NLP Group Meeting

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2017.01.18

- Lexical Systems Group: http://umlslex.nlm.nih.gov
- The SPECIALIST NLP Tools: http://specialist.nlm.nih.gov
- Intranet: https://lexdev.nlm.nih.gov

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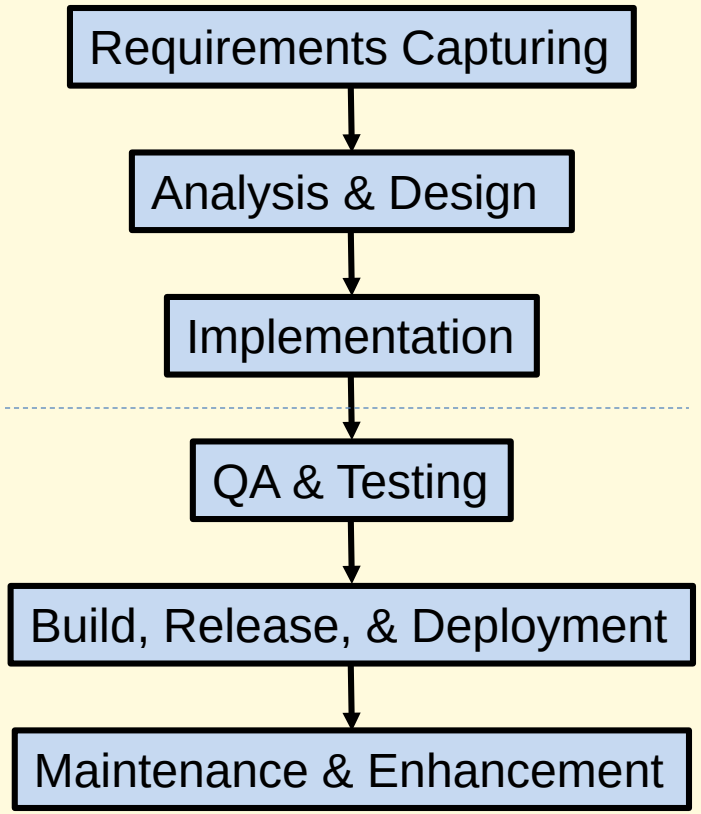
1. Overview: The SPECIALIST Lexicon and NLP Tools

- Lexical Systems Group: http://umlslex.nlm.nih.gov
  SPECIALIST NLP Tools: http://specialist.nlm.nih.gov
- Intranet: https://lexdev.nlm.nih.gov

The SPECIALIST NLP Tools

Life Cycle Development & Task Components



Task Components	Notes
SCR (Software Change Request)	Feature enhancements, bug fixes, library upgrades
Data updates & integration	Lexical Tools, LexAccess, STMT, MNS
Tests	All projects
Documentation	Design doc, user doc, API doc
Release package & backup	Annually & Semi-annually
Web-site & Web tools	All projects
Technical supports	All projects
Presentations	NLM summer Lectures, library associate talks, conferences
New research & development	Paper publications

Projects Maintenance Plan

Category	Descriptions	Projects (13)	Notes
1	Legacy Projects	gSpell, Text Tools, dTagger	Host project website
2	Completed Projects	Numbers, SCRT, VTT, TC	+Limited supports (approval required)
3	Supporting Projects	STMT	+Data updates (with UMLS release)
4	Core Supporting Projects	LB, LC	+Limited SCRs (approval required)
5	Core Projects	Lexicon, Lexical Tools, LexAccess	+Release & supports

The SPECIALIST NLP Tools

LexBuild Process (Computer-Aided)

Sources:

- Word candidates from MEDLINE
- Others
  - Dorland's Illustrated Medical Dictionary
  - American Heritage Word Frequency book (top 10K)
  - Longman's Dictionary of Contemporary English (Top 2K lexical items)
  - The Metathesaurus browser and retrieval system
  - The UMLS test collection
  - …

Reviewed by lexicographers:

- Google Scholar
- Dictionaries
- Biomedical publications
- Domain-specific databases
- Nomenclature guidelines
- books
- Essie Search Engine
- ...

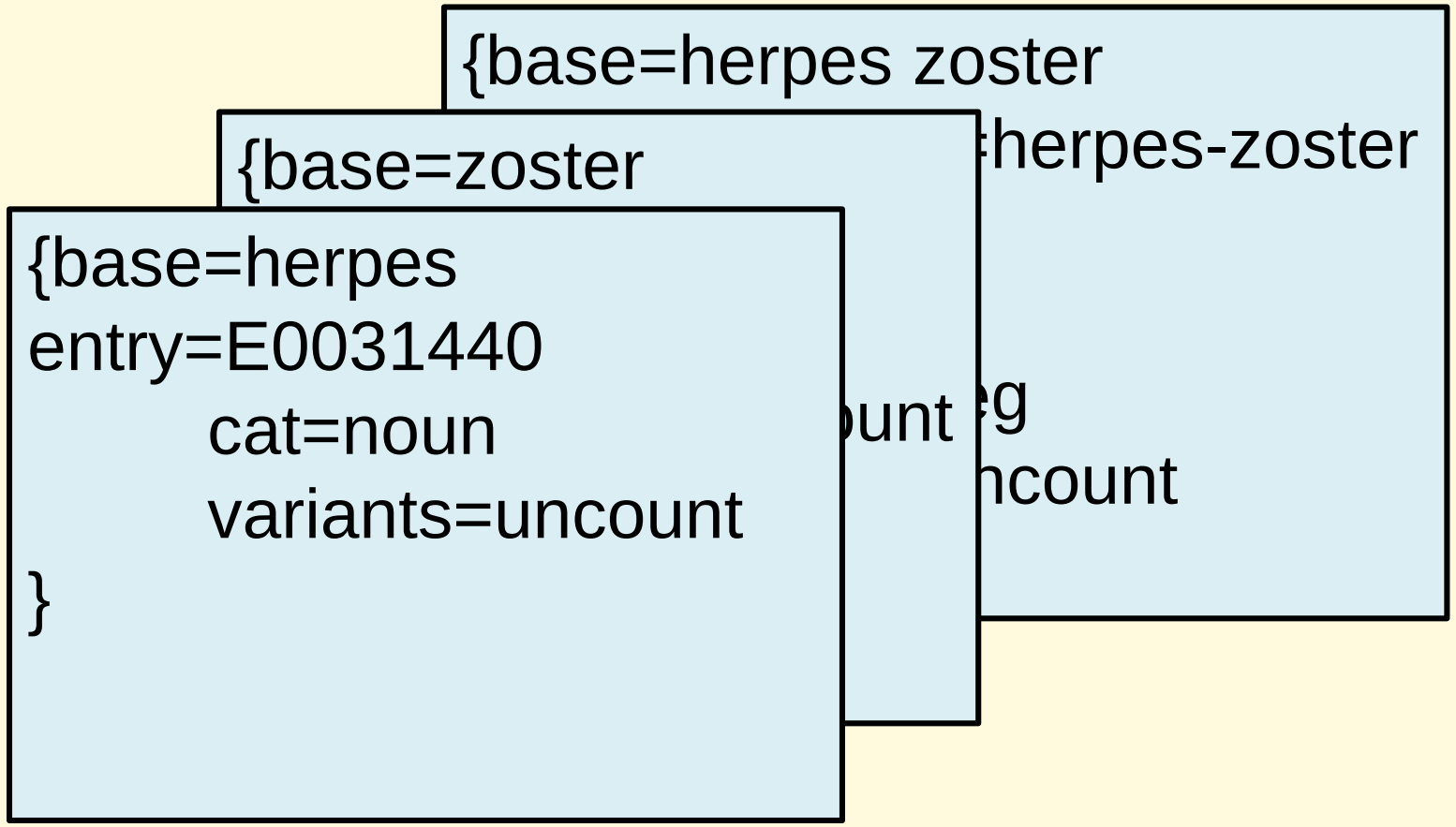
Build:

- **LexBuild**
- **LexAccess**
- **LexCheck**

Lexical Records

```
{base=make
entry=E0038623
        cat=verb
        variants=irreg|make|makes|made|made|making|
        intran;part(off)
        intran;part(out)
        intran;part(up)
        tran=np
        tran=np|headway|
        tran=np|love|
        tran=np|mischief|
        tran=np|merry|
        tran=np|believe|
        tran=np|decision|
        tran=np|it|
        tran=np;part(out)
        tran=np;part(up)
        tran=np;part(over)
        tran=pphr(after,np)
        tran=pphr(with,np);part(away)
        …
        nominalization=decisionmaking|noun|E0021045
        nominalization=lovemaking|noun|E0502721
        nominalization=makeup|noun|E0038625
}
```

Lexical Records



Lexical Information from the Lexical Records

{base=herpes
entry=E0031440
cat=noun
variants=uncount
}

{base=zoster
entry=E0066013
cat=noun
variants=uncount
}

{base=herpes zoster
spelling_variant=herpes-zoster
entry=E0201295
cat=noun
variants=reg
variants=uncount
}

Lexical Information|Base	herpes	zoster	herpes zoster
Part of speech	• noun	• noun	• noun
Inflectional morphology (inflections)	• herpes|1	• zoster|1	• herpes zoster|1 • **herpes zosters|8**
Orthography	• N/A	• N/A	• herpes-zoster
Abbreviation/Acronym	• N/A	• N/A	• N/A
Syntax (complementation)	• N/A	• N/A	• N/A
…	• …	• …	• …
Derivational morphology (derivations)	• **herpetic**	• postzoster • post-zoster	• N/A
LexSynonyms (Element Synonymous words for Query Expansion)	• N/A	• singles • zona • ..	• singles • **zona** • …

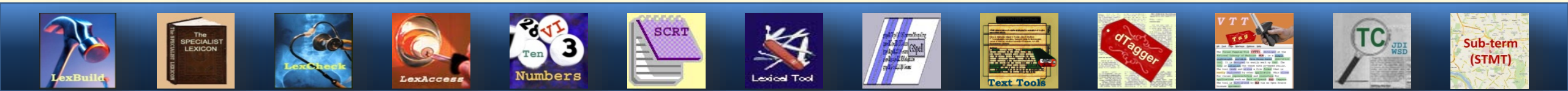
What are Lexicon (Multi)Words?

