FROM TEXT TO SPEECH
THE MITALK SYSTEM

Presented by
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MORPHOLOGICAL ANALYSIS ALGORITHM

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- The decomposition algorithm consists of three major components
  - A recursive morph partitioning algorithm
  - A set of spelling change rules for use at morph boundaries
  - A set of selectional rules to distinguish between legal and illegal morph sequences and to choose the best morph covering when multiple coverings exist

Recursive Morph Decomposition

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- If this recursive invocation fails to produce covering, then the original match is discarded and the next longest matching morph is used

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- Input to the decomposition procedure consists of
  - A word or remainder to be covered
  - A state flag that indicates which morph types are legal in the current context
  - A score value that is used to rank multiple decompositions

RECURSIVE MORPH DECOMPOSITION

find the longest morph which matches the right end of the current string

WHILE there is a match DO

IF the matching morph is compatible with the current context (state)

THEN remove the matched letters from the right side of the string,

update the current state and score as a function of the type of the matched morph.

find a set of possible spelling changes[1] at the right end of the remainder,

attempt a recursive decomposition for each spelling variation,

save the results of the best-scoring of these variations,

restore the remainder string, state, and score to their original values.

END IF,

find the next longest morph which matches the right end of the string.

END WHILE.

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- PREFIX: a prefix which can combine with roots and other prefixes e.g. pre, dis, mis

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- VOCALIC/NONVOCALIC: depends on whether the suffix begins with a vowel or consonant

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- RF-ROOT: a root which must be preceeded by a prefix e.g. mit in permit, submit, transmit

Legal Morph Sequences

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- The grammar recognized by the FSM is summarized in production rules given

effective-root = ROOT | LF-ROOT DERIV | PREFIX RF-ROOT | STRONG

suffix = DERIV | INFL

affixed-word = { PREFIX } effective-root { suffix }

absolute-word = ABSOLUTE | ABSOLUTE INFL { suffix } | INITIAL affixed-word

word = affixed-word | absolute-word

compound-absolute = absolute-word | absolute-word HYPHEN compound | ABSOLUTE INFL { suffix } compound-affixed

compound-affixed = affixed-word | affixed-word HYPHEN compound | affixed-word compound-affixed

compound = compound-affixed | compound-absolute

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- It is this state which is passed as a parameter to the recursive decomposition procedure

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- Std-root= {PREFIX}{std-root}
  (std-root {ROOT}|STRONG) {INFL}
- Coverings which match this form are to be preferred above all others

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- ROOT + DERIV + DERIV > ROOT + ROOT
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- The covering with lowest cost is the most desirable

RECOGNIZING MORPHOLOGICAL MUTATION

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- After a suffix has been removed from a word it is necessary to investigate possible spelling changes which may have taken place during composition e.g.
  - Y→I (embody-ment → embodiment)
  - Consonant doubling before a vocalic suffix (pad-ing → padding)
  - Dropping silent e before a vocalic suffix (fire-ing → firing)

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- Three categories of morph behavior are defined
  - Required: scar+ed → scarred
  - Forbidden: alloy+ing → alloying
  - Optional: change+able → changeable,
    change+ing → changing

RECOGNIZING MORPHOLOGICAL MUTATION

Recognizing Morphological Mutation

- The spelling changes performed by DECOMP consists of appending or deleting the last letter

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- The spelling changes performed by DECOMP consists of appending or deleting the last letter
- If the matched morph is a vocalic suffix then spelling changes are performed by a three character template against the last two remainder letters and the first letter of the matched morph.

Pattern	Change	Example
ck+.	none	packing → pack+ing
	ck → c	picnicking → picnic+ing
xx+i	none	telling → tell+ing
	xx → x	padding → pad+ing
	xx → xxe	silhouetting → silhouette+ing
xx+.	none	yeller → yell+er
	xx → x	reddest → red+est
e+e	e → ee (+)	freed → free+ed
e+i	none	dyeing → dye+ing
e+.	none	changeable → change+able
i+i	none	skiing → ski+ing
i+e	i → y	noisiest → noisy+est
	i → ie (+)	eeriest → eerie+est
	none	efficient → effici+ent
i+.	i → y	variation → vary+ation
	none	deviate → devi+ate
y+i	none (+)	flying → fly+ing
	y → ye (+)	eying → eye+ing
y+.	none	employer → employ+er
.+i	→ e	daring → dare+ing
	none	showing → show+ing
	→ y (*)	harmonize → harmony+ize
.+.	→ e	observance → observe+ance
	none	sender → send+er

