PARSING

David Kauchak
CS457 – Fall 2011

some slides adapted from Ray Mooney

Admin

- Survey
  - http://www.surveymonkey.com/s/TF75YJD

Admin

- Graduate school?
- Good time for last-minute programming contest practice sessions?
- Assignment 2 grading

Admin

- Java programming
  - What is a package?
    - Why are they important?
    - When should we use them?
    - How do we define them?
  - Interfaces:
    - say my interface has a method:
      public void myMethod();
    - If I'm implementing the interface is it ok to:
      public void myMethod() throws SomeCheckedException

Parsing

- Given a CFG and a sentence, determine the possible parse tree(s)

I eat sushi with tuna

```
S -> NP  VP
NP -> PRP
NP -> N PP
VP -> V NP
VP -> V NP PP
PP -> IN N
PRP -> I
V -> eat
N -> sushi
N -> tuna
IN -> with
```

Parsing

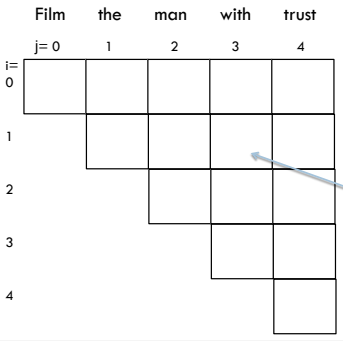
- Top-down parsing
  - start at the top (usually S) and apply rules
  - matching left-hand sides and replacing with right-hand sides

- Bottom-up parsing
  - start at the bottom (i.e. words) and build the parse tree up from there
  - matching right-hand sides and replacing with left-hand sides

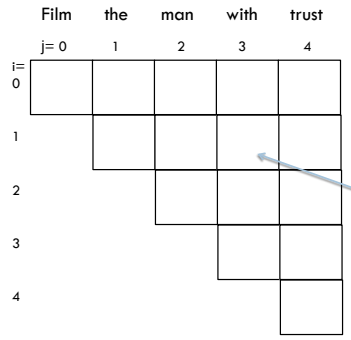
CKY

- First grammar must be converted to **Chomsky normal form (CNF)**
  - We'll allow all unary rules, though
- Parse bottom-up storing phrases formed from all substrings in a triangular table (chart)

CKY parser: the chart



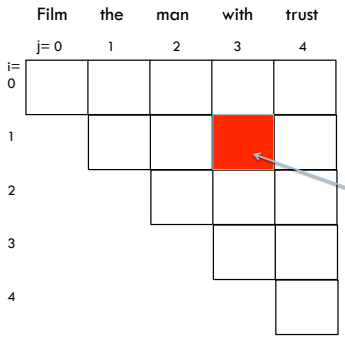
CKY parser: the chart



Cell[*i*,*j*] contains all constituents covering words *i* through *j*

all constituents spanning 1-3 or "the man with"

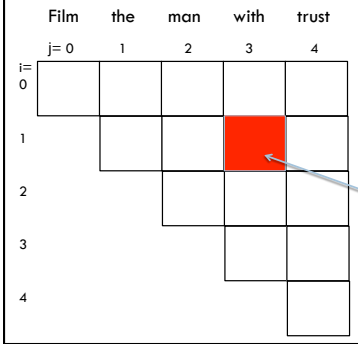
CKY parser: the chart



Cell[*i*,*j*] contains all constituents covering words *i* through *j*

how could we figure this out?