	Descriptions	Examples
Lexicon words and LexMultiwords (LMWs)	• Inflection morphology • POS • Specific meaning • Word order • **Space(s)**	• herpes zosters • frog erythrocytic virus, cardiac surgery • hot dog • trial and error, exercise training, training exercise, up and down • ice cream (ice-cream)
Non-Words (not in Lexicon)	• (Single) Words does not exist by itself, only exist in multiwords	• non: non drug coated, persona non grata • vitro: in vitro, in vitro diagnostic • vivo: ex vivo, in vivo grown • intra: intra vires, intra articular route • etc.

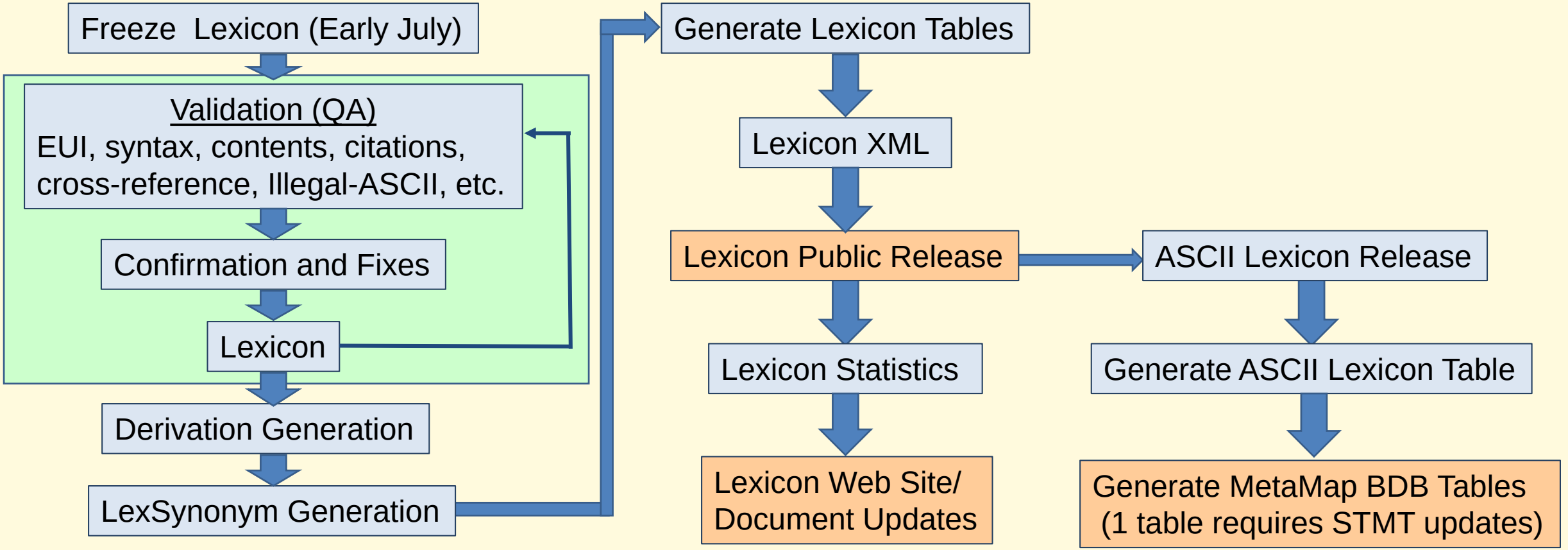
LMW, MWE, UMLS String

	Descriptions	Examples
LMWs and MWE (Overlap)	• Phrasal position • Adverb, adjective • Fixed phrases (non-decomposable)	• because of, due to • face down, in house • kingdom come, by and large
LMWs and MWE (Difference)	• Collocation • Specific meaning • Complementation • Idioms • …	• undergoing cardiac surgery • in the house • beat someone up, give birth • kick the bucket, shoot the breeze
UMLS String:	• Term[1] (conventionalized terminology) • Phrase[2]	• Food and water, pain and fever, [disease, Hodgkin's] • group 2, very low, may be a, not available • right heart failure due to pulmonary hypertension

1. A word or group of words with a specific meaning, especially in a particular field.
2. A phrase is a group of words that expressing a thought, but lacking a subject or a verb or both.

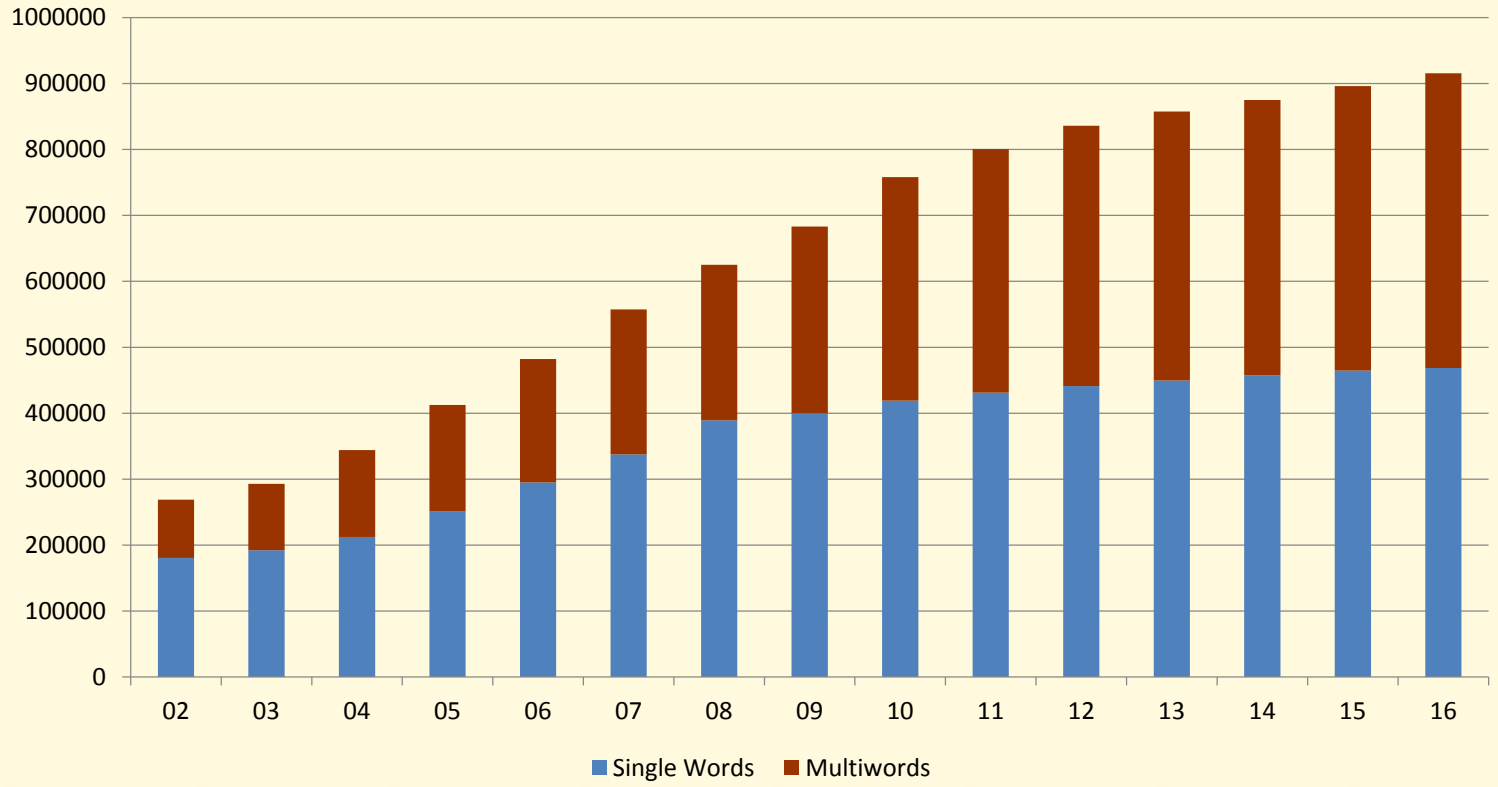


Annual Lexicon Release Procedures



Lexicon Growth – 2002 to 2016

- 491,639 lexical records
- 1,090,050 words (categories and inflections)
- 915,583 forms (spelling only)
  - Single words: 468,655 (51.19%); Multiwords: 446,928 (48.81%)



Lexicon Unigram Coverage – Without WC

- Total unique word for MEDLINE (2016): 3,619,854
- Lexicon covers 10.62 % unigrams in MEDLINE

Types	Word Count	Percentage %	Accu. %
LEXICON (S)	296,747	8.1978%	8.1978%
NUMBER	62	0.0017%	8.1995%
DIGIT	87,437	2.4155%	10.6150%
NON-WORD*	43,811	1.2103%	11.8253%
NEW	3,191,797	88.1747%	100.0000%
Total	3,619,854		

* NON-WORD: a single word only exist in multiword, such as “non”, “vitro”, “vivo”, “intra”, etc.

