

# 树到串统计机器翻译方法

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# 自然语言的差异性

Язык

sprache

langue

language

语言

언어

اللغة

भाषा

idioma

利用Google翻译生成

# 翻译很难



来源：[www.english.com](http://www.english.com)

# 机器翻译

布什与沙龙举行了会谈



Bush held a talk with Sharon

# 基于词的方法

布什 与 沙龙 举行 了 会谈

(Brown et al., 1993)

# 基于词的方法

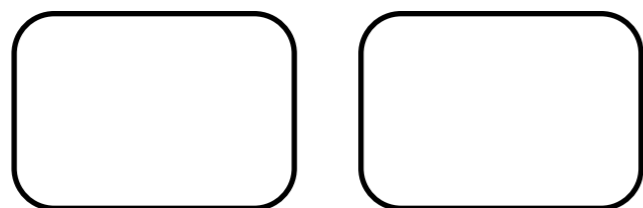
布什 与 沙龙 举行 了 会谈



(Brown et al., 1993)

# 基于词的方法

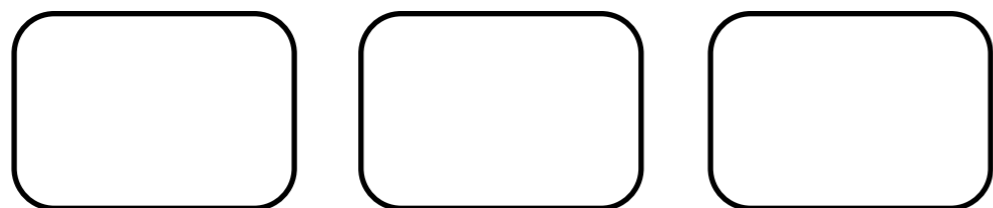
布什 与 沙龙 举行 了 会谈



(Brown et al., 1993)

# 基于词的方法

布什 与 沙龙 举行 了 会谈

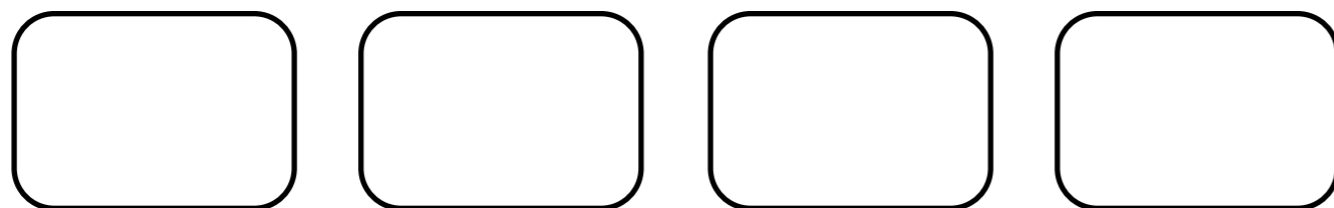


(Brown et al., 1993)



# 基于词的方法

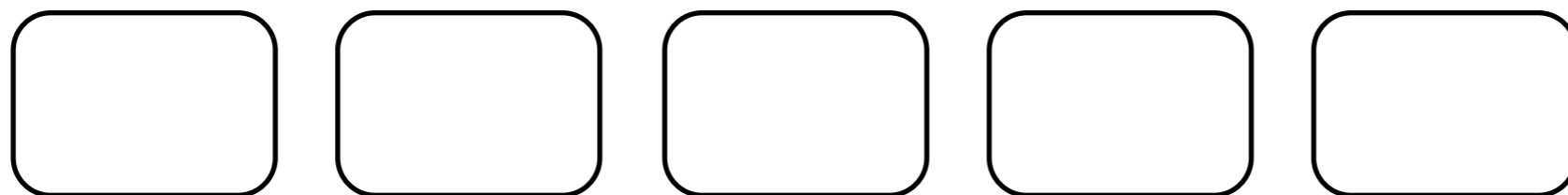
布什 与 沙龙 举行 了 会谈



(Brown et al., 1993)

# 基于词的方法

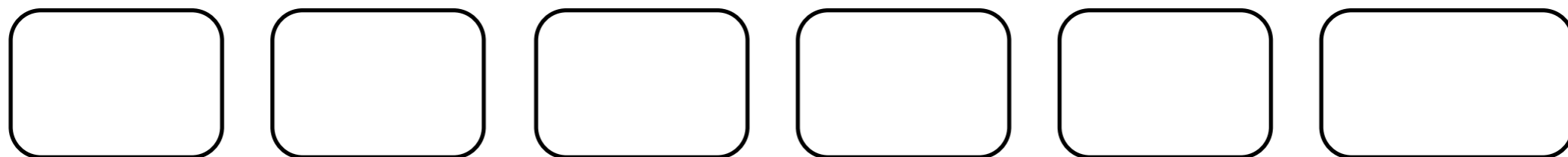
布什 与 沙龙 举行 了 会谈



(Brown et al., 1993)

# 基于词的方法

布什 与 沙龙 举行 了 会谈



(Brown et al., 1993)

# 基于词的方法

布什 与 沙龙 举行 了 会谈

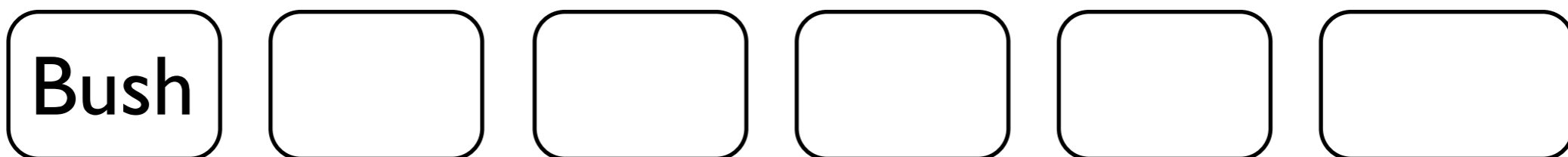
⋮

(Brown et al., 1993)

# 基于词的方法

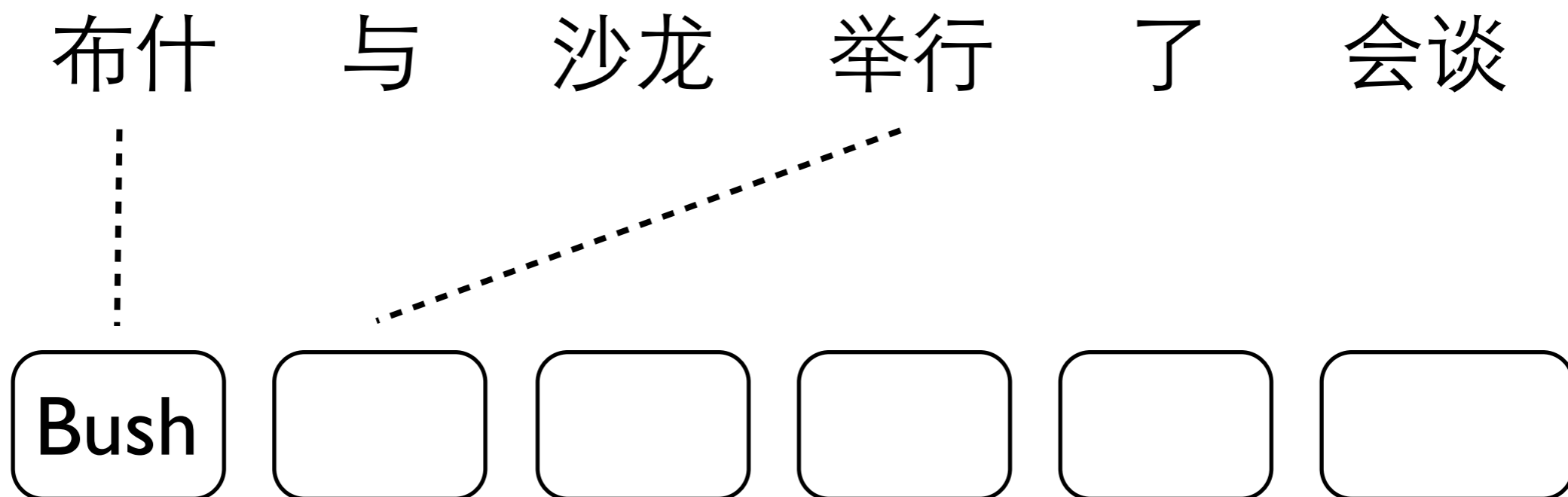
布什 与 沙龙 举行 了 会谈

⋮



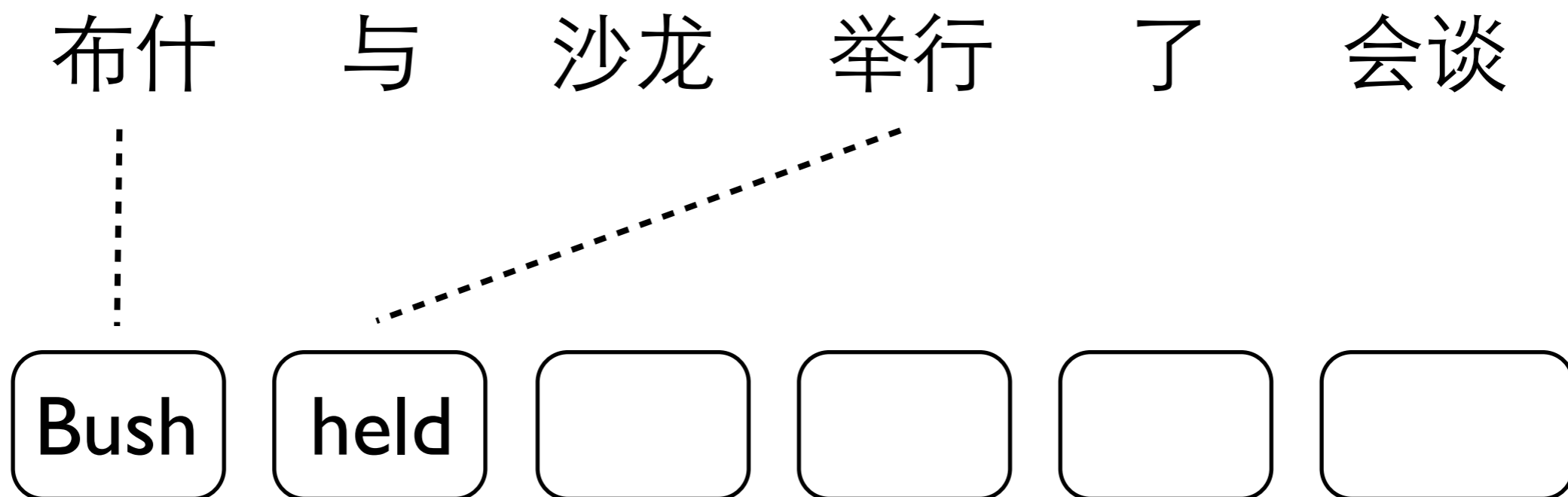
(Brown et al., 1993)