CKY parser: the chart

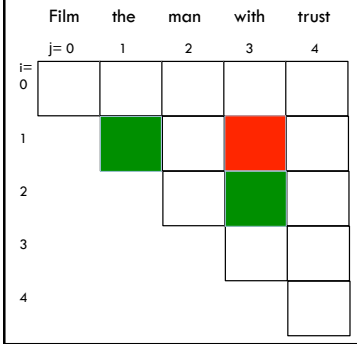


Cell[*i*,*j*] contains all constituents covering words *i* through *j*

Key: rules are binary and only have two constituents on the right hand side

VP -> VB NP
NP -> DT NN

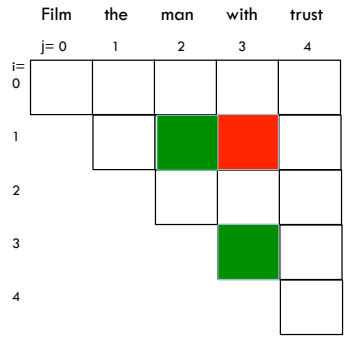
CKY parser: the chart



Cell[*i*,*j*] contains all constituents covering words *i* through *j*

See if we can make a new constituent combining any for "the" with any for "man with"

CKY parser: the chart



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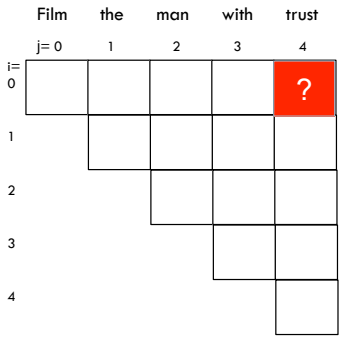
See if we can make a new constituent combining any for "the man" with any for "with"

CKY parser: the chart



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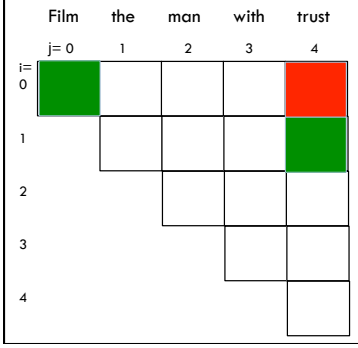
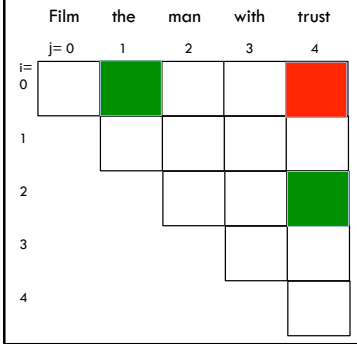


Cell[*i,j*] contains all constituents covering words *i* through *j*

See if we can make a new constituent combining any for "Film" with any for "the man with trust"

CKY parser: the chart



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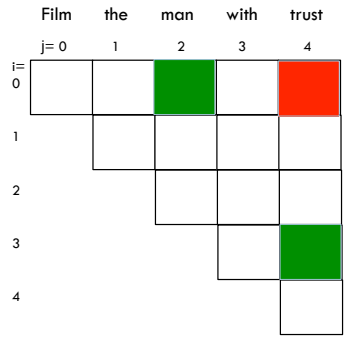
CKY parser: the chart



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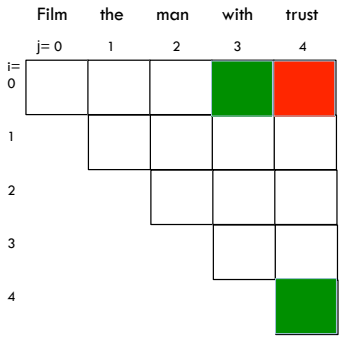
See if we can make a new constituent combining any for "Film the man" with any for "with trust"

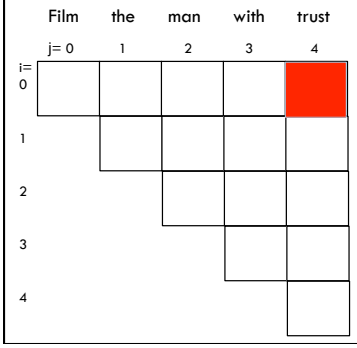
CKY parser: the chart



Cell[*i,j*] contains all constituents covering words *i* through *j*

See if we can make a new constituent combining any for "Film the man with" with any for "trust"

CKY parser: the chart



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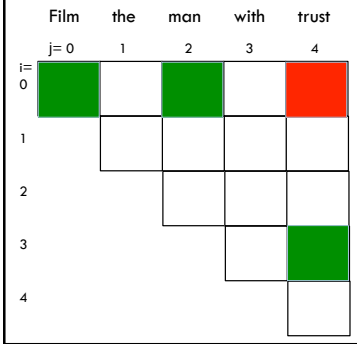
What if our rules weren't binary?