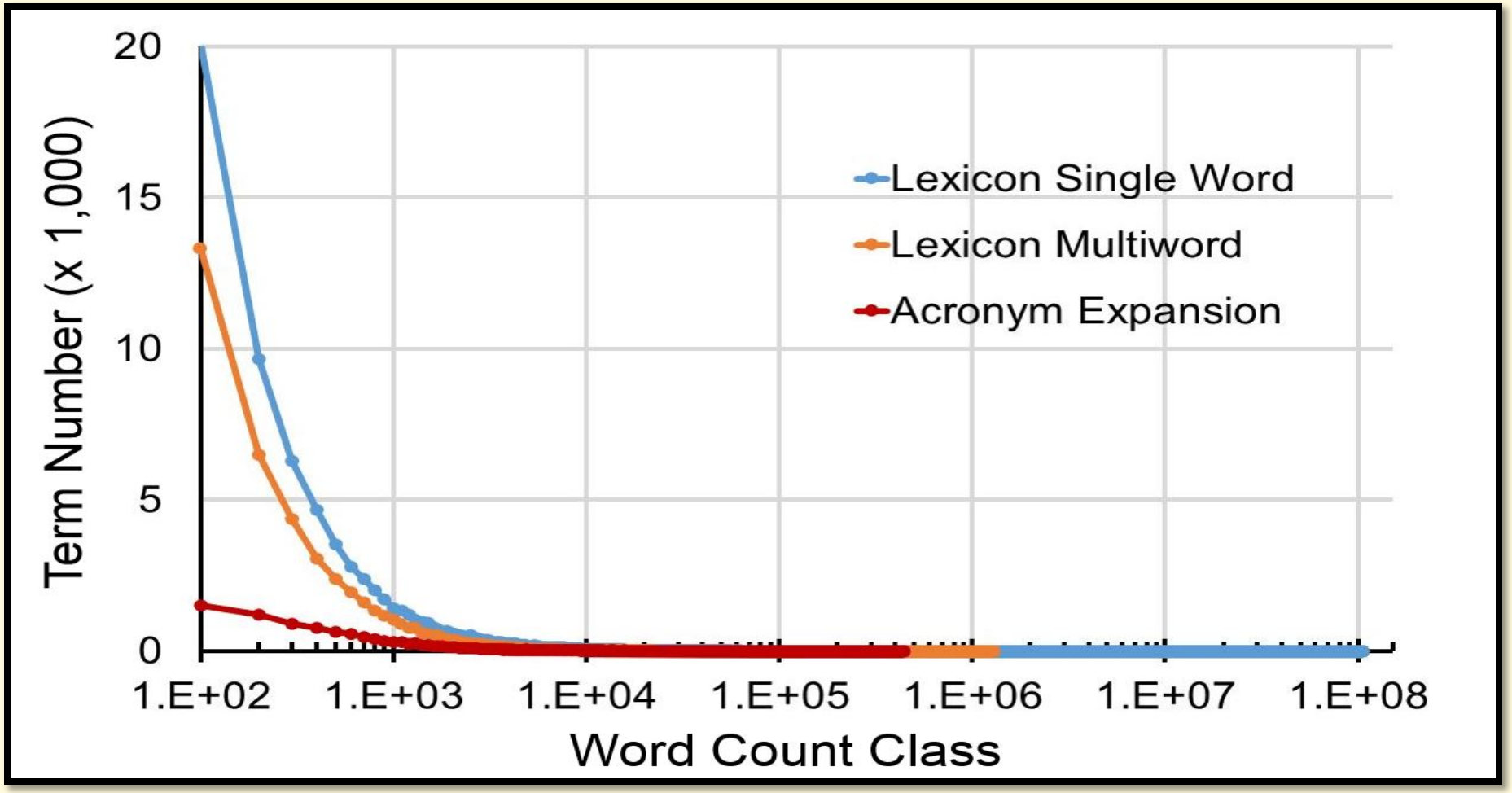
Lexicon Unigram Coverage – With Frequency (WC)

- Total word count for MEDLINE (2016): 3,114,617,940
- Lexicon covers > 98% unigrams from MEDLINE

Types	Word Count	Percentage %	Accu. %
LEXICON	2,911,156,308	93.4675%	93.4675%
NUMBER	8,753,120	0.2810%	93.7485%
DIGIT	145,548,882	4.6731%	98.4216%
NON-WORD*	19,148,557	0.6148%	99.0364%
NEW	30,011,073	0.9636%	100.0000%
Total	3,114,617,940		

* NON-WORD: a single word only exist in multiword, such as “non”, “vitro”, “vivo”, “intra”, etc.

The Frequency Spectrum of Lexicon (Multi)words on MEDLINE



The Frequency Spectrum of Alice in Wonderland

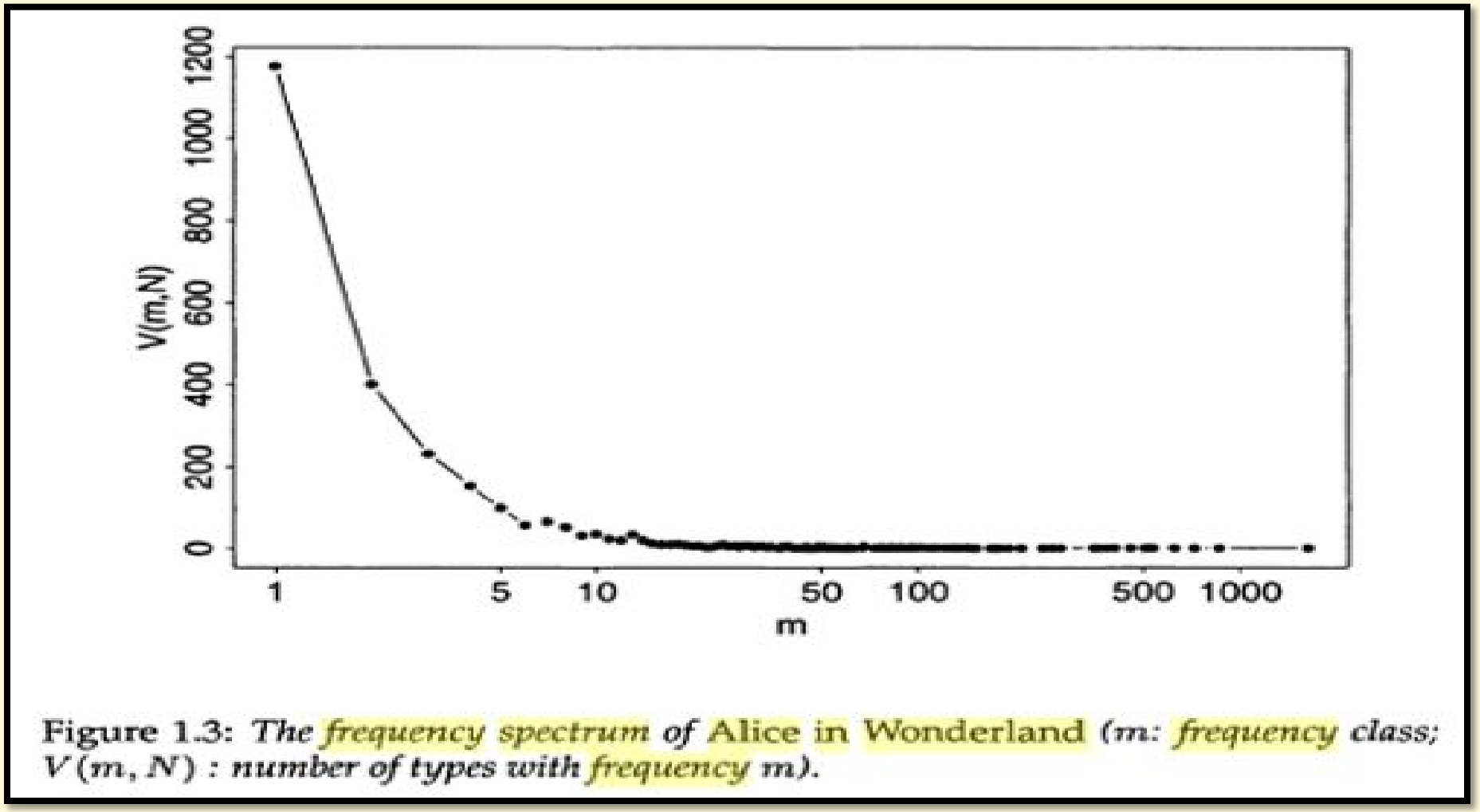
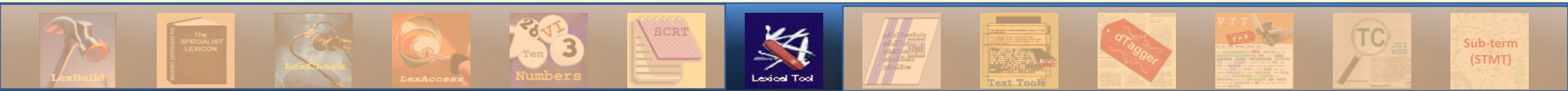