RECOGNIZING MORPHOLOGICAL MUTATION

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- For each possible spelling of the remainder the following steps are performed
  - Make the change
  - Recursively decompose the remainder
  - If a morph matches the right end of the remainder, check its spelling change code to see if it is compatible with the change

```
Decomp: "SCARCITY" [state = word <0> inflectional suffix] =>
Decomp:  Matched "CITY" (root) -- decompose remainder
Decomp:   "SCAR" [state = <101> root] =>
Decomp:    Matched "SCAR" (root) -- decompose remainder
Decomp:     "" [state = <234> root] =>
Decomp:      Matched start of word, final score = 234
Decomp:    Matched "CAR" (root) min. score = 268 -- too expen-
     sive!
Decomp:    Matched "AR" (derivational suffix) min. score = 234
     -- too expensive!
Decomp:  Matched "ITY" (derivational suffix) -- decompose
     remainder
Decomp:   "SCARCE" [state = root <35> derivational suffix] =>
Decomp:    Matched "SCARCE" (root) -- decompose remainder
Decomp:     "" [state = <136> root] =>
Decomp:      Matched start of word, final score = 136
Decomp:   "SCARC" [state = root <35> derivational suffix] =>
Decomp:    Matched "ARC" (root) min. score = 170 -- too expen-
     sive!
Decomp:   "SCARCY" [state = root <35> derivational suffix] =>
Decomp:    Matched "Y" (derivational suffix) min. score = 136 --
     too expensive!
Decomp:  Matched "Y" (derivational suffix) -- decompose
     remainder
Decomp:   "SCARCITE" [state = root <35> derivational suffix] =>
Decomp:    Matched "CITE" (root) min. score = 170 -- too expen-
     sive!
Decomp:   "SCARCIT" [state = root <35> derivational suffix] =>
Decomp:    Matched "IT" (absolute) -- illegal!
DECOMP: SCARCITY                                  word spelling
DECOMP:     NOUN (NUMBER = SINGULAR)              part of speech and features
DECOMP:   =>                                      decomposition follows
DECOMP:     SCARCE [ROOT] :                       first morph spelling and type
DECOMP:         1SKE*RS (ADJECTIVE)               pronunciation and part of speech
DECOMP:     ITY [DERIVATIONAL VOCALIC SUFFIX] :   second morph
DECOMP:         *T-E^ (NOUN)
```

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- Phrase recognition is accomplished via an Augmented Transition Network ATN and the grammars for noun groups and verb group

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- NGR: pronoun(him, several), pronoun with modification(almost anything green), an integer (nearly hundred thousand), a noun phrase up to head noun(his own red and black car) or any of the above preceded by a preposition

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- VBL: verbal group which is either infinitive phrase (to walk slowly) or a participle phrase

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- Output
  - For each node, the number of words covered by that node, the pos of the node, and a property list is given
  - Each word is accompanied by its spelling and pos set
  - For each pos a property list is given

PARTS OF SPEECH

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- The following are the parts of speech of the open class words

VERB (INF TR) (PL TR) = infinitive form of verb

VERB (SING TR) (PL TR) = past tense verb

ADJ = adjective

ADV (VMOD TR) (ADJMOD TR) =
adverb which can modify either an adjective or a verb

ADV (ADJMOD TR) = adverb which can modify an adjective

PREP = preposition

CONJ = conjunction

INTG = integer

INTG (NUM SING) = one

INTG (DEF FL) = integer which requires a (e.g. thousand)

VERBING = present participle

VERBEN = past participle

TO = to

SCONJ = sentential conjunction (e.g. whether)

CONTR = contraction (e.g. 're)

INTERJ = interjection (e.g. oh)

PARTS OF SPEECH PROCESSOR

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- It is based on the Allen’s Preprocessor