CKY parser: the chart



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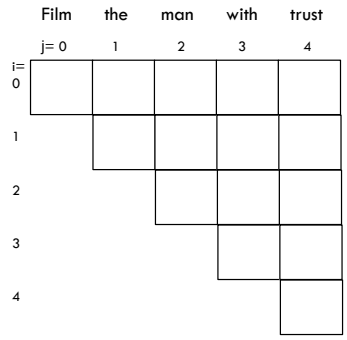
See if we can make a new constituent combining any for "Film" with any for "the man" with any for "with trust"

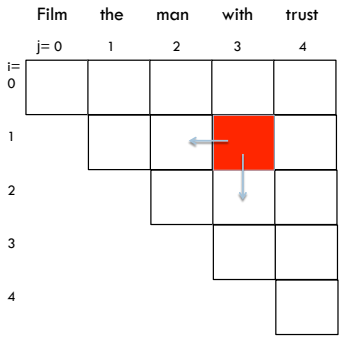
CKY parser: the chart



Cell[*i,j*] contains all constituents covering words *i* through *j*

What order should we fill the entries in the chart?

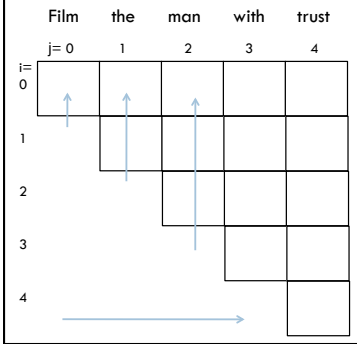
CKY parser: the chart



Cell[*i,j*] contains all constituents covering words *i* through *j*

What order should we traverse the entries in the chart?

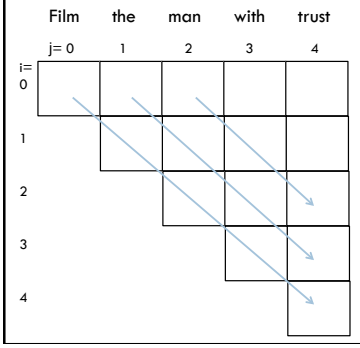
CKY parser: the chart



Cell[*i,j*] contains all constituents covering words *i* through *j*

From bottom to top, left to right

CKY parser: the chart



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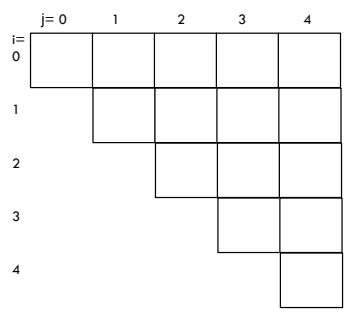
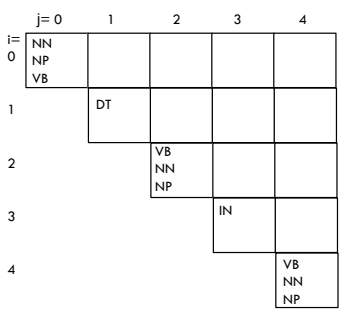
Top-left along the diagonals moving to the right

CKY parser: the chart



S -> VP
VP -> VB NP
VP -> VP2 PP
VP2 -> VB NP
NP -> DT NN
NP -> NN
NP -> NP PP
PP -> IN NP
DT -> the
IN -> with
VB -> film
VB -> man
VB -> trust
NN -> man
NN -> film
NN -> trust

CKY parser: the chart



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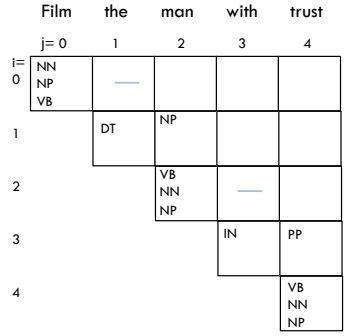