# 基于词的方法



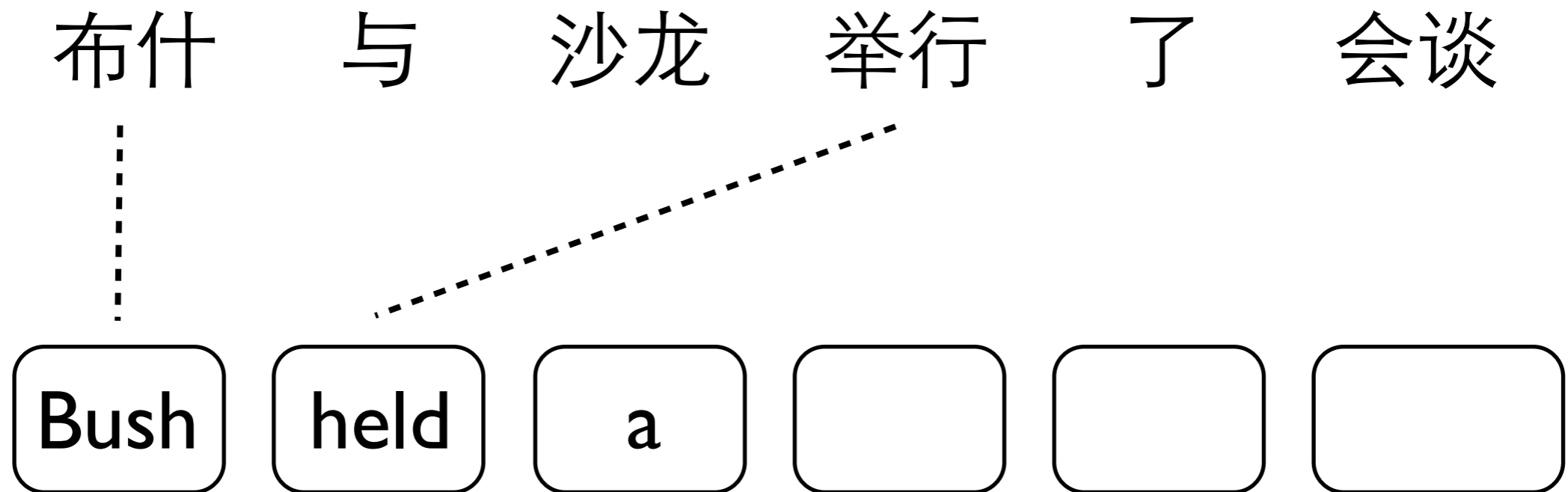
(Brown et al., 1993)

# 基于词的方法



(Brown et al., 1993)

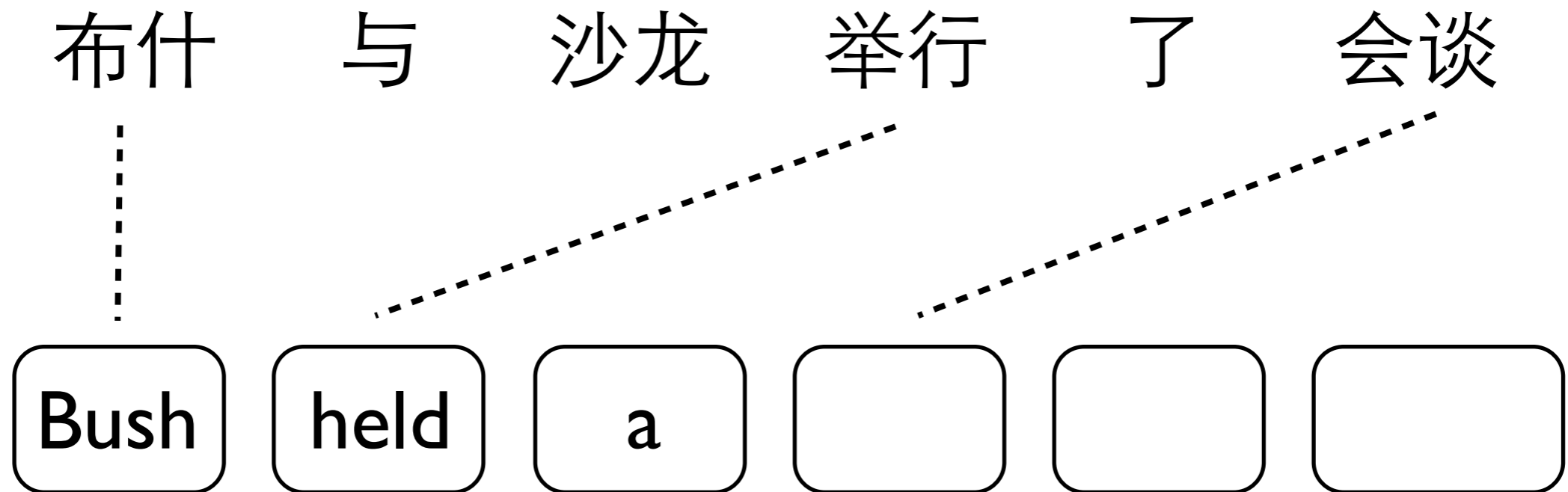
# 基于词的方法



(Brown et al., 1993)

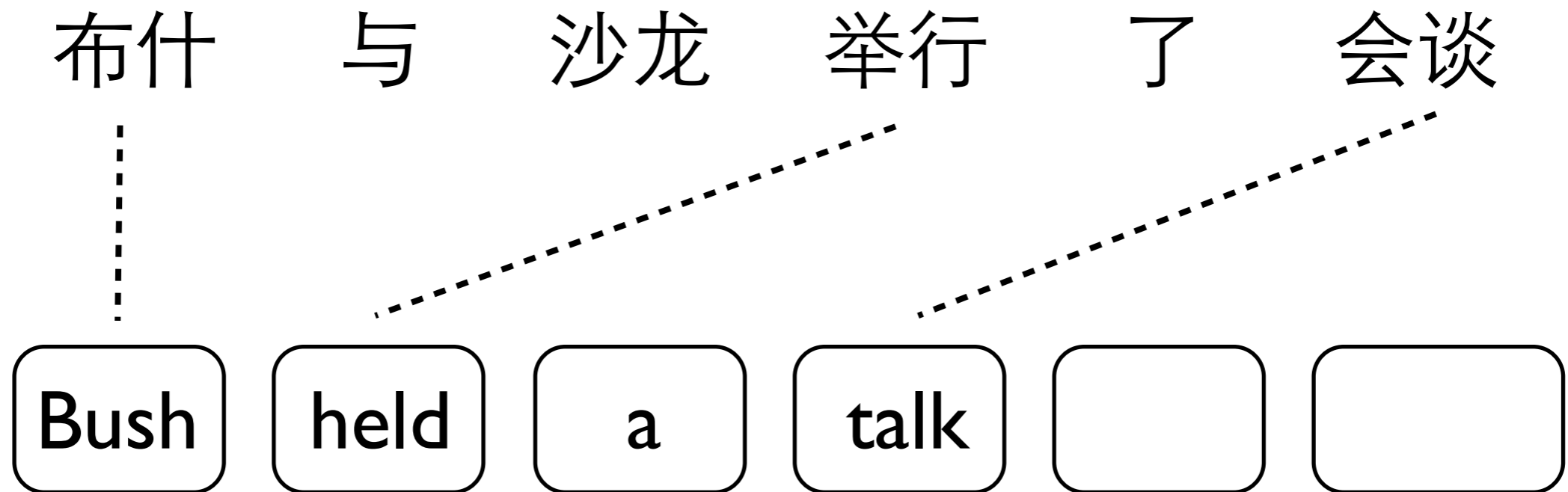


# 基于词的方法



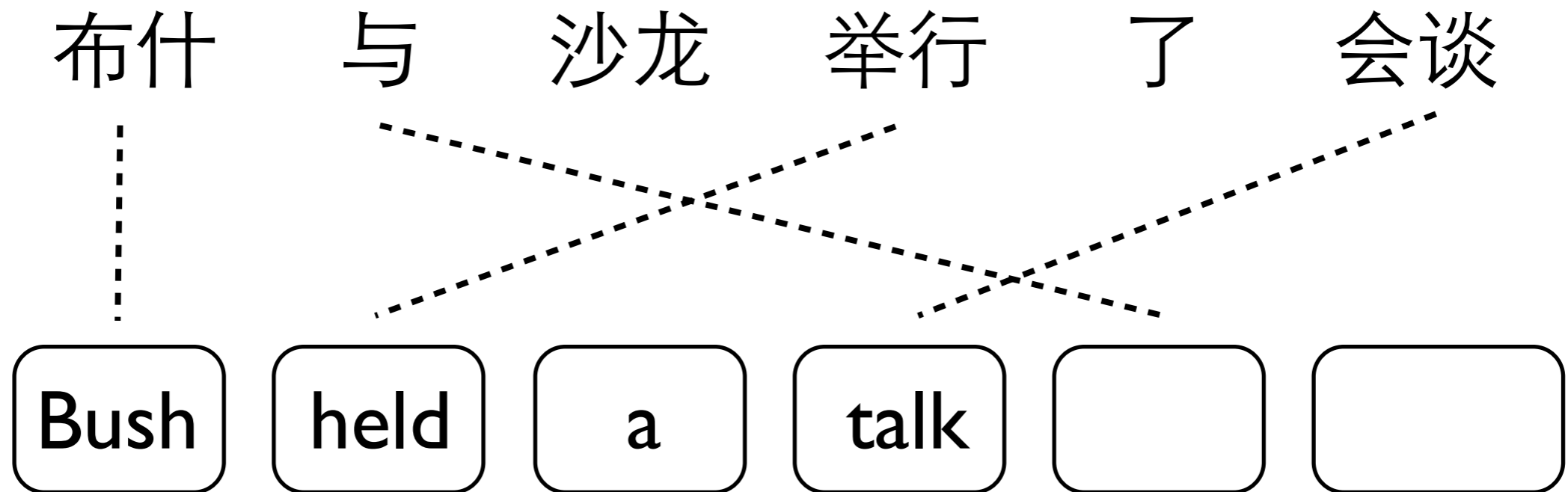
(Brown et al., 1993)