Figure 1.3: *The frequency spectrum of* Alice in Wonderland *(m: frequency class; V (m, N) : number of types with frequency m).*

Lexical Tools

- Lexical Tools: Algorithm + Data (directly or derived from the Lexicon)
  - Command line tools
    - lvg (Lexical Variants Generation, base of all of tools)
    - norm (UMLS - MRXNS, MRXNW)
    - luiNorm (UMLS - LUI)
    - wordInd (UMLS - MRXNW)
    - toAscii (MetaMap - BDB Tables)
    - fields (Lexicon Tables, MetaMap - BDB Tables, etc.)
  - Lexical Gui Tool (lgt)
  - Web Tools
  - Java API's



Lexical Tools Release Procedures

Library Updates
Java, Unicode, DB, Installations, etc. updates

Unit Tests

Lexical Tools Baseline

Software Change Requests (SCRs): bug fixes and feature enhancements

Lexical Tools (software Updates)

DB Integration - 1:
- Generate DB tables from Lexicon
- Integrated to Lexical Tools

DB Integration - 2:
- Generate DB tables from LVG
- Integrated to Lexical Tools

SD-Rules Optimization

Unit Tests

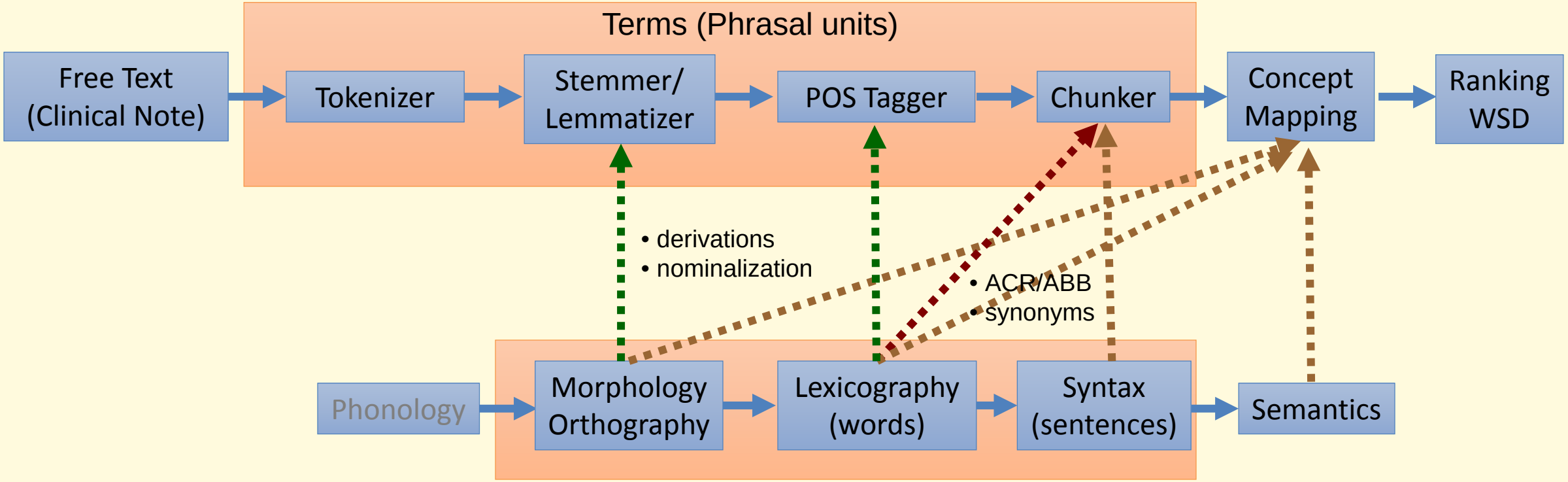
Lexical Tools (Internal Release)

Component Updates:
- GUI Tools
- Examples
- Documents
- Web Site/Web Tools

Tests
- Unit Test
- ASCII Test
- Platform Test
- Performance Test

Lexical Tools (Public Release)

2. NLP Usage


Terms (Phrasal units)
Free Text (Clinical Note)
Tokenizer
Stemmer/ Lemmatizer
POS Tagger
Chunker
Concept Mapping
Ranking WSD
• derivations
• nominalization
• ACR/ABB
• synonyms
Phonology
Morphology Orthography
Lexicography (words)
Syntax (sentences)
Semantics

Phrasal Level: Name Entity Recognition (The Longest Lead-Term)

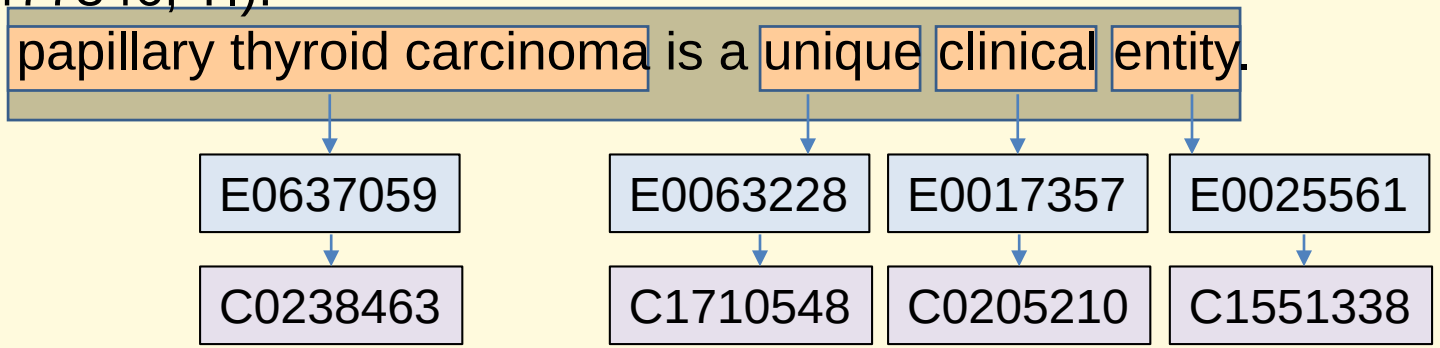
- Example (PMID 23477346, TI):
- Follicular variant of papillary thyroid carcinoma is a unique clinical entity.

=> papillary thyroid carcinoma is a unique clinical
=> papillary thyroid carcinoma is a unique
=> papillary thyroid carcinoma is a
=> papillary thyroid carcinoma is
=> papillary thyroid carcinoma -> Match
=> is a unique clinical entity
=> is a unique clinical
=> is a unique
=> is a
=> is
=> a unique clinical entity
=> …
=> papillary thyroid carcinoma is a unique clinical entity.

C0238463 C1710548 C0205210 C1551338

Phrasal Level - Name Entity Recognition

- Example (PMID 23477346, TI):
- Follicular variant of papillary thyroid carcinoma is a unique clinical entity.

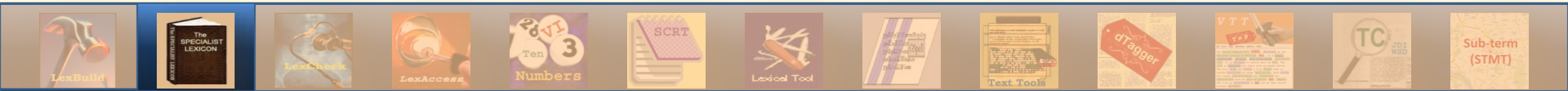


- Lexicon Subterm Finder (LSF):
  Find all subterms that have mapped CUI
  - Load Lexicon (multi)words to Trie (normalized, have mapped CUI).
  - Retrieve subterms from Trie