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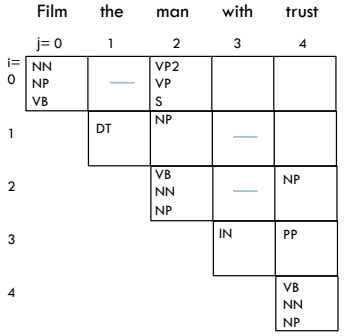

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VB -> man
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CKY parser: the chart

	Film	the	man	with	trust
	j= 0	1	2	3	4
i= 0	NN NP VB	—	VP2 VP S	—	
1		DT	NP	—	NP
2			VB NN NP	—	NP
3				IN	PP
4					VB NN NP

S -> VP
VP -> VB NP
VP -> VP2 PP
VP2 -> VB NP
NP -> DT NN
NP -> NN
NP -> NP PP
PP -> IN NP
DT -> the
IN -> with
VB -> film
VB -> man
VB -> trust
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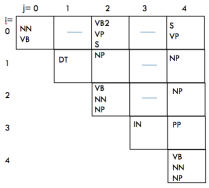
CKY parser: the chart

	Film	the	man	with	trust
	j= 0	1	2	3	4
i= 0	NN NP VB	—	VP2 VP S	—	S VP VP2
1		DT	NP	—	NP
2			VB NN NP	—	NP
3				IN	PP
4					VB NN NP

S -> VP
VP -> VB NP
VP -> VP2 PP
VP2 -> VB NP
NP -> DT NN
NP -> NN
NP -> NP PP
PP -> IN NP
DT -> the
IN -> with
VB -> film
VB -> man
VB -> trust
NN -> man
NN -> film
NN -> trust

CKY: some things to talk about

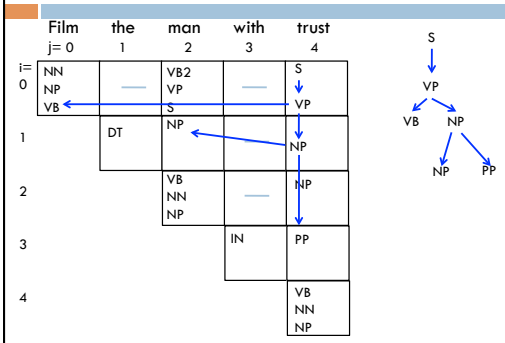
- After we fill in the chart, how do we know if there is a parse?
  - If there is an **S** in the upper right corner
- What if we want an actual tree/parse?



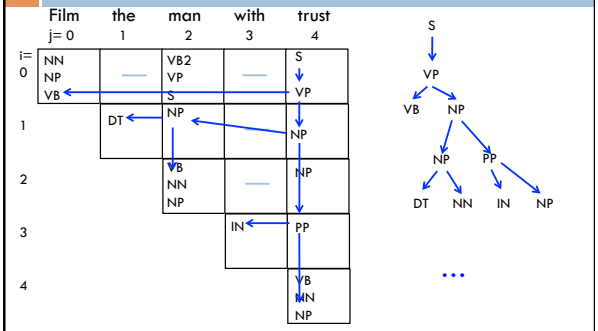
CKY: retrieving the parse

	Film	the	man	with	trust
	j= 0	1	2	3	4
i= 0	NN NP VB	—	VB2 VP S	—	S VP
1		DT	NP	—	NP
2			VB NN NP	—	NP
3				IN	PP
4					VB NN NP

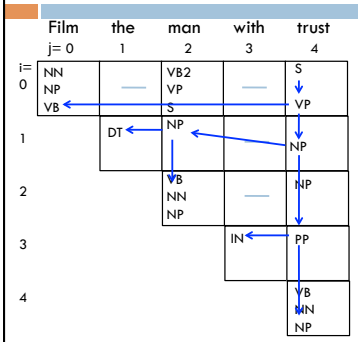
CKY: retrieving the parse



CKY: retrieving the parse

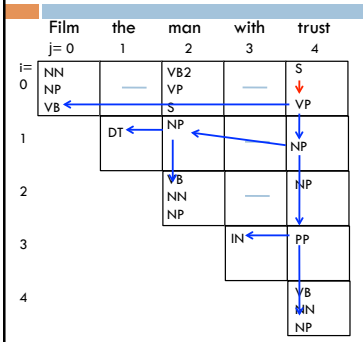


CKY: retrieving the parse



Where do these arrows/ references come from?