# 基于词的方法



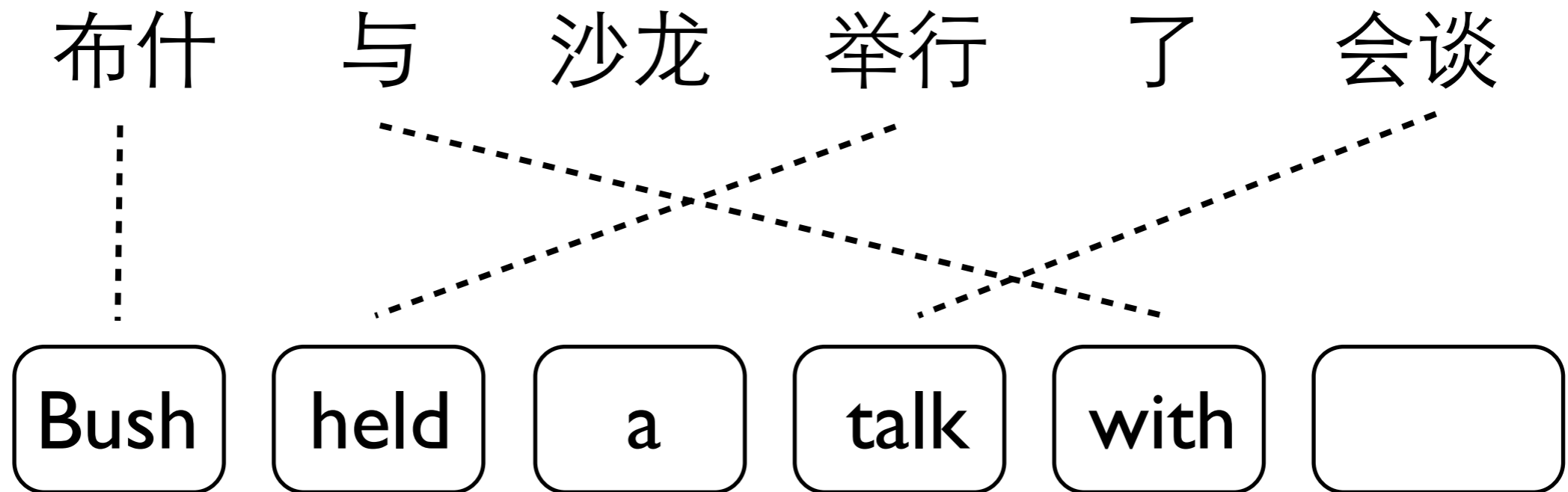
(Brown et al., 1993)

# 基于词的方法



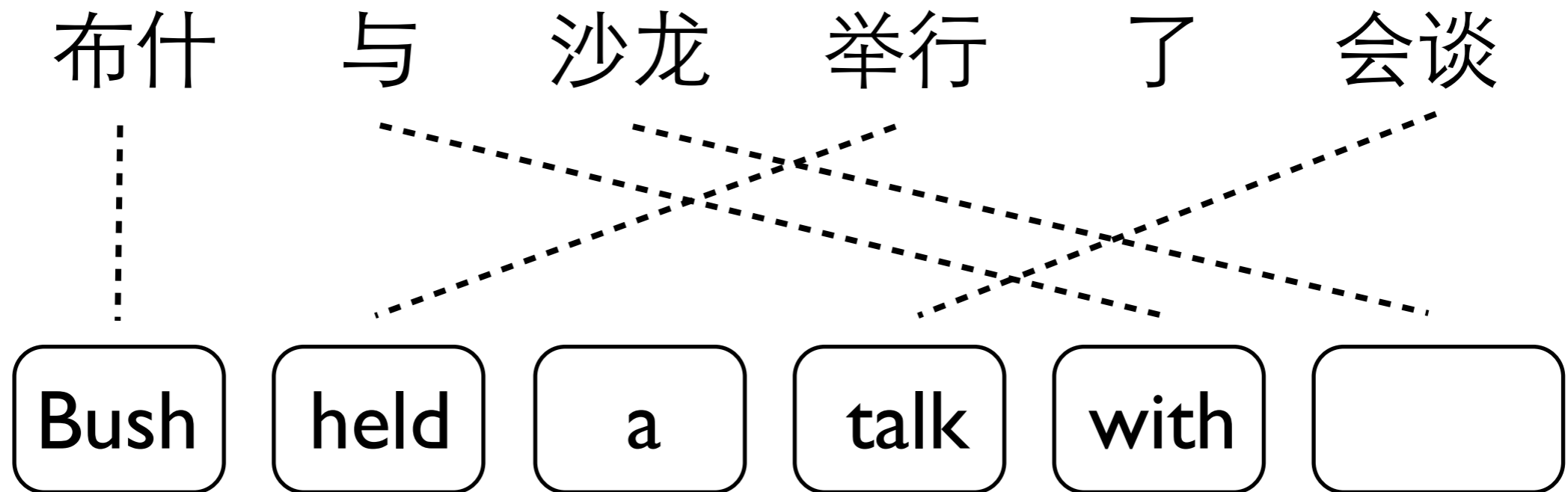
(Brown et al., 1993)

# 基于词的方法



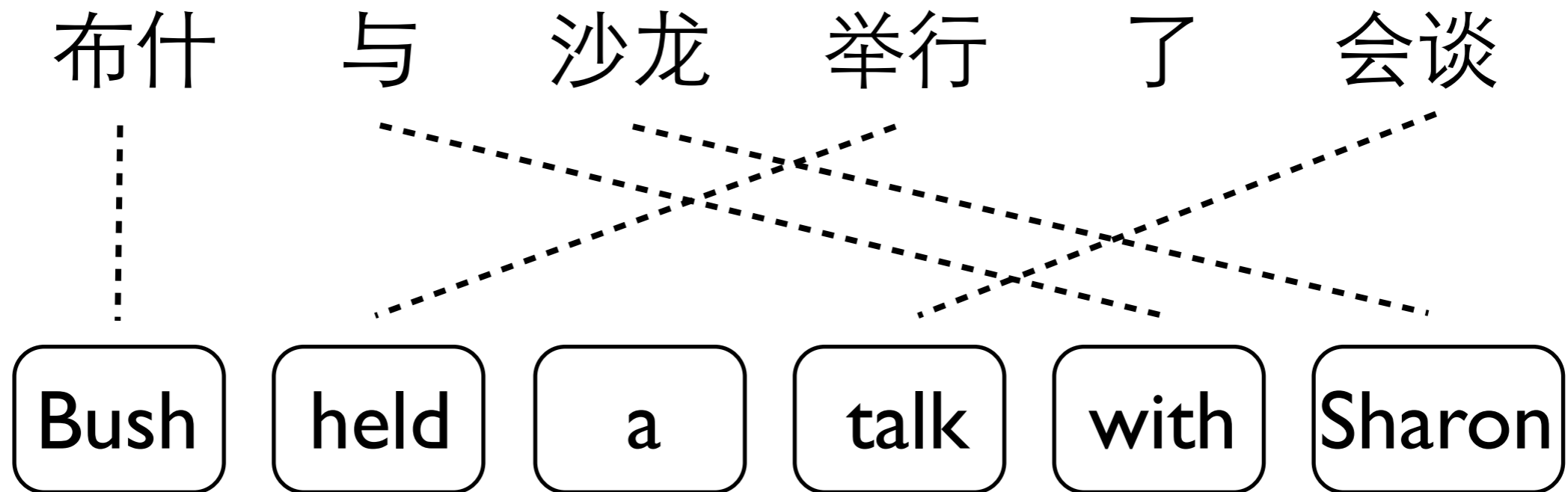
(Brown et al., 1993)

# 基于词的方法



(Brown et al., 1993)

# 基于词的方法



(Brown et al., 1993)

# 基于短语的方法

布什 与 沙龙 举行 了 会谈

(Koehn et al., 2003)

# 基于短语的方法

布什

与 沙龙

举行 了 会谈

(Koehn et al., 2003)



# 基于短语的方法

布什 与 沙龙 举行 了 会谈

(Koehn et al., 2003)