Processed Thesaurus: Lexicon (Multi)words - LSF

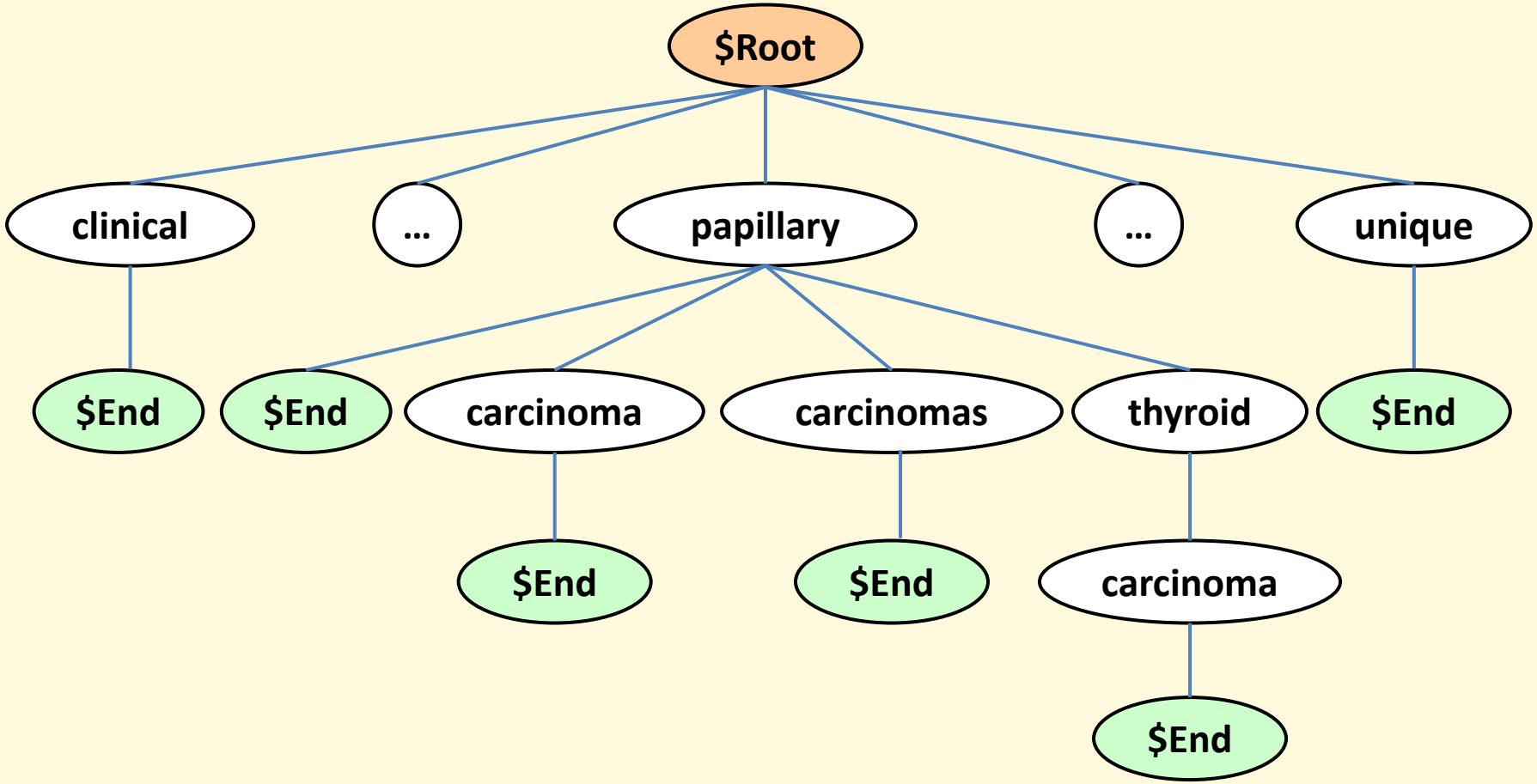
Normalized* InflVars	EUI	CUI	STI
…	…	…	…
carcinoma	E0015213	C0007097	T191|Neoplastic Process
clinical	E0017357	C0205210	T080|Qualitative Concept
entity	E0025561	C1551338	T071|Entity
papillary	E0045335	C0205312	T080|Qualitative Concept
papillary carcinoma	E0045337	C0007133	T191|Neoplastic Process
papillary carcinomas	E0045337	C0007133	T191|Neoplastic Process
papillary plasma flow	E0700280	No CUI	N/A
papillary thyroid carcinoma	E0637059	C0238463	T191|Neoplastic Process
thyroid	E0060948	C0040132	T023|Body Part, Organ, or Organ Component
unique	E0063228	C1710548	T080|Qualitative Concept
…			…

* Norm: Remove genitive, remove parenthetical plural forms (s), (es), (ies), remove punctuation, lower cases, trim, remove duplicated results



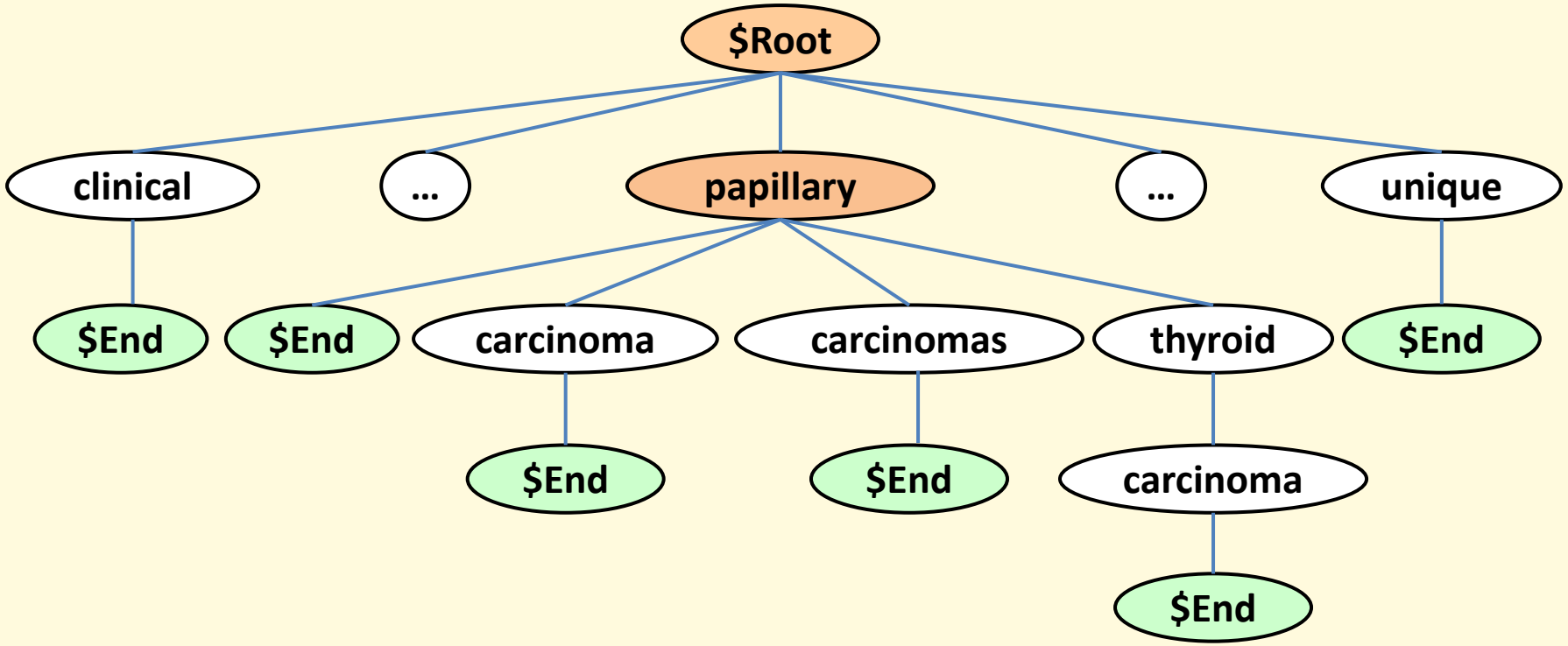
LSF – Load Lexicon (Multi)words to Trie

Normalized InflVars
…
clinical
entity
papillary
papillary carcinoma
papillary carcinomas
~~papillary plasma flow~~
papillary thyroid carcinoma
thyroid
unique
…