CKY: retrieving the parse

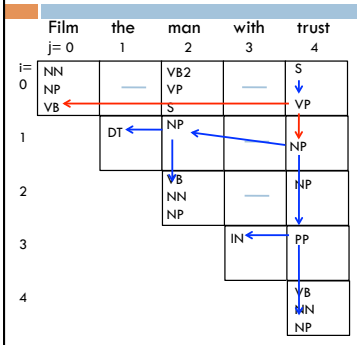


S -> VP

To add a constituent in a cell, we're applying a rule

The references represent the smaller constituents we used to build this constituent

CKY: retrieving the parse

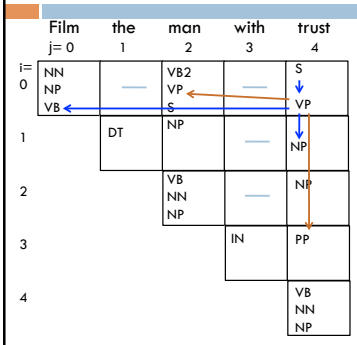


VP -> VB NP

To add a constituent in a cell, we're applying a rule

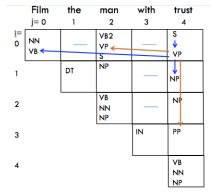
The references represent the smaller constituents we used to build this constituent

CKY: retrieving the parse



What about ambiguous parses?

CKY: retrieving the parse



- We can store multiple derivations of each constituent
- This representation is called a "parse forest"
- It is often convenient to leave it in this form, rather than enumerate all possible parses. Why?

CKY: some things to think about

CNF

S -> VP
VP -> VB NP
VP -> VP2 PP
VP2 -> VB NP
NP -> DT NN
NP -> NN
…

We get a CNF parse tree

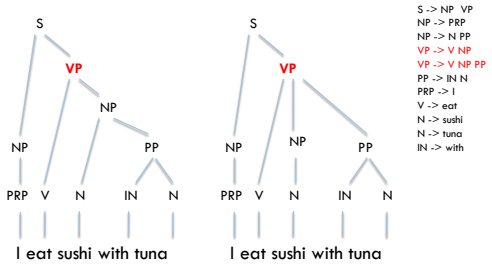
Actual grammar

S -> VP
VP -> VB NP
VP -> VB NP PP
NP -> DT NN
NP -> NN
…

but want one for the actual grammar

Ideas?

Parsing ambiguity

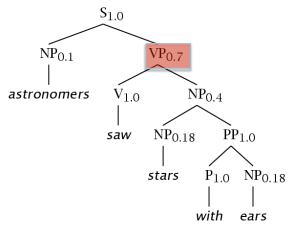


How can we decide between these?

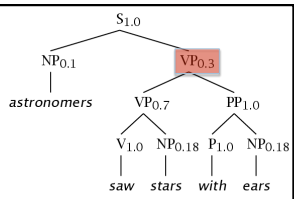
A Simple PCFG

Probabilities!