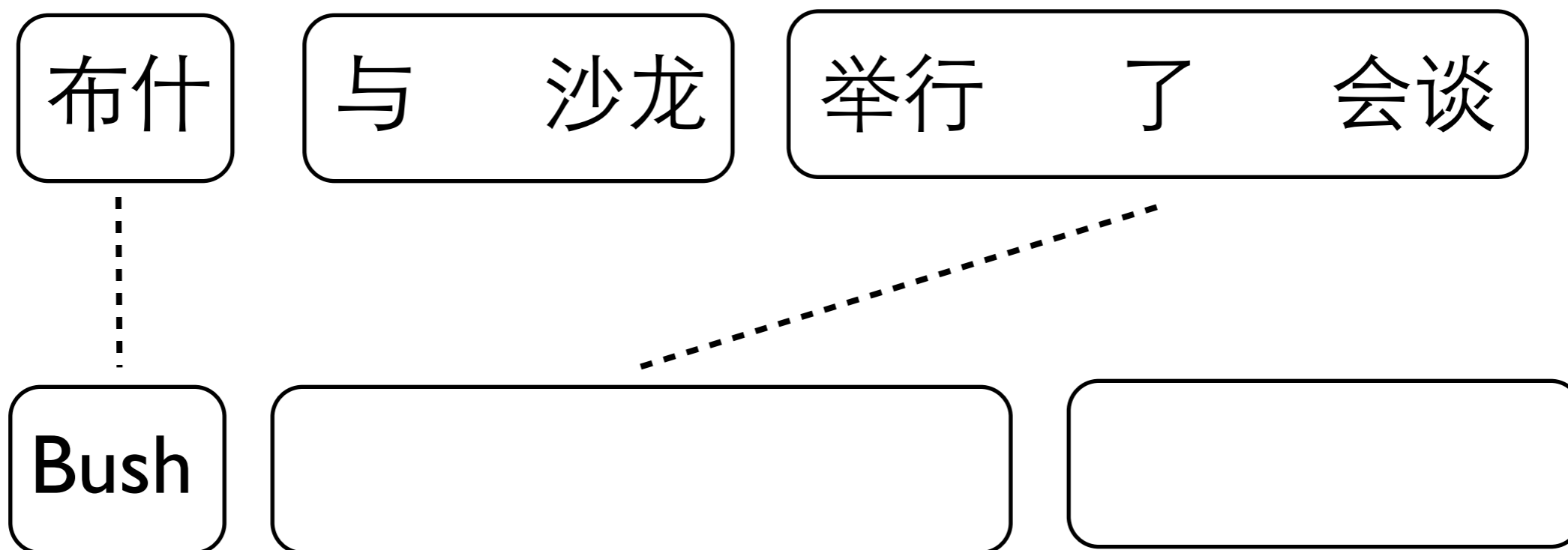


# 基于短语的方法



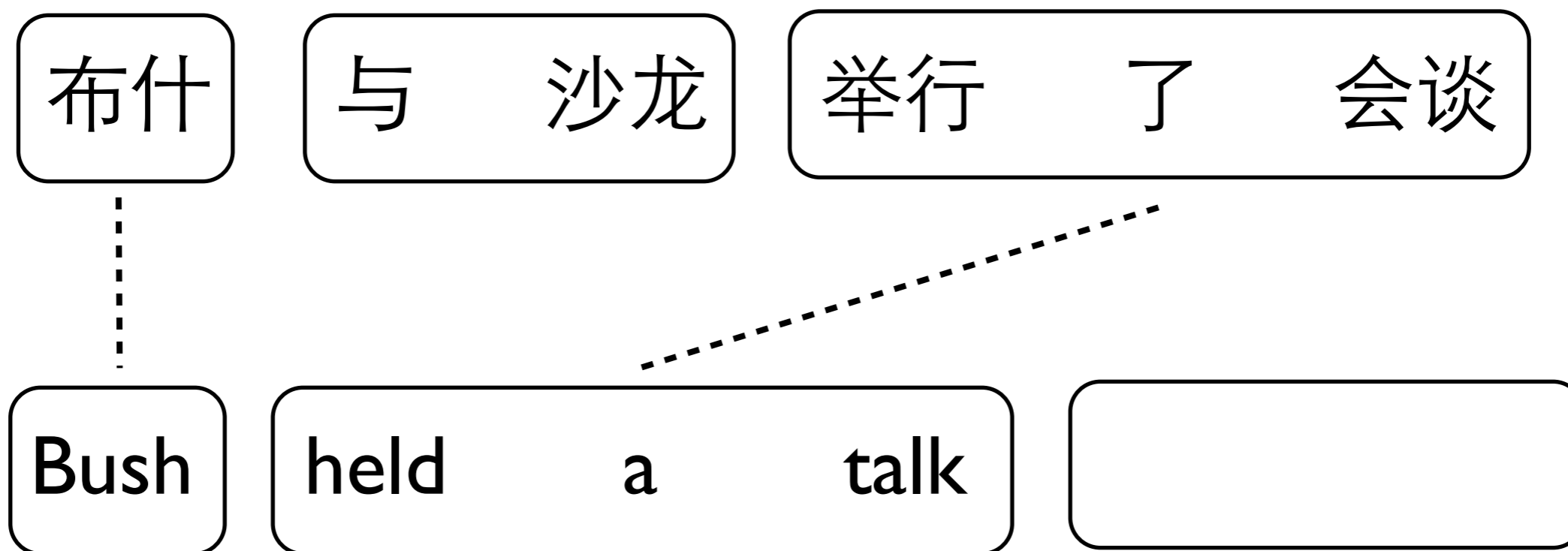
(Koehn et al., 2003)

# 基于短语的方法



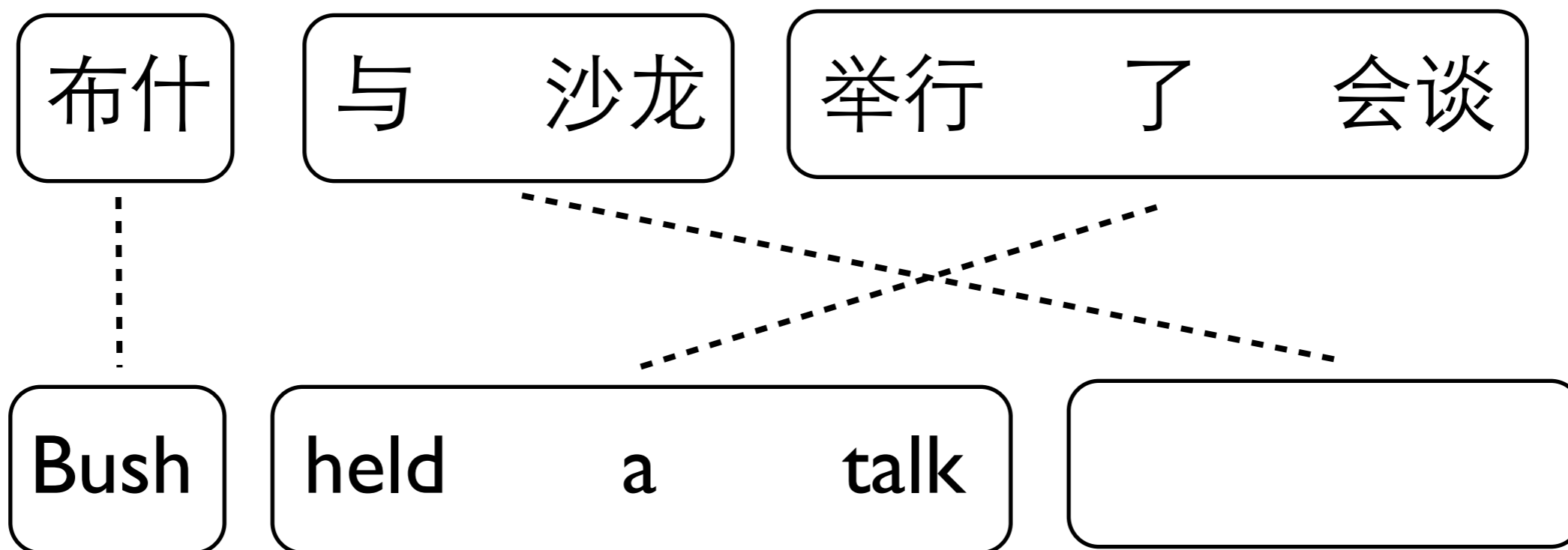
(Koehn et al., 2003)

# 基于短语的方法



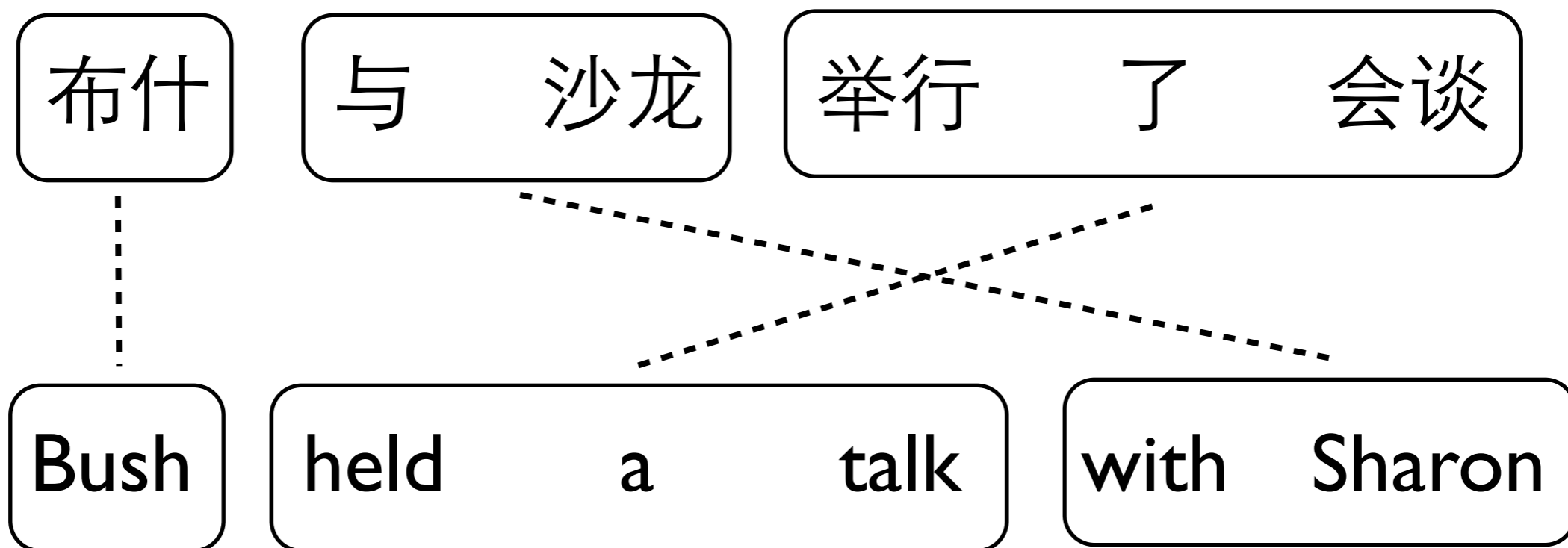
(Koehn et al., 2003)

# 基于短语的方法



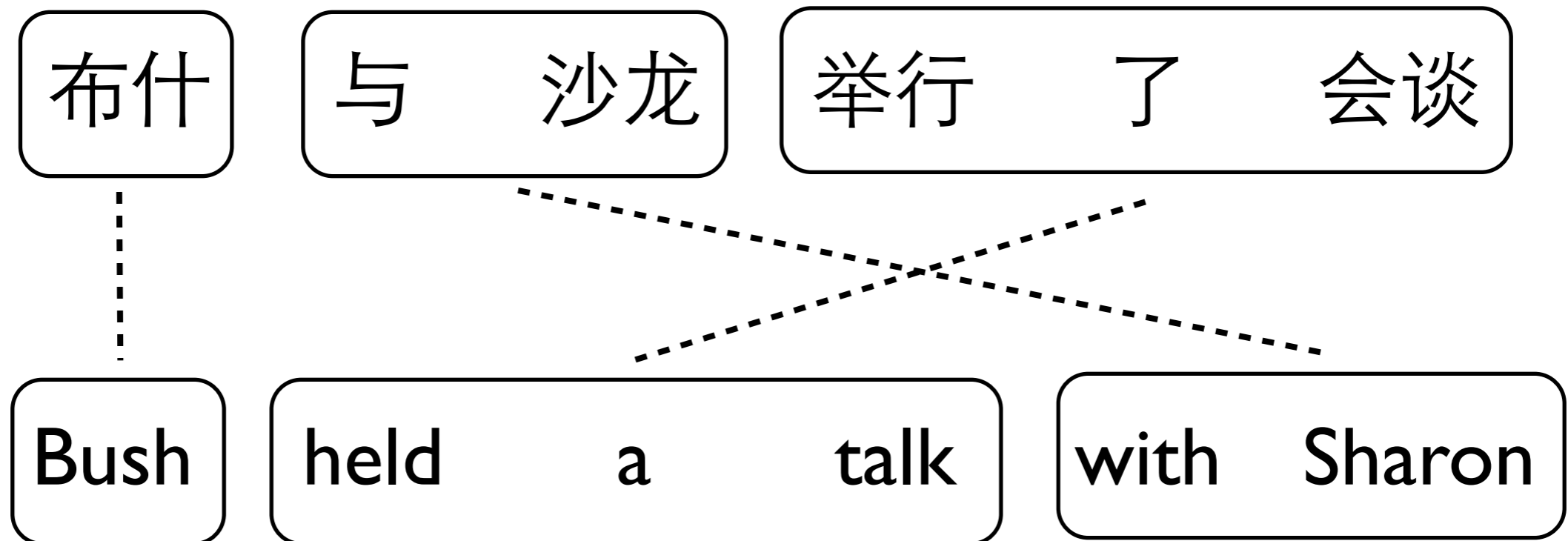
(Koehn et al., 2003)

# 基于短语的方法



(Koehn et al., 2003)