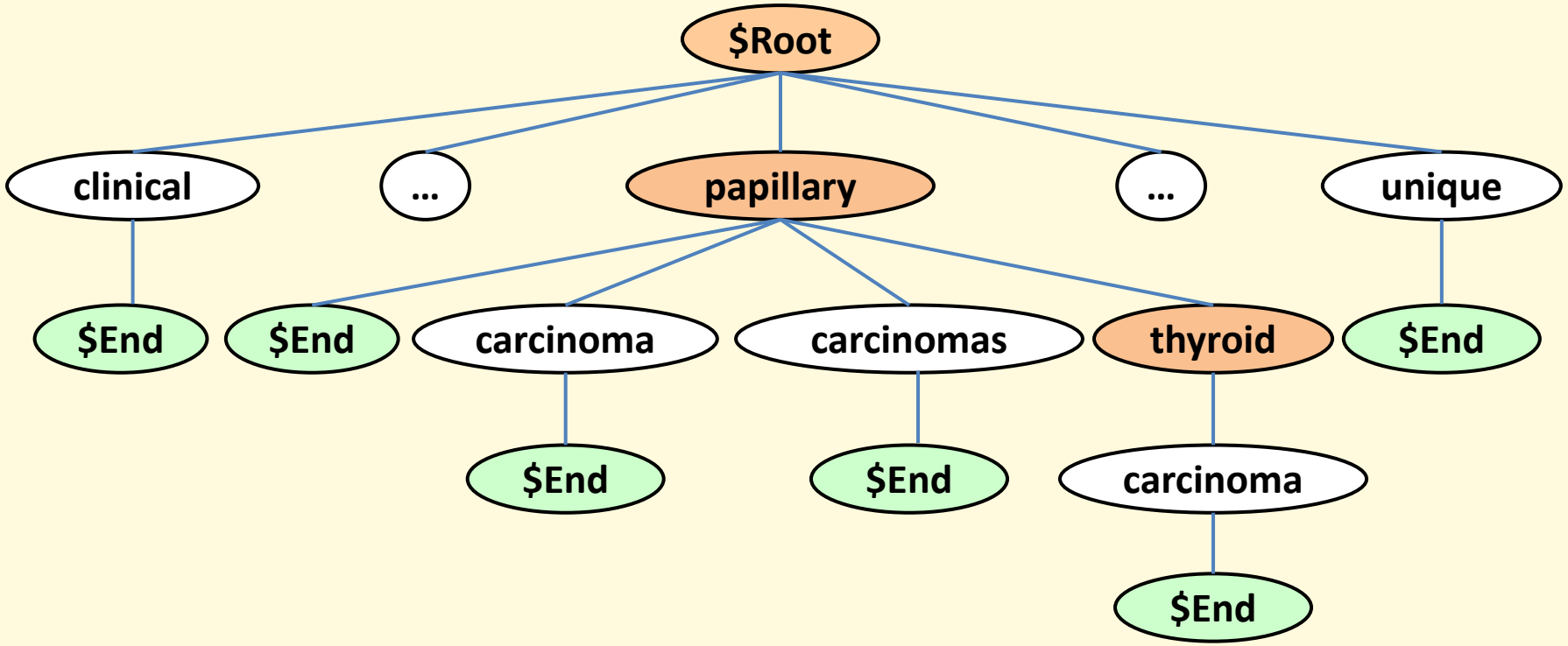
LSF – Load Lexicon (Multi)words to Trie

- **Example:** | papillary | thyroid carcinoma is a unique clinical entity |



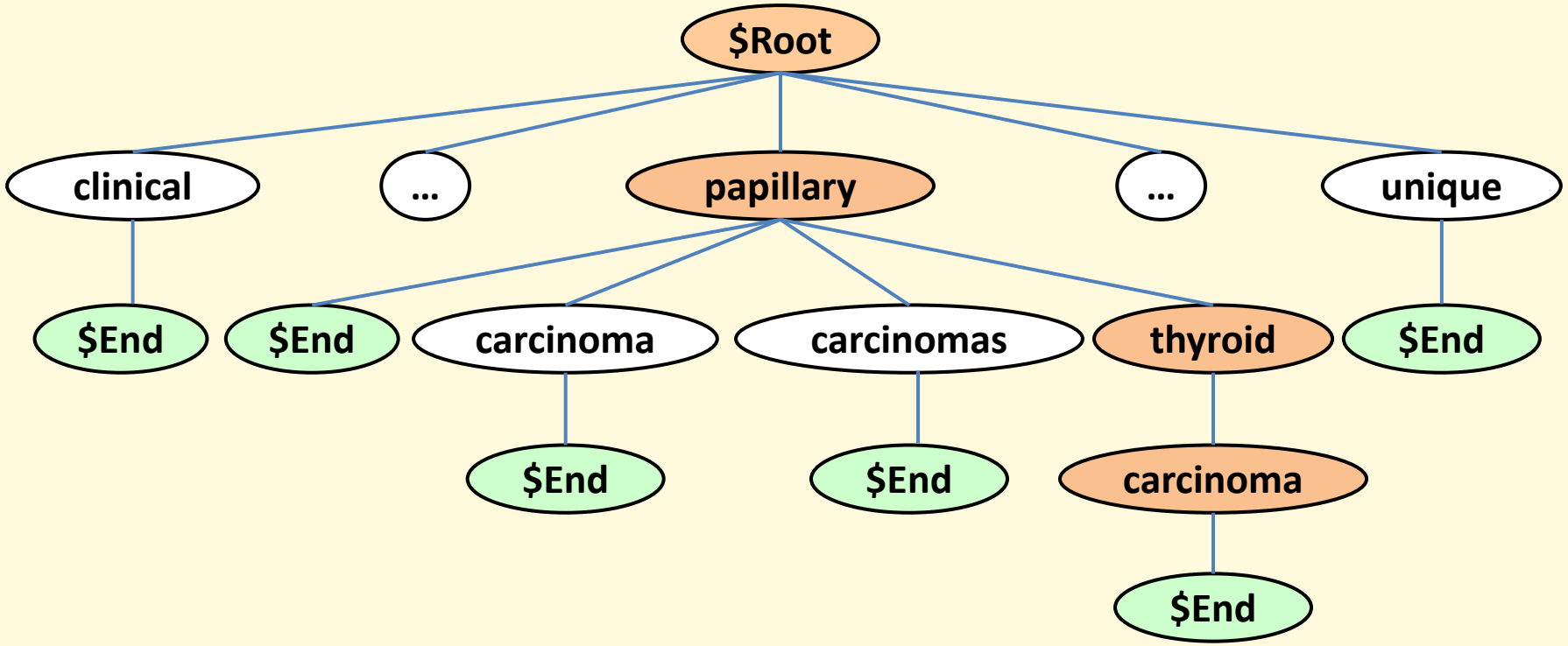
LSF – Load Lexicon (Multi)words to Trie

- **Example:** | papillary thyroid | carcinoma is a unique clinical entity |



LSF – Load Lexicon (Multi)words to Trie

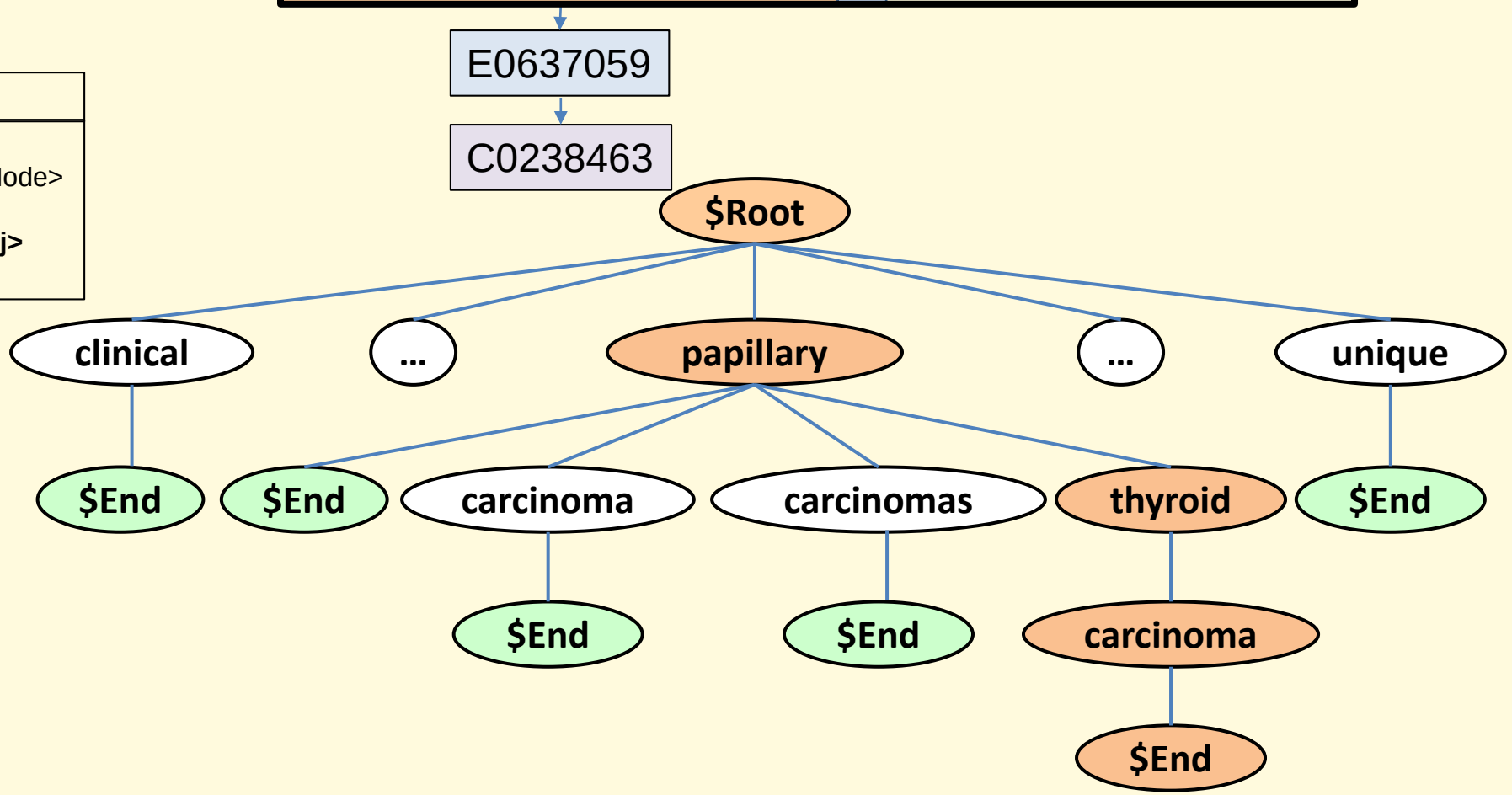
- **Example:** papillary thyroid carcinoma | is a unique clinical entity