S	→	NP VP	1.0	NP	→	NP PP	0.4
VP	→	V NP	0.7	NP	→	*astronomers*	0.1
VP	→	VP PP	0.3	NP	→	*ears*	0.18
PP	→	P NP	1.0	NP	→	*saw*	0.04
P	→	*with*	1.0	NP	→	*stars*	0.18
V	→	*saw*	1.0	NP	→	*telescope*	0.1



= 1.0 * 0.1 * 0.7 * 1.0 * 0.4 * 0.18
* 1.0 * 1.0 * 0.18
= 0.0009072



= 1.0 * 0.1 * 0.3 * 0.7 * 1.0 * 0.18
* 1.0 * 1.0 * 0.18
= 0.0006804

Parsing with PCFGs

- How does this change our CKY algorithm?
  - We need to keep track of the probability of a constituent
- How do we calculate the probability of a constituent?
  - Product of the PCFG rule times the product of the probabilities of the sub-constituents (right hand sides)
  - Building up the product from the bottom-up
- What if there are multiple ways of deriving a particular constituent?
  - max: pick the most likely derivation of that constituent

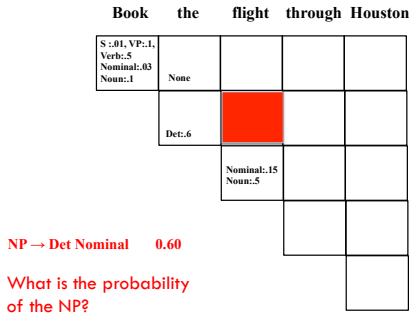
Probabilistic CKY

- Include in each cell a probability for each non-terminal
- Cell[*i*,*j*] must retain the *most probable* derivation of each constituent (non-terminal) covering words *i* through *j*
- When transforming the grammar to CNF, must set production probabilities to preserve the probability of derivations

Probabilistic Grammar Conversion

Original Grammar		Chomsky Normal Form	
S → NP VP	0.8	S → NP VP	0.8
S → Aux NP VP	0.1	S → X1 VP	0.1
		X1 → Aux NP	1.0
S → VP	0.1	S → book | include | prefer	
		0.01 0.004 0.006	
		S → Verb NP	0.05
		S → VP PP	0.03
NP → Pronoun	0.2	NP → I | he | she | me	
		0.1 0.02 0.02 0.06	
NP → Proper-Noun	0.2	NP → Houston | NWA	
		0.16 .04	
NP → Det Nominal	0.6	NP → Det Nominal	0.6
Nominal → Noun	0.3	Nominal → book | flight | meal | money	
		0.03 0.15 0.06 0.06	
Nominal → Nominal Noun	0.2	Nominal → Nominal Noun	0.2
Nominal → Nominal PP	0.5	Nominal → Nominal PP	0.5
VP → Verb	0.2	VP → book | include | prefer	
		0.1 0.04 0.06	
VP → Verb NP	0.5	VP → Verb NP	0.5
VP → VP PP	0.3	VP → VP PP	0.3
PP → Prep NP	1.0	PP → Prep NP	1.0

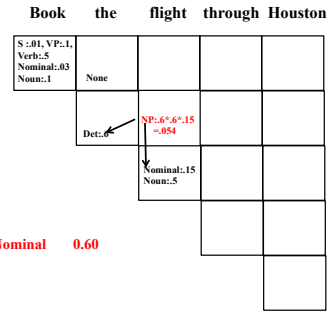
Probabilistic CKY Parser



NP → Det Nominal 0.60

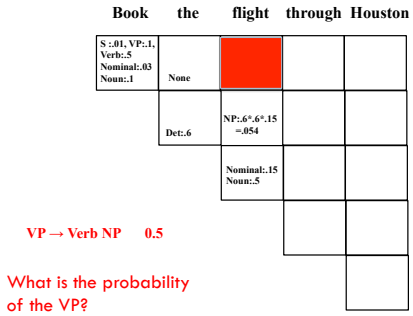
What is the probability of the NP?

Probabilistic CKY Parser



NP → Det Nominal 0.60

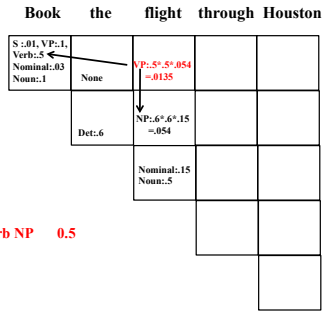
Probabilistic CKY Parser



VP → Verb NP 0.5

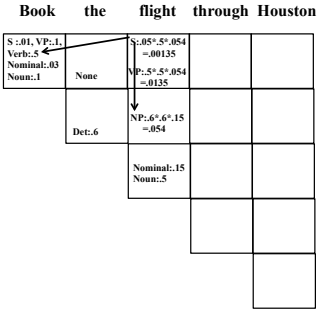
What is the probability of the VP?