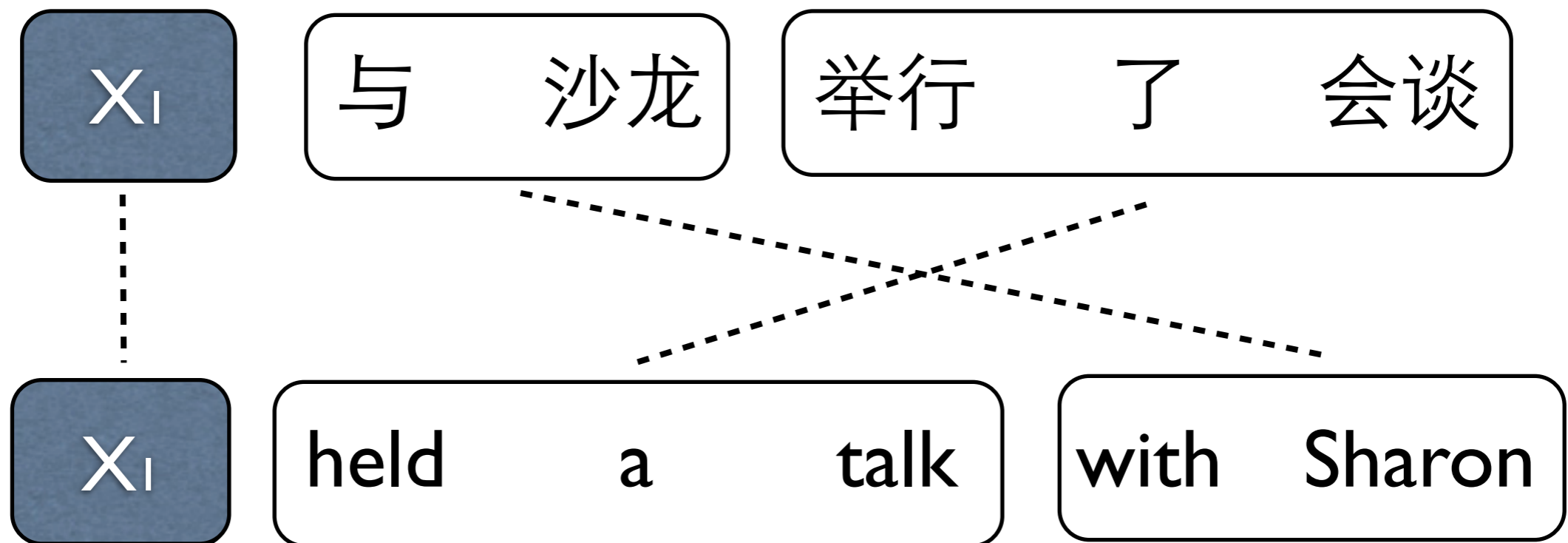
# 基于层次短语的方法



(Chiang, 2005)

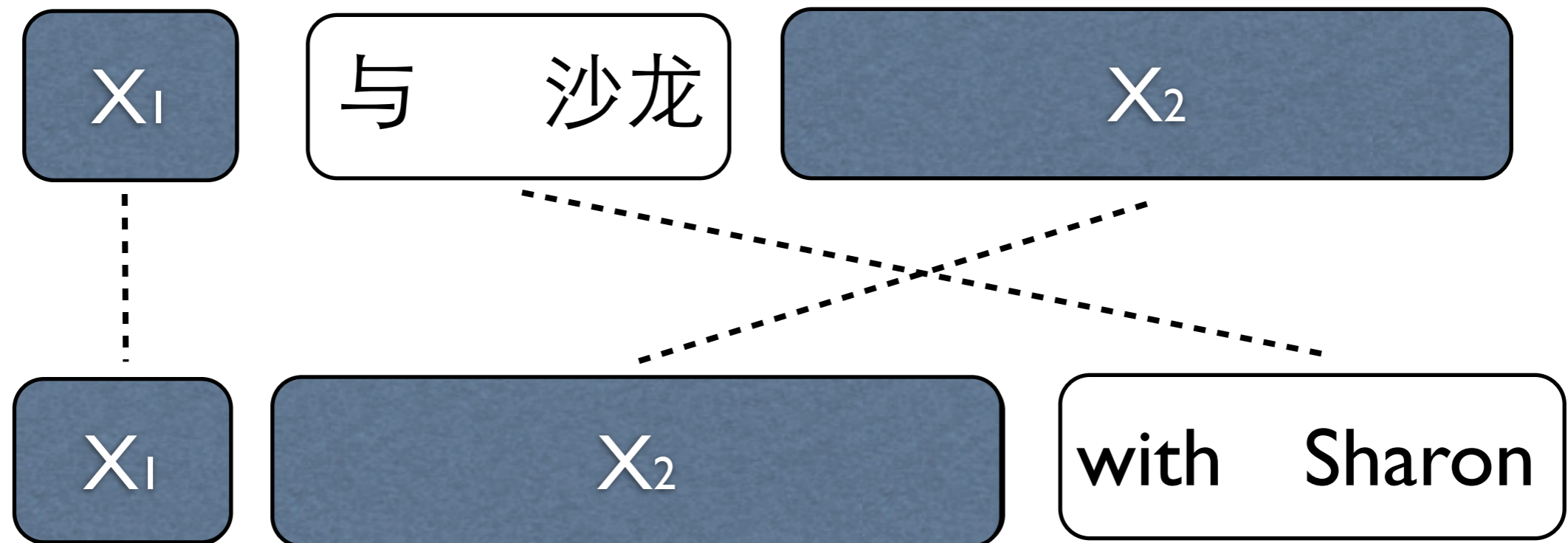


# 基于层次短语的方法



(Chiang, 2005)

# 基于层次短语的方法



(Chiang, 2005)

# 类比

# 类比

汉语



英语

# 类比

汉语



英语

1. 理解汉语句子
2. 生成英语句子

# 类比

汉语



英语

1. 理解汉语句子
2. 生成英语句子

C++



汇编

# 类比

汉语



英语

1. **理解**汉语句子
2. **生成**英语句子

C++



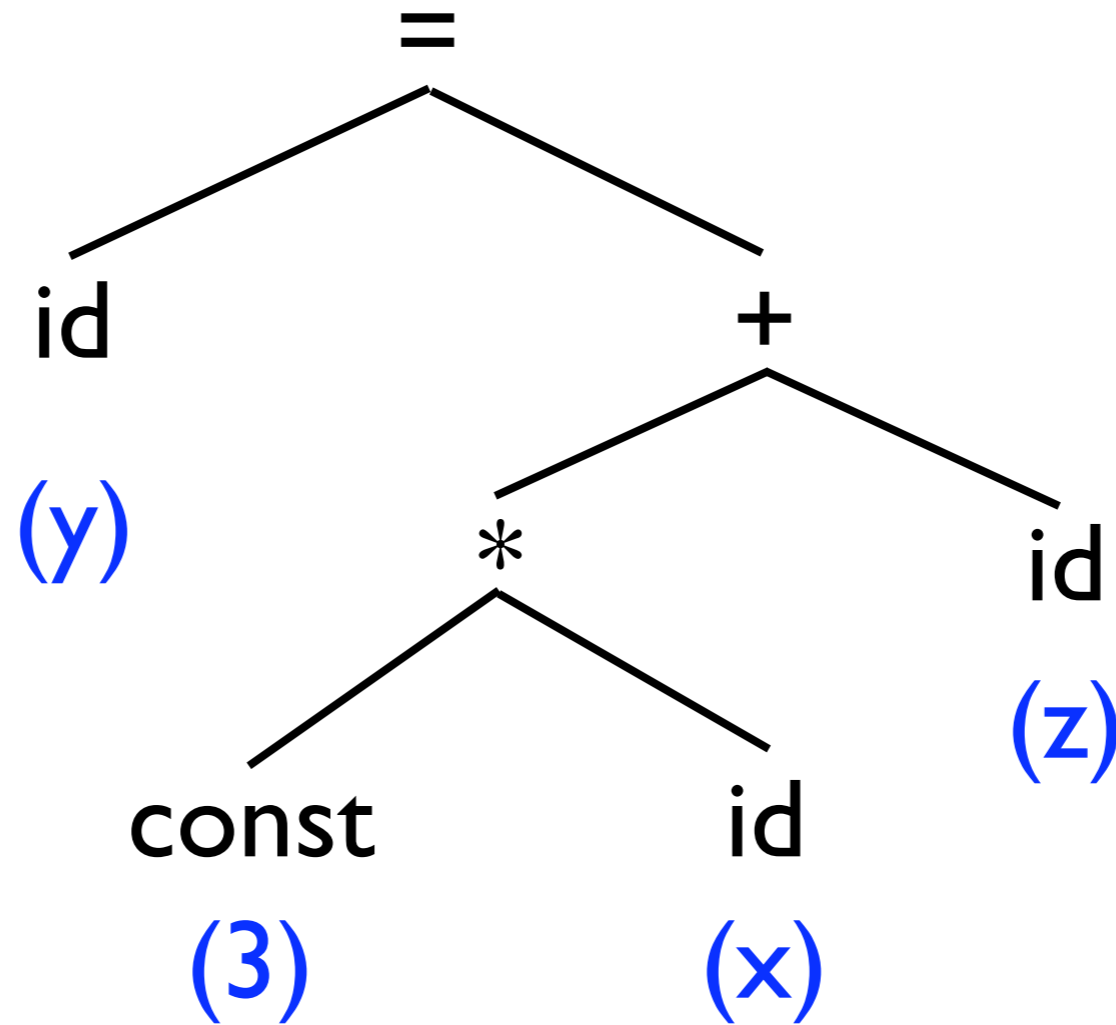
汇编

1. **分析**C++程序，获取句法树
2. 利用句法树**生成**汇编代码

# 句法指导的翻译

● 输入： $y=3*x+z$

● 分析：



(Irons, 1961)



# 类比

汉语



英语

1. **理解**汉语句子
2. **生成**英语句子

C++



汇编

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2. 利用句法树**生成**汇编代码

汉语



英语

# 类比

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1. **分析**汉语句子，获取句法树
2. 利用句法树**生成**英语句子