LSF – Load Lexicon (Multi)words to Trie

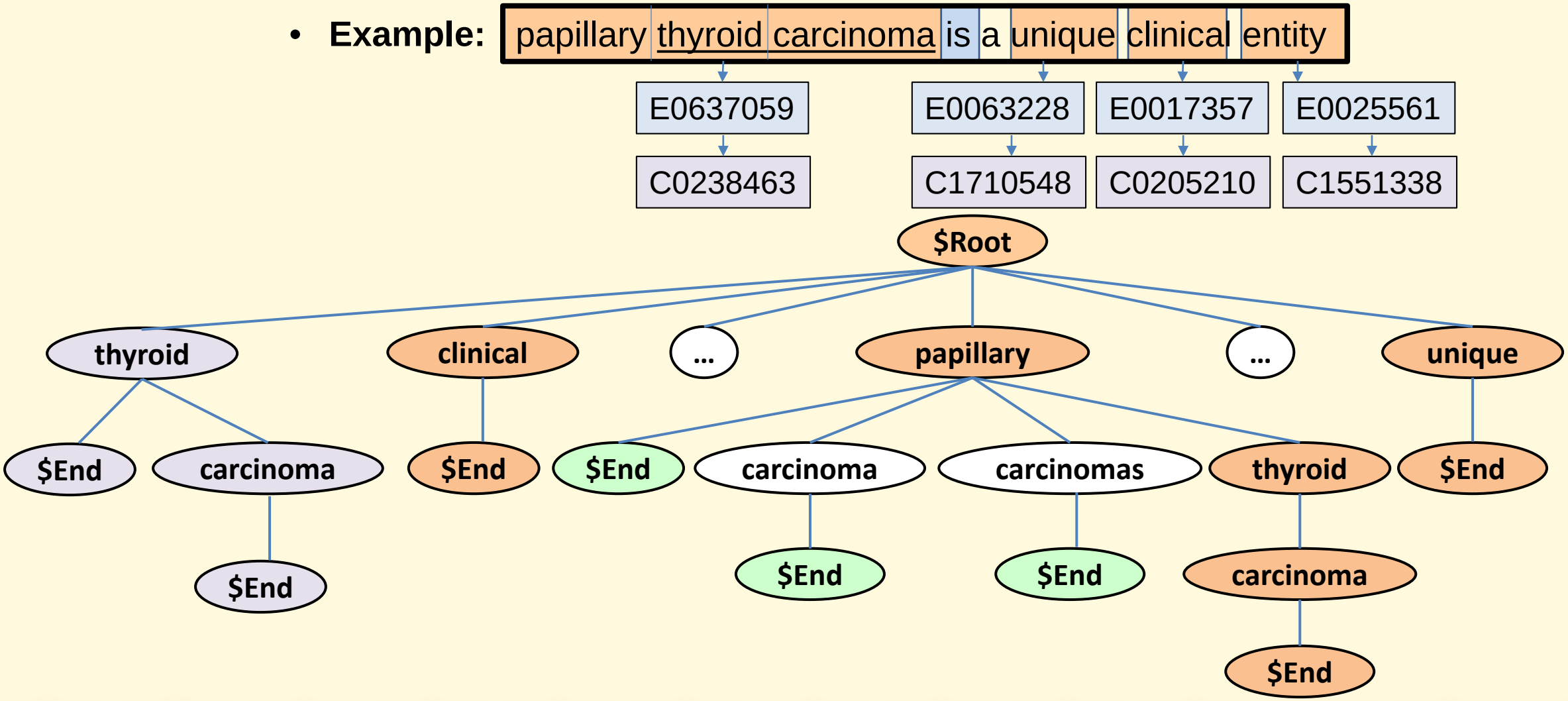
- **Example:** papillary thyroid carcinoma | is | a unique clinical entity

TrieNode
-key: string -child: hashMap<String, TrieNode> -eui: list<String> **-euiCuiSti: list<euiCuiStiObj>** ….



LSF – Load Lexicon (Multi)words to Trie

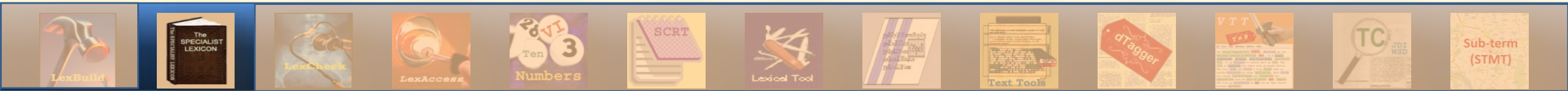
- **Example:** papillary | thyroid | carcinoma | is | a | unique | clinical | entity



Overlap Issues: Lead-Term, End-Term, Mid-Term?

- Example (PMID 12792778, TI):
- Inhibition of metastatic brain tumor growth by intramuscular administration of the endostatin gene.
  - Lead-Term: metastatic brain tumor growth: C0220650
  - End-Term: metastatic brain tumor growth: C0598934
  - LMWs: metastatic brain tumor|C0220650, brain tumor|C0006118, tumor growth|C0598934, ..

- Example (PMID 20162874, AB):
- In the present patient right pulmonary agenesis is co-occurring with VACTERL syndrome.
  - Lead-Term: the present patient right pulmonary agenesis: C0030706
  - End-Term: the present patient right pulmonary agenesis: C0265784
  - LMWs: patient right|C0030706, right pulmonary agenesis|C0265784, pulmonary agenesis|…



POS Parser Issues –> Sentence Level

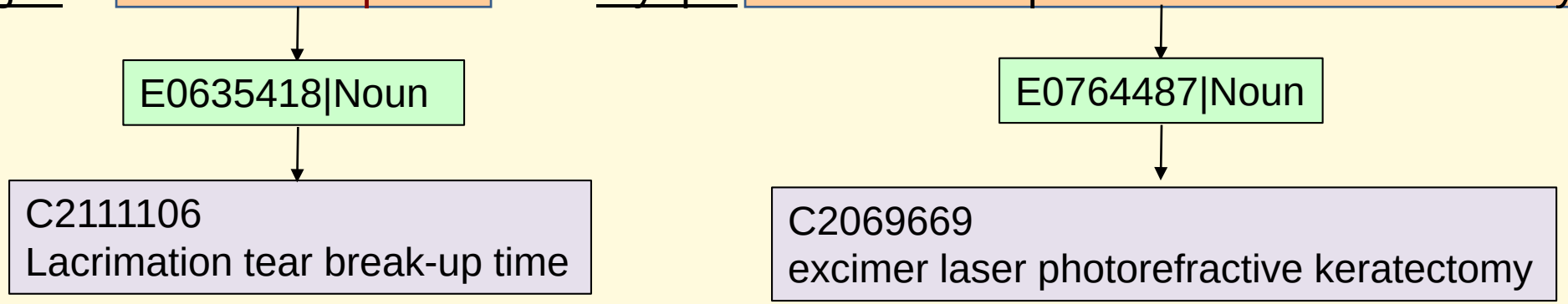
- Example (PMID 9510650, TI):
  - **Shallow Parser's (U of Illinois):**

The changes	of	tear	break	up	time	after	myopic excimer laser photorefractive keratectomy
NP	PP	NP	VP	PRT	NP	PP	NP

  - **Parser (Stanford):**

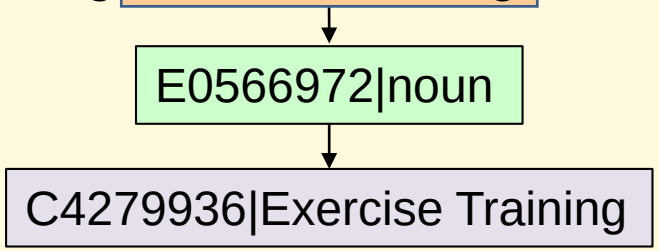
The changes	of	tear	break	up	time	after	myopic excimer laser photorefractive keratectomy
NP	PP	NP	VP	PRT	NP	SBAR	NP

  - Multiword Approach:
  - The changes of tear break up time after myopic excimer laser photorefractive keratectomy

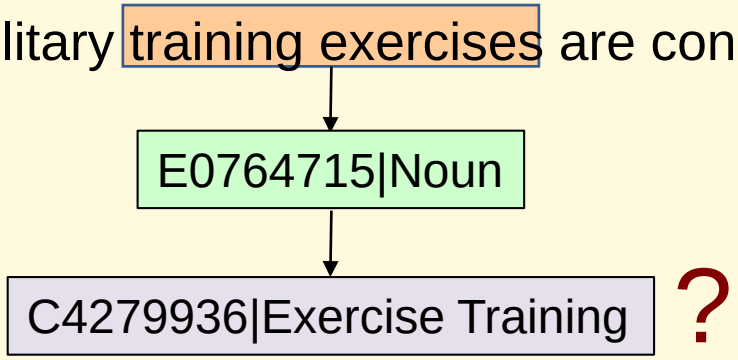


Order Issues (Norm)

- Example (PMID 5820369, TI):
  - Cardiac arrest during exercise training.



- Example (PMID 14719633, AB):
  - Military training exercises are conducted routinely in the Mojave Desert.



Concept Ranking (CR) – The Longest Word?