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- The current algorithm goes right to left across morphs and uses the part of speech of the rightmost morph for a compound as well as for the cases where there is a suffix
- This is justified by the facts that
  - Suffixes determine the pos of a word with regularity e.g. …ness is a NOUN
  - The POS of compounds is very idiosyncratic and the best heuristic is to use the POS set of the rightmost root

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- The global level reflects the parsing strategy, which has been found to give the best phrases, it is base on three empirical facts
  - There are more noun groups than verb groups
  - The initial portions of noun groups are easier to detect than verb groups. Verb groups frequently begins with the verb itself which often has both NOUN and VERB in its POS set

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- The local level merely interprets the ATN grammar

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- If neither type of group is found the word pointer is simply incremented and the process begins again

The Parser Algorithm

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- There are two pointers, one pointing to the word in the sentence currently being examined and one pointing to the current state in the net
- The parser tries each arc leading from the current state in the order in which they appear in the net

THE PARSER ALGORITHM

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- Testing an arc is done as follows
  - If the arc is JUMP or POP, then the exit routine associated with that arc is tested. If it is successful then
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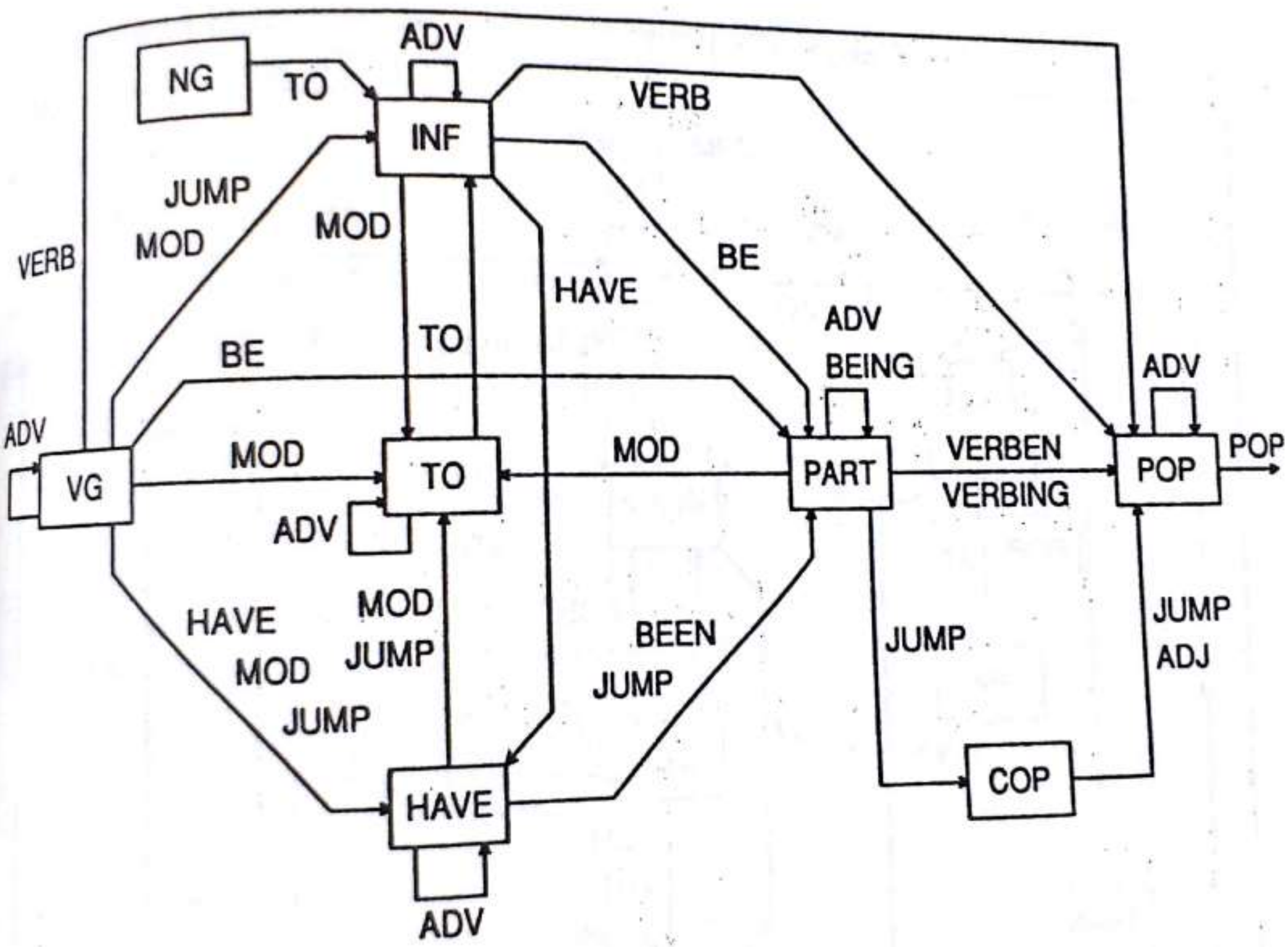
- If the arc is a part of speech and the current word does not have this pos, the parser continues with the next arc