# 句法指导的翻译

- 输入：布什与沙龙举行了会谈
- 分析：

布什 与 沙龙 举行 了 会谈

# 句法指导的翻译

- 输入：布什与沙龙举行了会谈
- 分析：

NPB

|

布什

与

沙龙

举行

了

会谈

# 句法指导的翻译

- 输入：布什与沙龙举行了会谈
- 分析：

NPB	P					
布什	与	沙龙	举行	了		会谈

# 句法指导的翻译

- 输入：布什与沙龙举行了会谈
- 分析：

NPB	P	NPB			
布什	与	沙龙	举行	了	会谈

# 句法指导的翻译

- 输入：布什与沙龙举行了会谈
- 分析：

NPB	P	NPB	VS		
布什	与	沙龙	举行	了	会谈

# 句法指导的翻译

- 输入：布什与沙龙举行了会谈
- 分析：

NPB	P	NPB	VS	AS	
布什	与	沙龙	举行	了	会谈



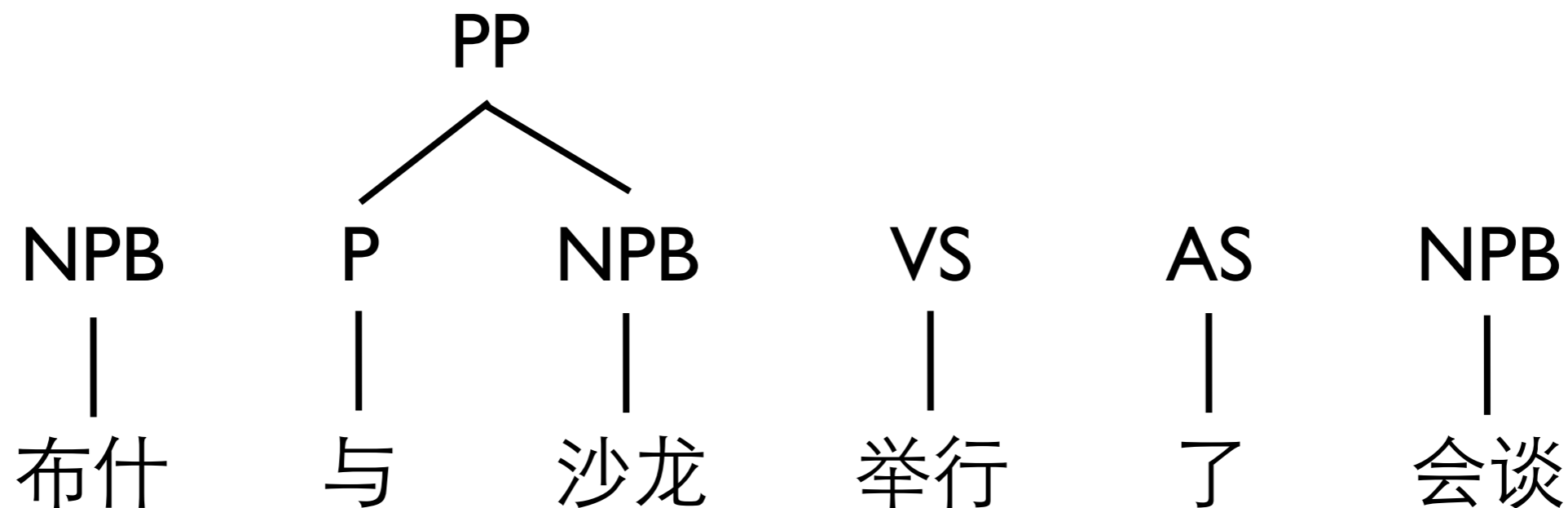
# 句法指导的翻译

- 输入：布什与沙龙举行了会谈