- Example (PMID 9510650, TI):

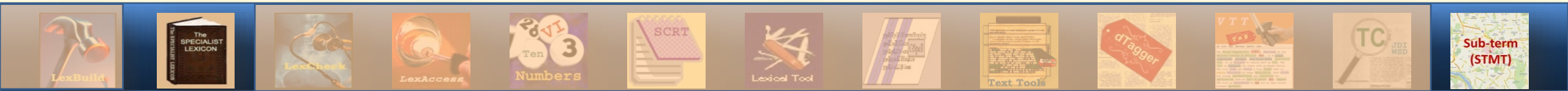
The changes of tear break up time after myopic excimer laser photorefractive keratectomy

Noun

Noun

sub-term	Lexicon - EUI
tear	E0060021, E0060022
break	E0013997, E0013998
up	E0063423, E0063424, …
time	E0061086, E0061087
break up	E0220309
break up time	E0635415
tear break up time	E0635418

sub-term	Lexicon - EUI
myopic	E0041717, E0041718
excimer	E0319304
laser	E0036924, E0336817
photorefractive	E0418725
keratectomy	E0036428
excimer laser	E0514806
photorefractive keratectomy	E0225495
excimer laser photorefractive keratectomy	E0764487



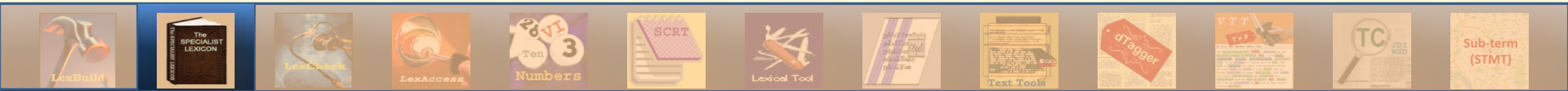
CR on Overlap case – The Longest Word?

- Example (PMID 4771012, TI) – Overlap:
- Early diagnosis and management of infected artificial heart valve.

- Lead-Term: infected artificial heart valve.

- End-Term: infected artificial heart valve.

sub-term	EUI	CUI
infected	E0034360, ..	C0439663
artificial	E0010589	C2004457
heart	E0030957	C0018787, ..
valve	E0063958	C0184252, ..
artificial heart	E0010602	C0018829
heart valve	E0030978	C0018826, …
artificial heart valve	E0584205	C0018825, …

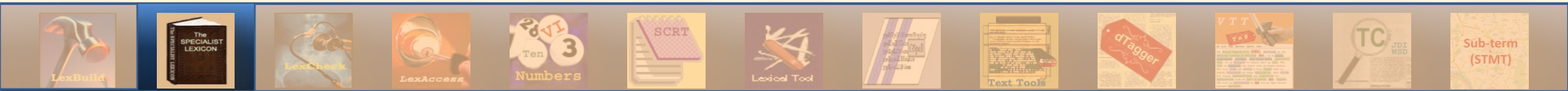


CR: The Longest Word in the Sentence Level?

- Example (PMID 23477346, TI) – Beginning:
  - Follicular variant of papillary thyroid carcinoma is a unique clinical entity.

- Example (PMID 581461, TI) – Ending:
  - Nucleolar abnormalities in human papillary thyroid carcinoma.

- Example (PMID 6143549 , AB) – Middle:
  - Coexisting papillary thyroid carcinoma occurred in three patients with HCA.

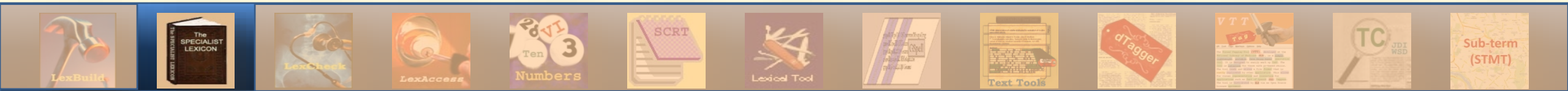


Strings, MWEs, or Words

- Example of UMLS String (PMID 15528223, AB):
- Right heart failure due to pulmonary hypertension causes significant morbidity and mortality.
  - UMLS String: right heart failure due to pulmonary hypertension|C1960038
  - ⇒ Search: “Right heart failure because of pulmonary hypertension”
  - LMW: right heart failure|C0235527, pulmonary hypertension|C0020542

- Example of MWE (PMID 23477346, TI):
- Thirty patients undergoing cardiac surgery and 7 patients undergoing thoracic surgery not involving the heart were studied.
  - MWE: Undergoing cardiac surgery (MWE), no meaning, no POS, no morphology
  - LMW: cardiac surgery (MWE): C0018821

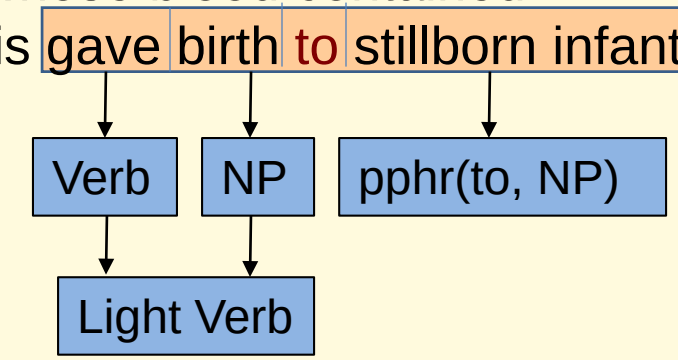
- Strings and MWEs do not have all 4 criteria of LMWs: POS, morphology, order, specific meaning



Pattern: Complementation - Verb

- Example (PMID: 47945, AB):

Two of ten women whose blood contained
Mycoplasma hominis gave birth to stillborn infants.




```
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        variants=irreg|give|gives|gave|given|giving|
        intran
        intran;part(out)
        …
        ditran=np|birth|,pphr(to,np)
        cplxtran=np,infcomp:objr
        cplxtran=np,infcomp:objr;part(out)
        cplxtran=np,ingcomp:arbc;part(over)
        nominalization=gift|noun|E0029737
}
```
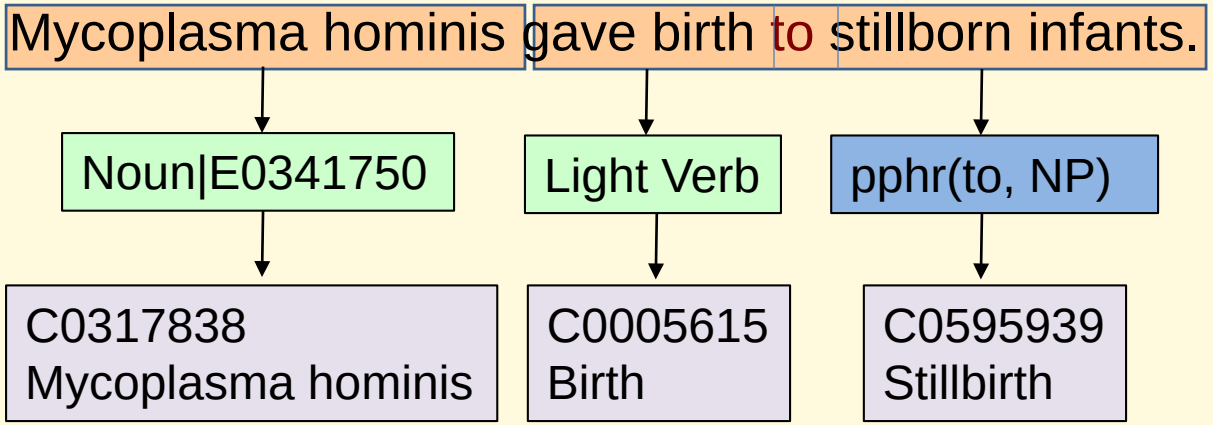

Multiwords, Patterns, StopWords

- Example (PMID: 47945, AB):

~~Two~~ ~~of~~ ~~ten~~ women ~~whose~~ blood contained Mycoplasma hominis gave birth to stillborn infants.

Number Pattern Pronoun

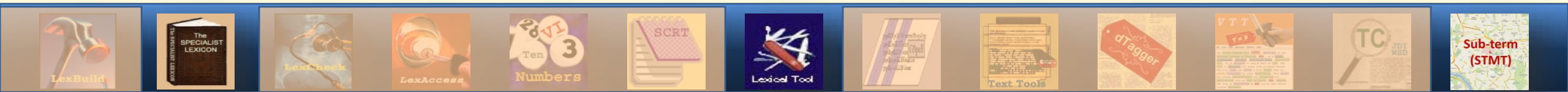


- Multiword: “Mycoplasma hominis”
- Patterns:
  - complementation: “gave birth”
  - Measurement: (0.1-2.3 mg/day)
  - title: Mr. Song, Dr. Coma
  - …
- StopWords: preposition, auxiliary, modal, determiner, conjunction, complementizer, pronoun, numbers, …

Summary

- Coverage:
  - How many multiwords do we need?
  - Query Expansion
  - Hybrid: use multiword as default, single word as supplement
- Other Resources (MWE? UMLS String?)
  - Linguistics concerns: POS, morphology, order, specific meaning
  - Technical concerns (size – performance):

	Size	Notes
The Lexicon - InflVars	0.9 M	Biomedical and general English
UMLS Strings	9.4 M	Terms and phrases, no POS, no morphology, …
UMLS Norm Terms	11 M	+Word order is not preserved after Norm, morphology issues, …
WordNet	0.15 M	General English, only 4 POS, no morphology, …



Conclusion

- Single word approach vs. multiword approach:
  - Data driven – embedded knowledge (Facts instead of Rules)
- The concept of approach (identify words), not the algorithm

- Other Components:
  - Morphology: inflections, uninflections, derivations
  - POS tagger (frog erythrocytic virus)
  - Norm (left pulmonary veins)
  - Query Expansion (zona vaccine)
  - Element Synonyms (zona -> herpes zoster)
  - Standard data set
  - etc.