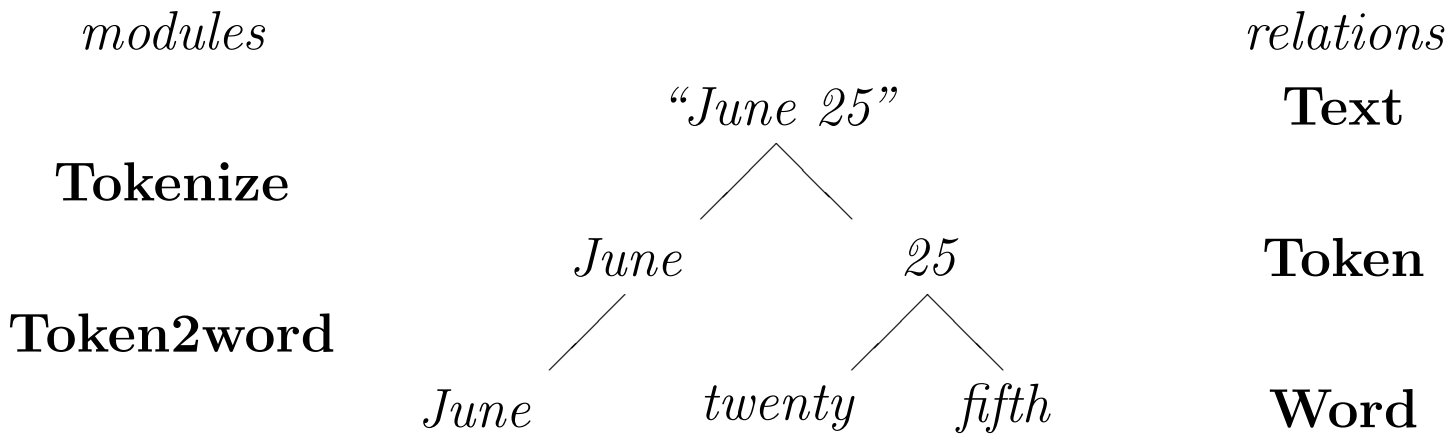
Tokenize

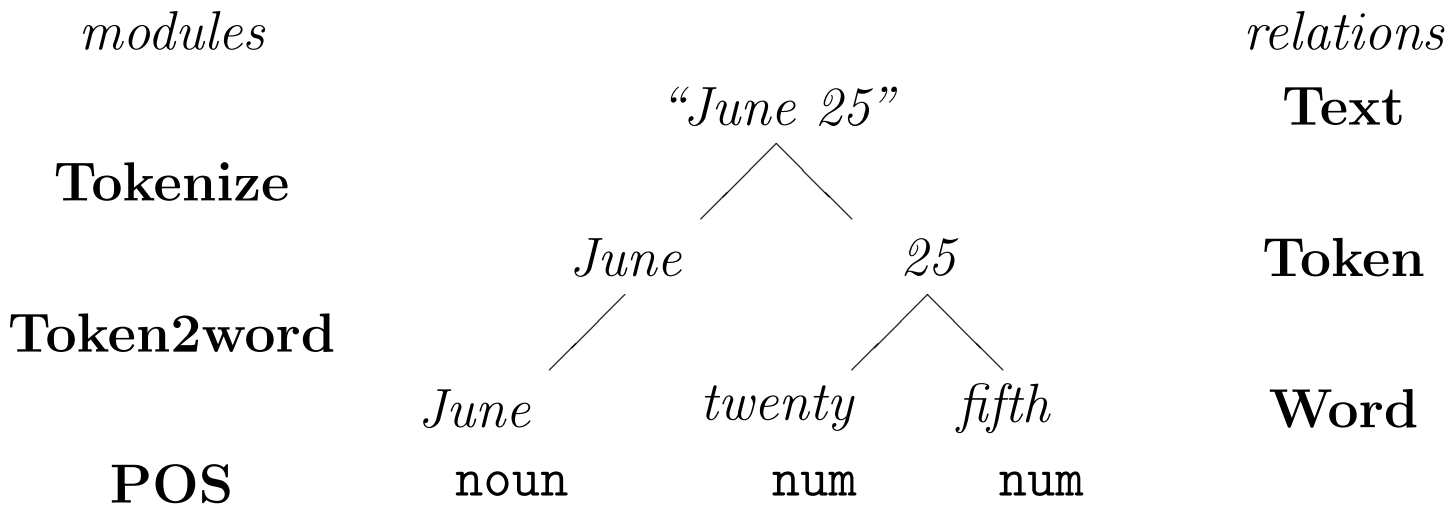


relations

Text

Token


modules
relations
“June 25”
Text
Tokenize
June
25
Token
Token2word
June
twenty
fifth
Word