- 分析：

NPB	P	NPB	VS	AS	NPB
布什	与	沙龙	举行	了	会谈

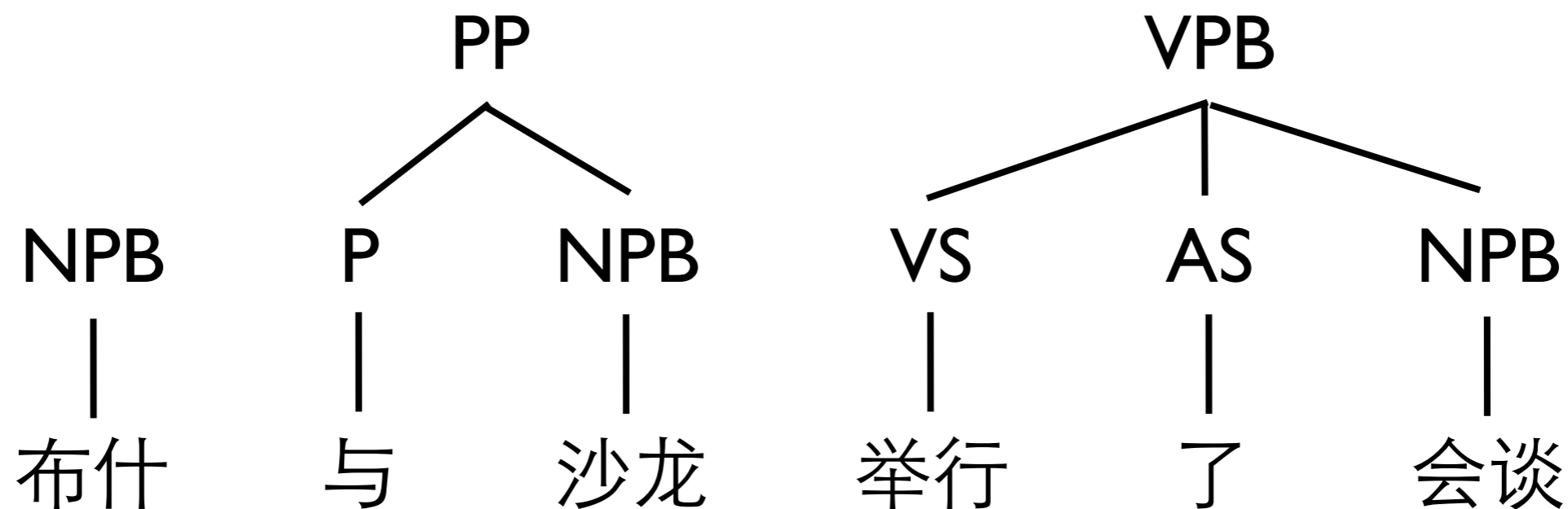
# 句法指导的翻译

- 输入：布什与沙龙举行了会谈
- 分析：



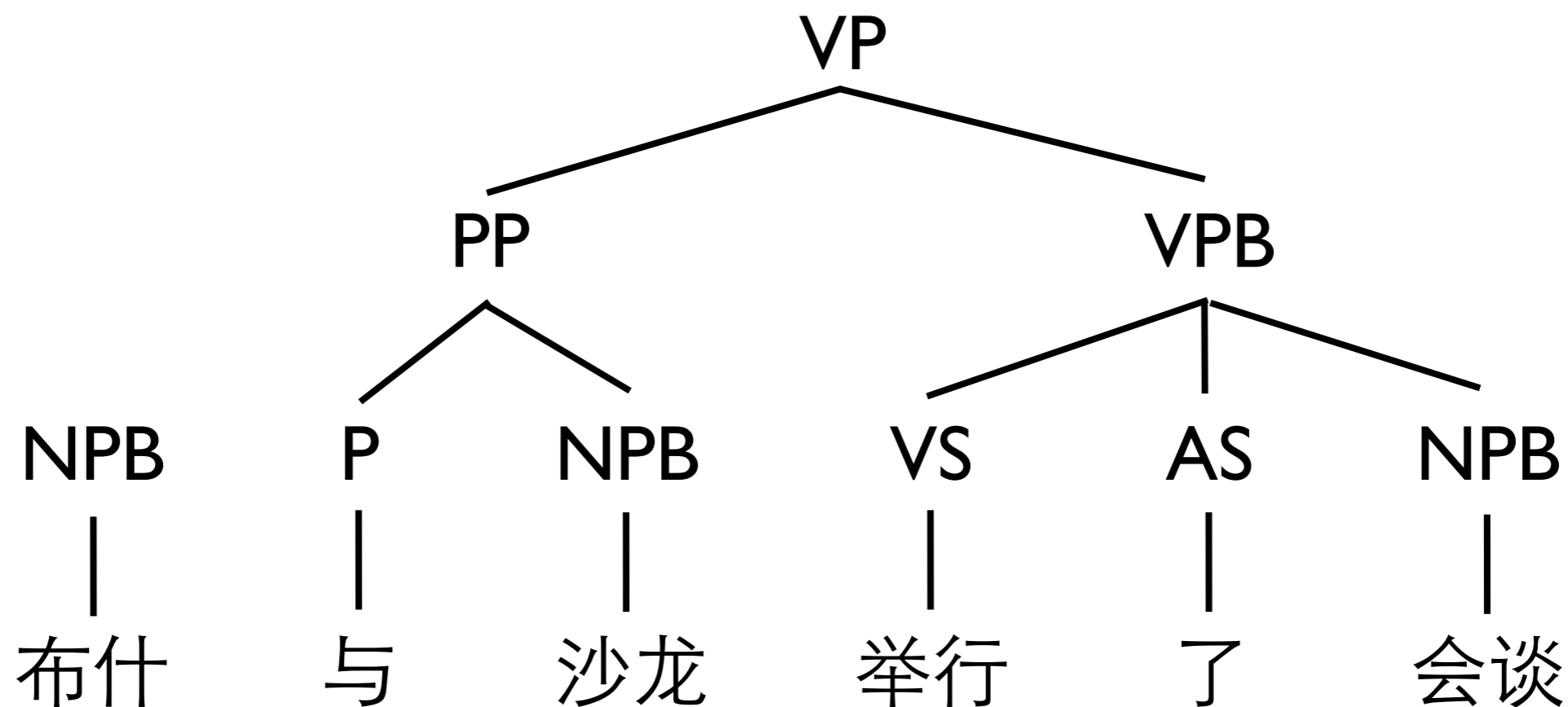
# 句法指导的翻译

- 输入：布什与沙龙举行了会谈
- 分析：



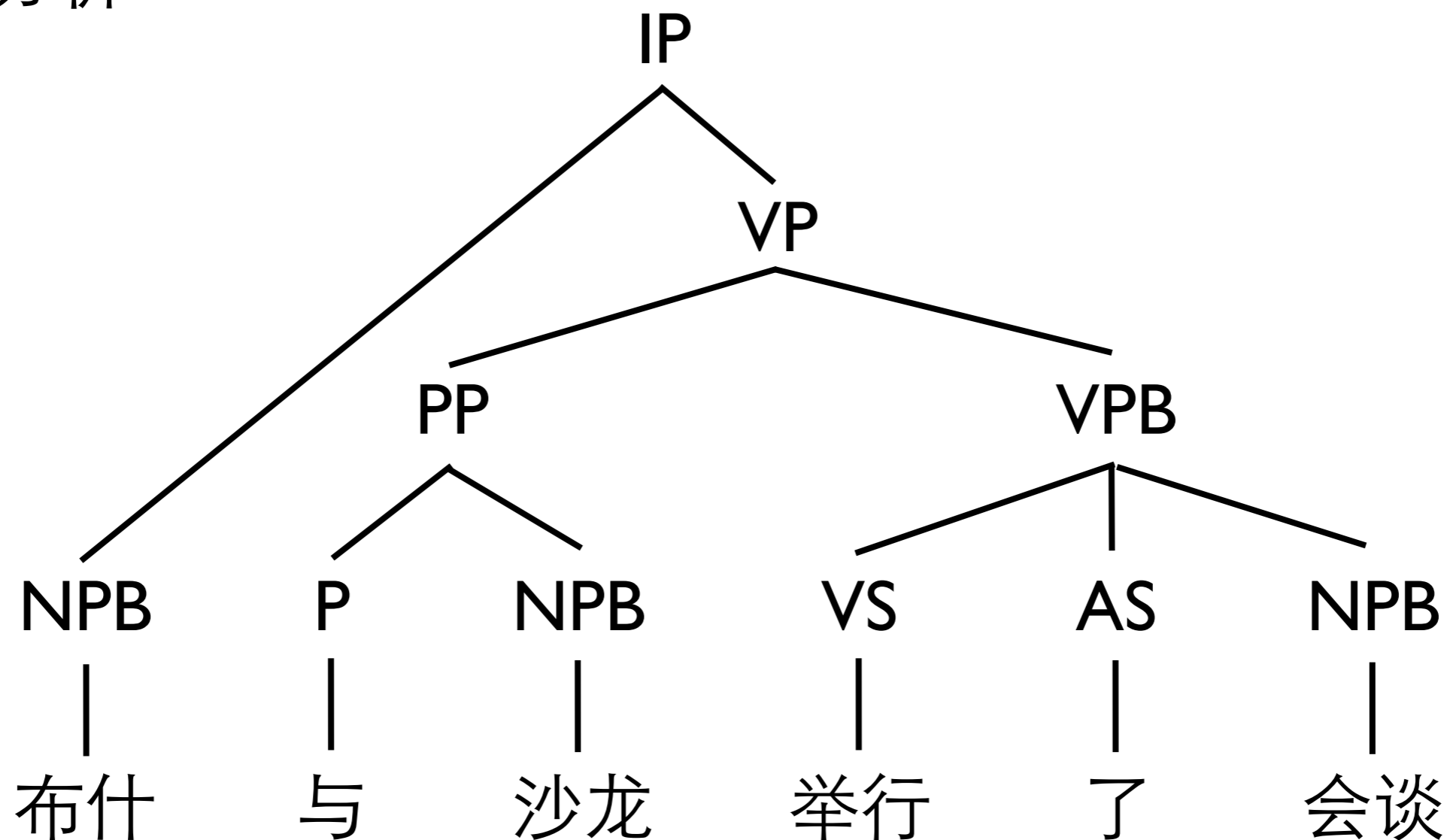
# 句法指导的翻译

- 输入：布什与沙龙举行了会谈
- 分析：

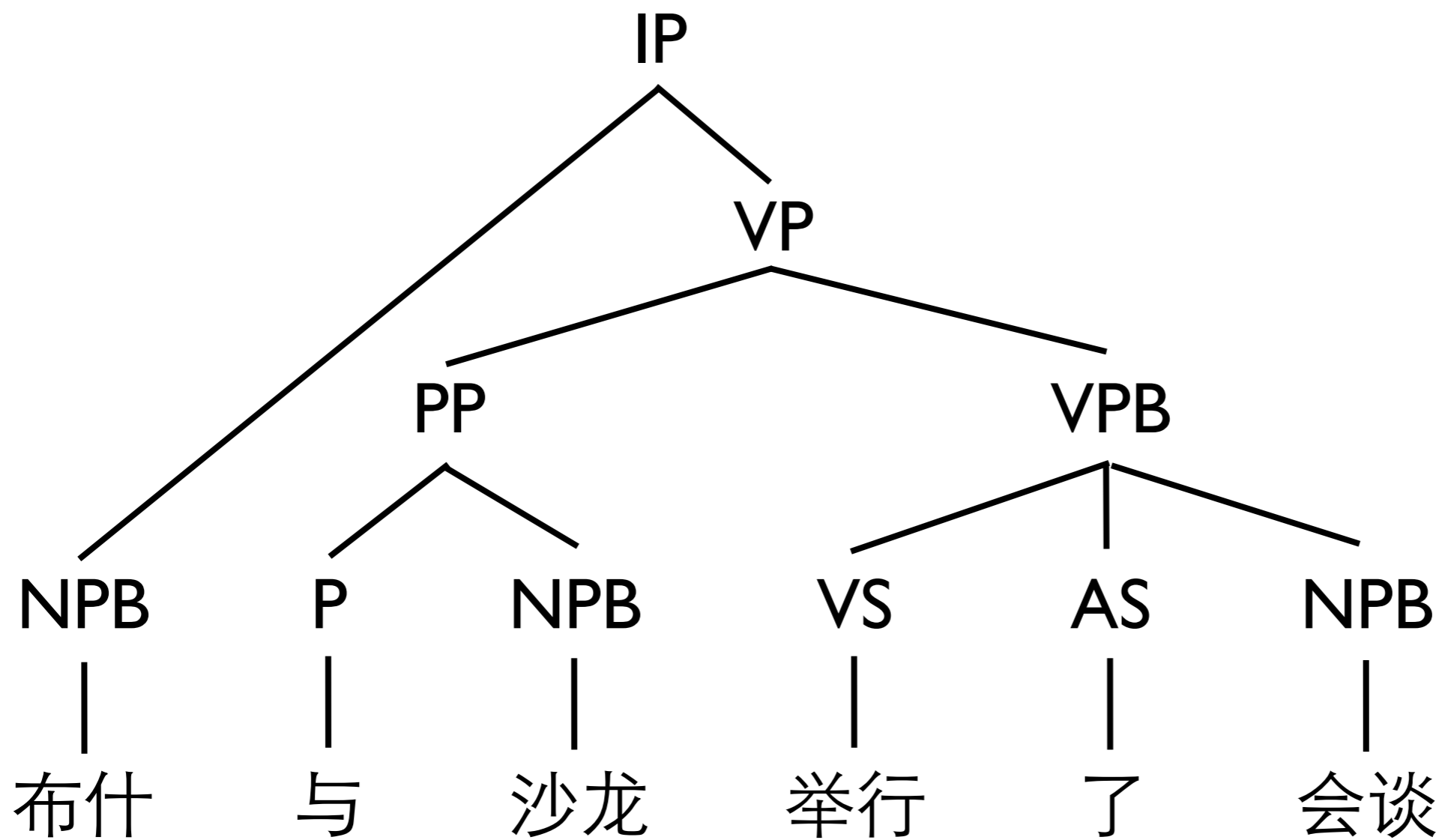


# 句法指导的翻译

- 输入：布什与沙龙举行了会谈
- 分析：

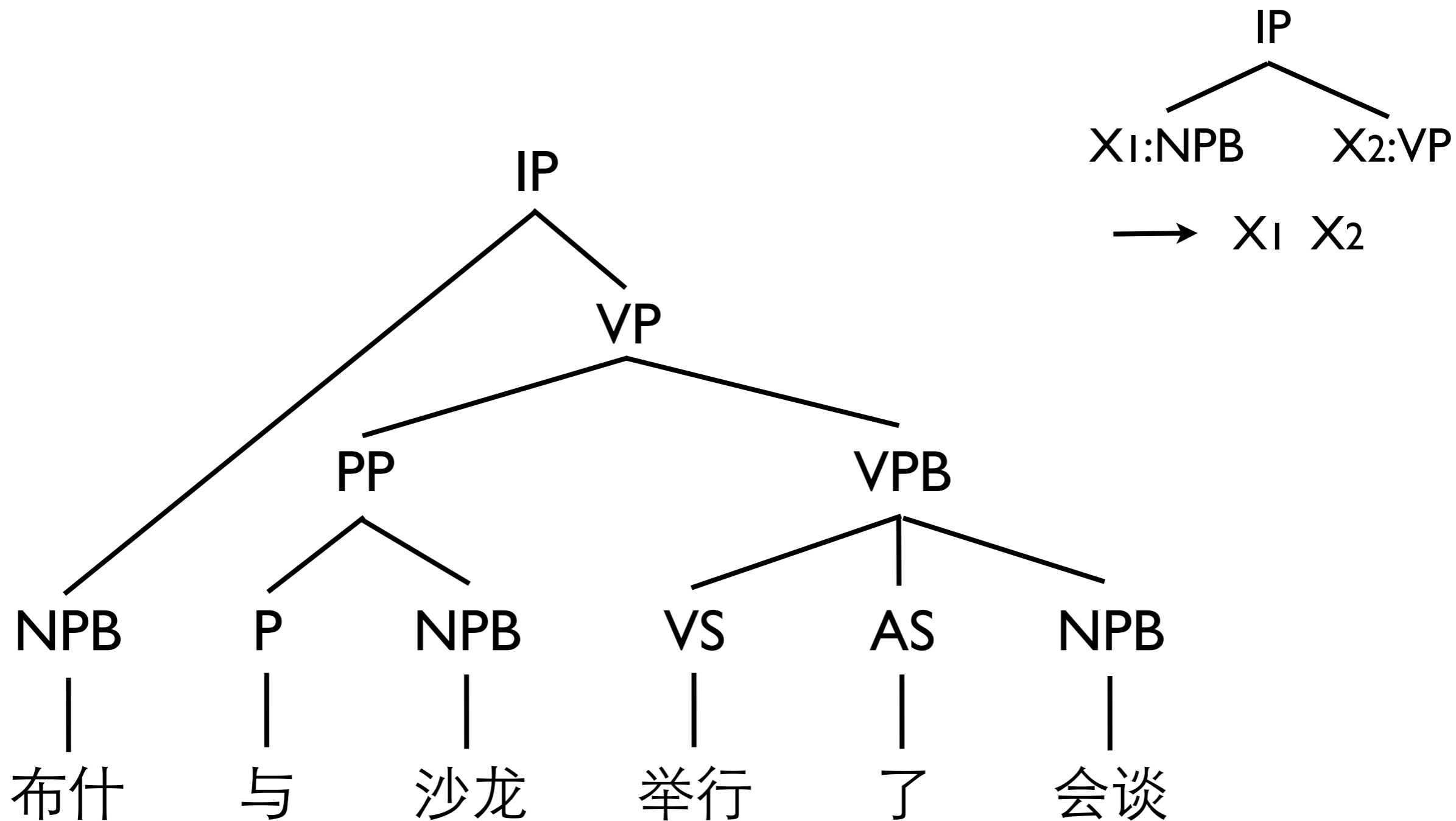


# 树到串翻译



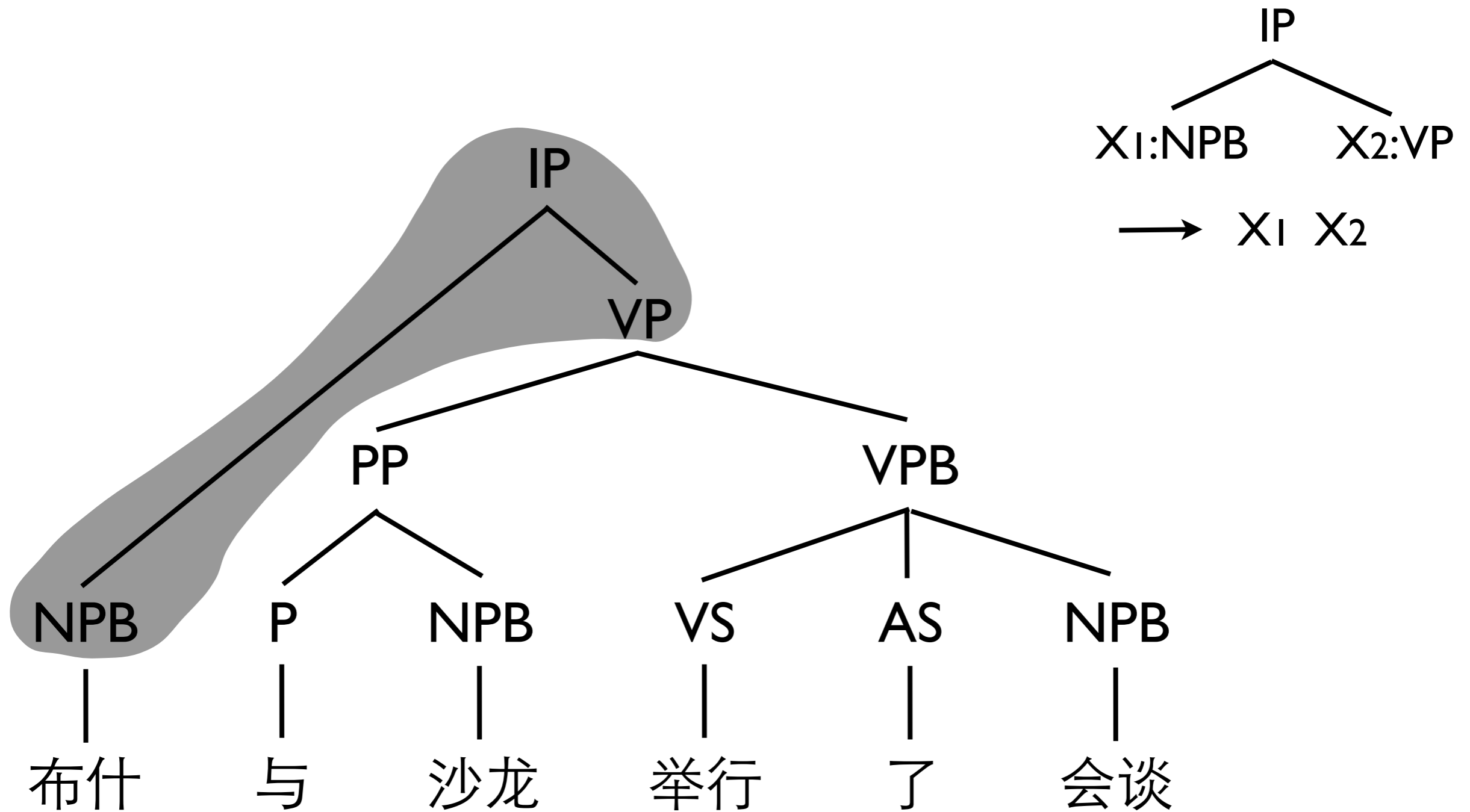