Probabilistic CKY Parser

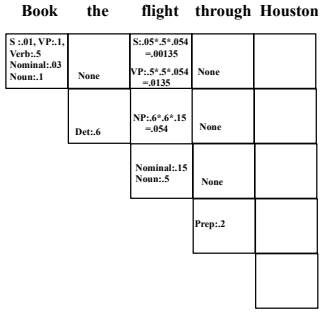


VP → Verb NP 0.5

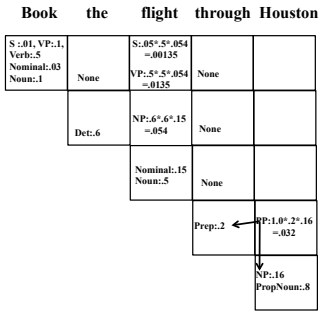
Probabilistic CKY Parser



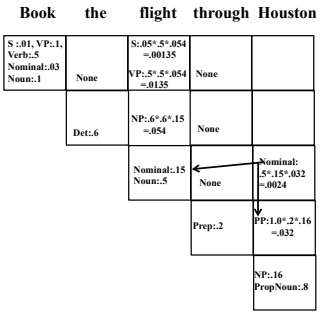
Probabilistic CKY Parser



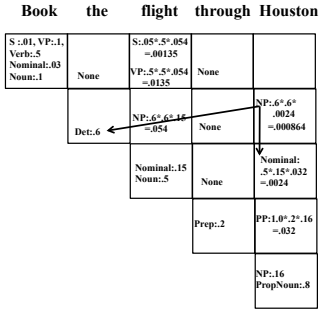
Probabilistic CKY Parser



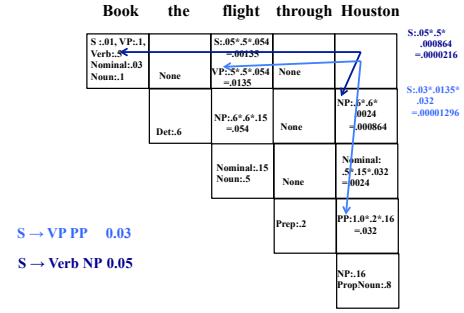
Probabilistic CKY Parser



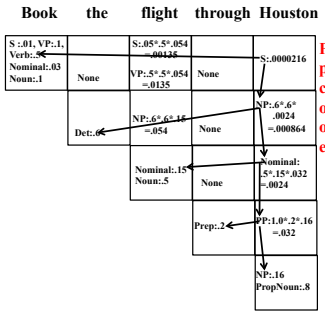
Probabilistic CKY Parser



Probabilistic CKY Parser



Probabilistic CKY Parser



Pick most probable parse, i.e. take max to combine probabilities of multiple derivations of each constituent in each cell

Generic PCFG Limitations

- PCFGs do not rely on specific words or concepts, only general structural disambiguation is possible (e.g. prefer to attach PPs to Nominals)
  - Generic PCFGs cannot resolve syntactic ambiguities that require semantics to resolve, e.g. ate with fork vs. meatballs
- Smoothing/dealing with out of vocabulary
- MLE estimates are not always the best

Article discussion

- Smarter Marketing and the Weak Link In Its Success
  - http://searchenginewatch.com/article/2077636/Smarter-Marketing-and-the-Weak-Link-In-Its-Success
- What are the ethics involved with tracking user interests for the purpose of advertising? Is this something you find preferable to 'blind' marketing?
- Is possible to get an accurate picture of someone's interests from their web activity? What sources would be good for doing so?
- How do you feel about websites that change content depending on the viewer? What are the implications of sites that behave this way?