modules
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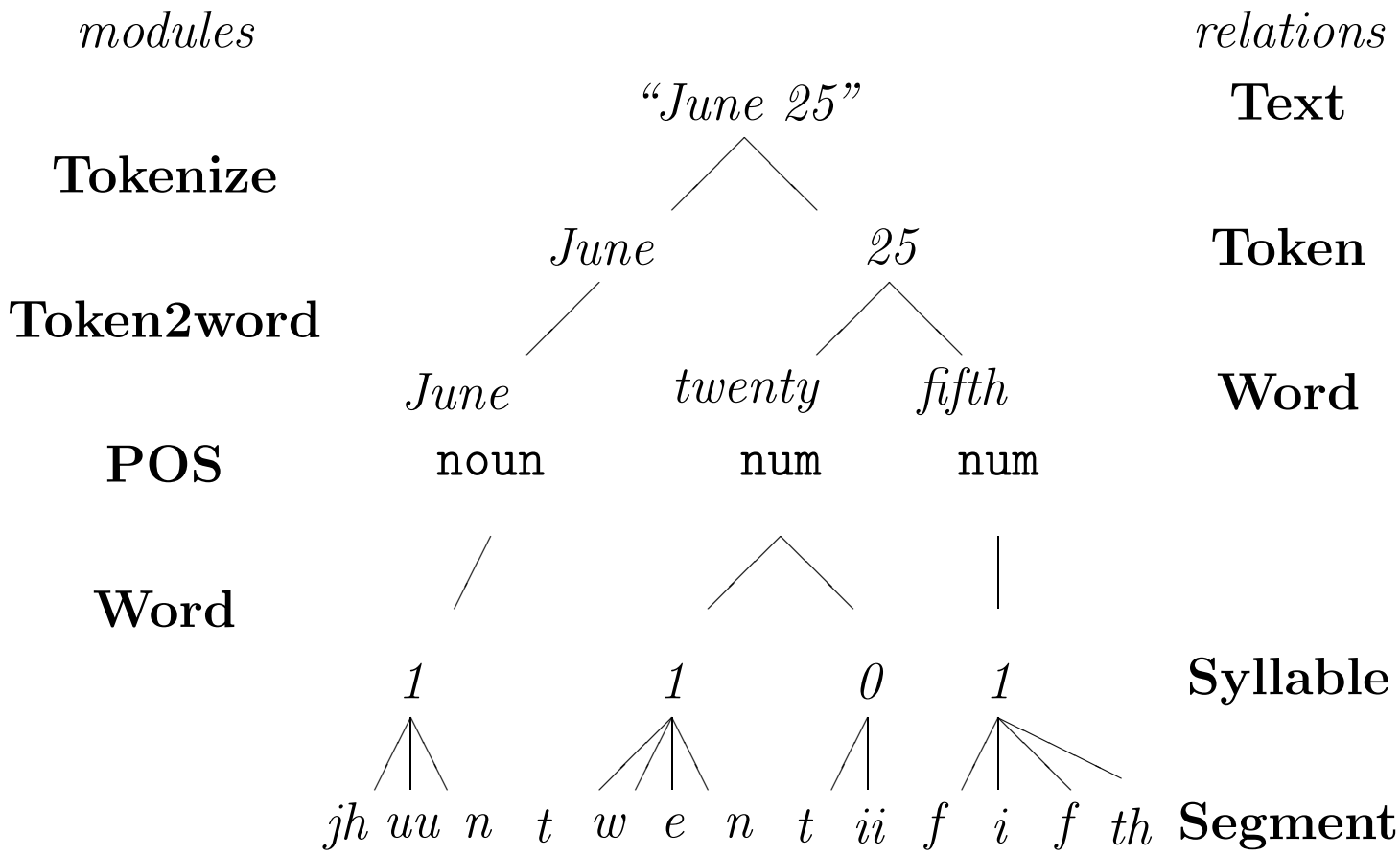
Word
POS
noun
num
num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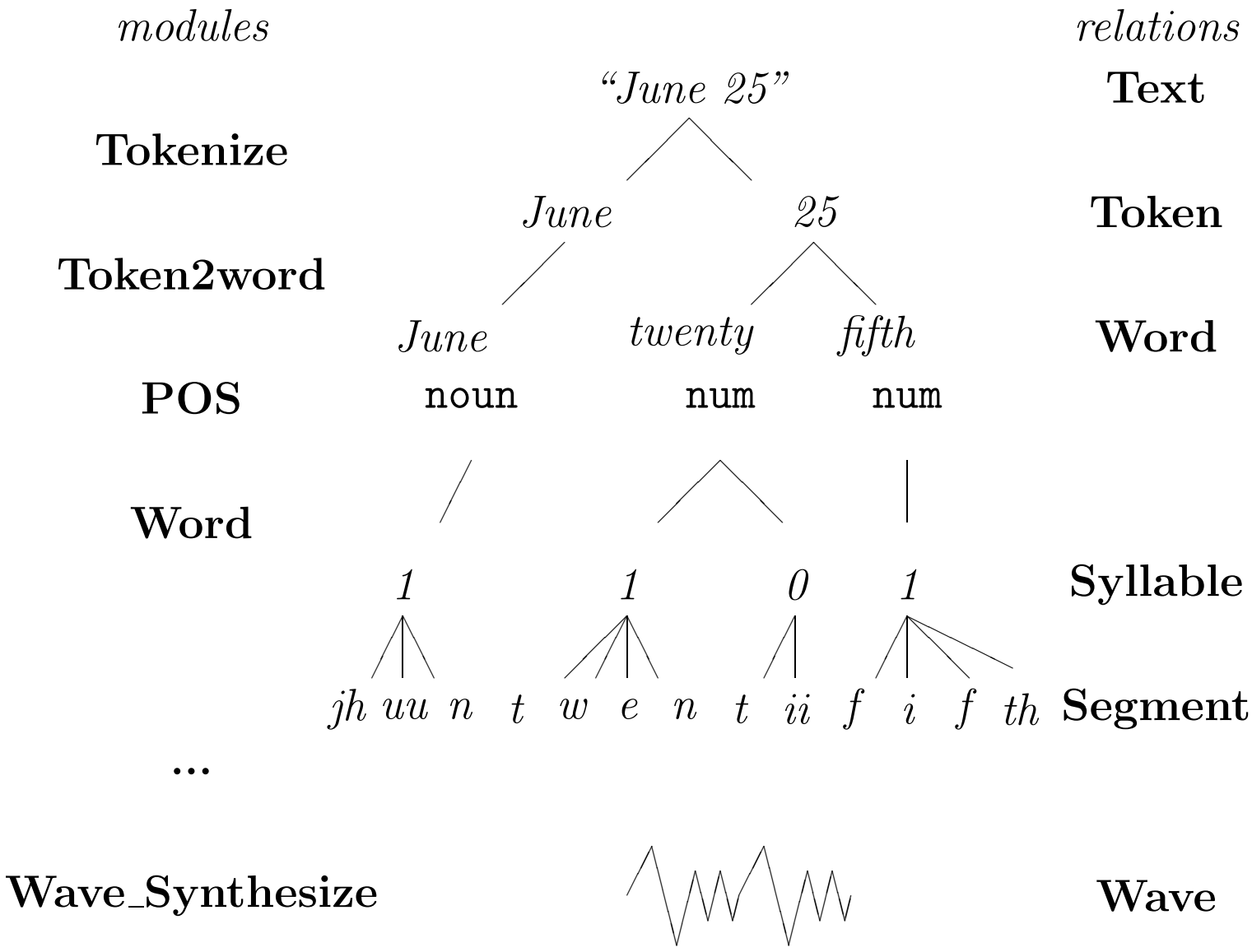
Syllable
jh uu n t w e n t ii f i f th
Segment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jh uu n t w e n t ii f i f th
Segment
...
Wave_Synthesize
Wave