NG
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PART
VERBEN
VERBING
POP
POP
VG
ADV
HAVE
MOD
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JUMP
BEEN
JUMP
JUMP
JUMP
ADJ
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MORPHOPHONEMICS AND STRESS ADJUSTMENTS

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- Module SOUND1 checks for contexts in which such changes occur and changes the pronunciation

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- Input
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- Output
  - The output stream from SOUND1 consists of a string of phonetic segment labels, stress marks and syllable and morph boundaries for each word

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- The following rules are applied to modify morph pronunciations when necessary
- Words which end in ss,zz,sh,zh,ch and jj form their plural and possessives by the concatenation of the segment string IH ZZ or in its vowel reduced form IX ZZ (busses, churches, garages)

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- Preceing e, i, and y the suffix ic is changed from IH KK to IH SS (electricity

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- Suffixes which shift the primary stress in a word such as ee, eer, esce and ation are entered in the lexicon with primary stress
- The stress on any root to which they attach is reduced to secondary (trainee, auctioneer)

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- This comprehensiveness is provided by the letter to sound section of SOUND1
- The letter strings which it receives are converted into stressed phonetic segments strings using two sets of ordered phonological rules

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LETTER TO SOUND AND LEXICAL STRESS

- The first set to be applied converts letters to phonetic segments, first stripping affixes, then converting consonants and finally converting vowels and affixes
- The second set applies an ordered set of rules which determine the stress contour of the segment string

LETTER TO SOUND

- The conversion of a letter string to a phonetic segment string in the letter to sound program proceeds in three stages
- In the first stage prefixes and suffixes are detected
- Suffixes are detected right to left and prefixes are detected left to right

LETTER TO SOUND

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- In the first stage prefixes and suffixes are detected
- Suffixes are detected right to left and

fin+ish+ing		*possible suffix analysis*
ing:	(a)	nominal or verbal suffix
	(b)	follows nominal or verbal suffix
ish:	(a)	adjectival suffix
		parts of speech not compatible
	(b)	follows nominal or adjectival suffix
finish+ing		*correct analysis*

LETTER TO SOUND

- Domain of application:
- The domain of application of the second stage is assumed to be a single-root morph
- This stage is intended for consonant rules and proceeds from left of the string to the right
- Extending the domain to the whole letter again for the third stage, a phonemic representation is given to affixes, vowels and vowel digraphs.
- Phonemic representations are produced by a set of ordered rules in a given context

RULE ORDERING

- Because the pronunciation of consonants is least dependent upon context, phonological rules for consonants are applied first
- Rules for vowels and affixes requiring more specification of environment are applied in the third stage
- Within the sets of rules for conversion of consonants and vowels, ordering proceeds from longer strings to shorter strings (cch then cc, ch)

APPLICATION OF LETTER TO SOUND RULES TO CARIBOU

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Sound1: Stripped   : C  A  R  I  B  O  U      Stage 1
Sound1: Consonants: KK ?? RR ?? BB ?? ??      Stage 2
Sound1: Prefixes   : KK ?? RR ?? BB ?? ??
Sound1: Vowels     : KK AE RR IH BB UW        Stage 3
Sound1: Suffixes   : KK AE RR IH BB UW
 SOUND1:  KK 'AE RR - IX - BB UW
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Thank You