(Liu et al., 2006; Huang et al., 2006)

# 树到串翻译



(Liu et al., 2006; Huang et al., 2006)

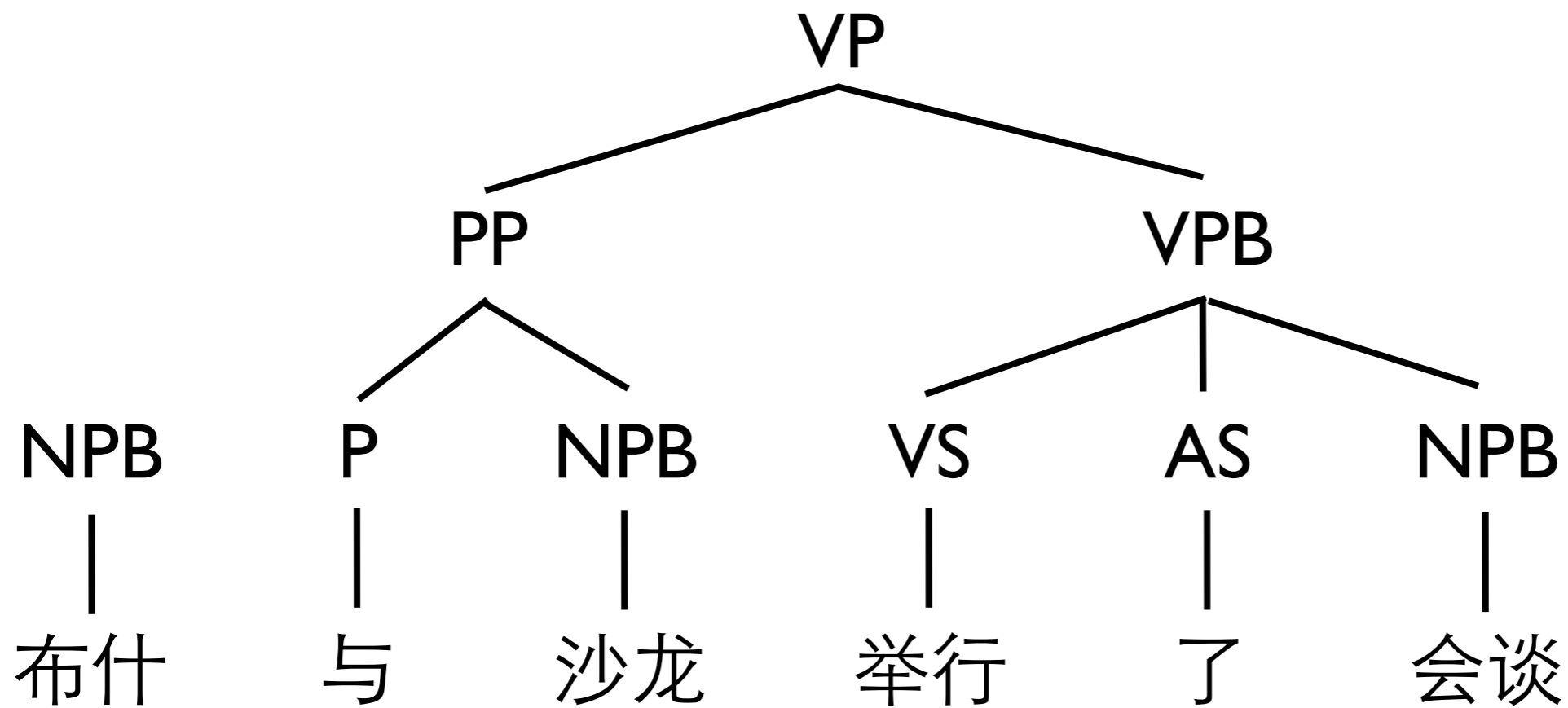
# 树到串翻译



(Liu et al., 2006; Huang et al., 2006)

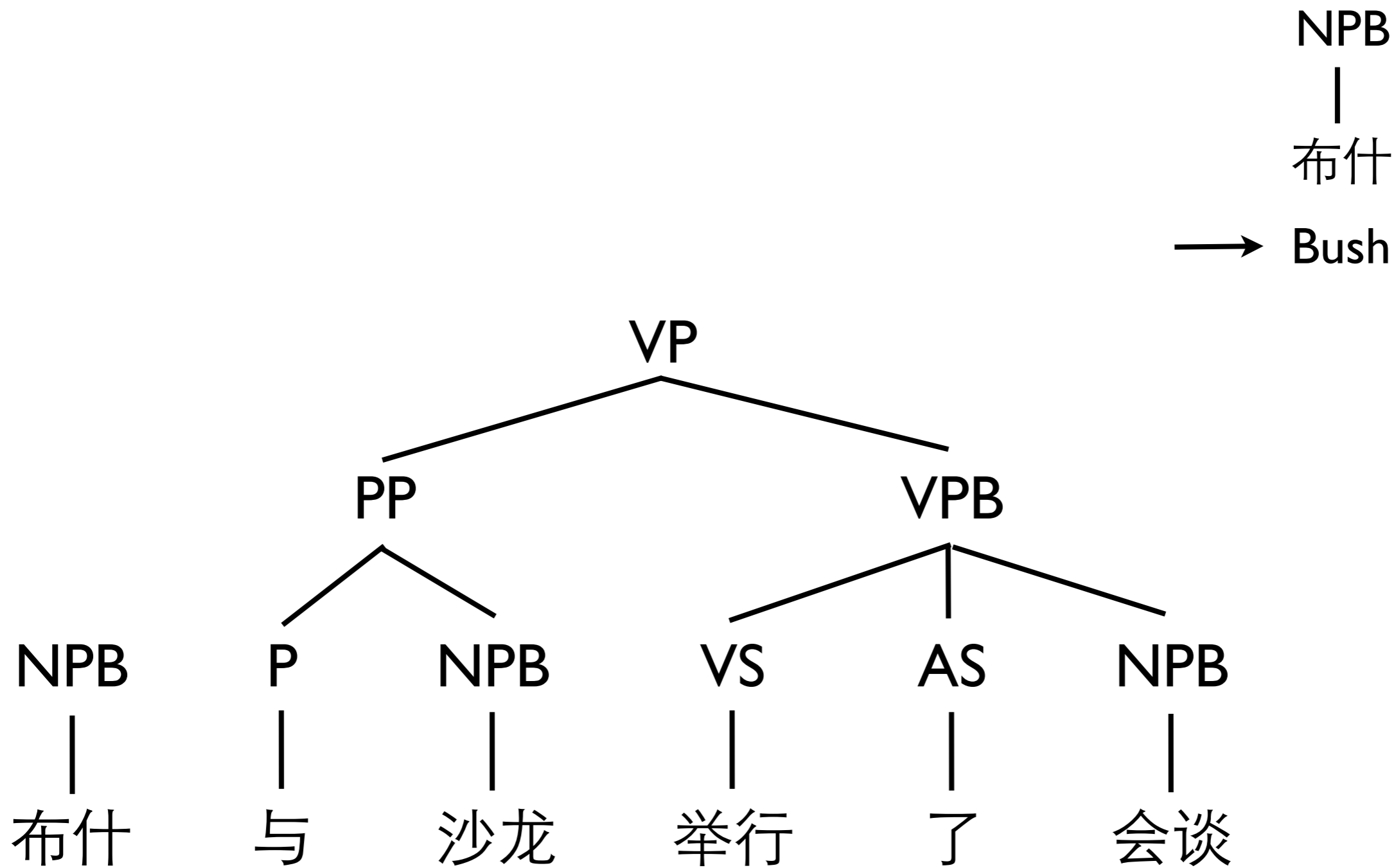


# 树到串翻译



(Liu et al., 2006; Huang et al., 2006)

# 树到串翻译



(Liu et al., 2006; Huang et al., 2006)

# 树到串翻译

NPB

|  
布什

→ Bush

VP

PP

VPB

NPB

|  
布什

P

|  
与

NPB

|  
沙龙

VS

|  
举行

AS

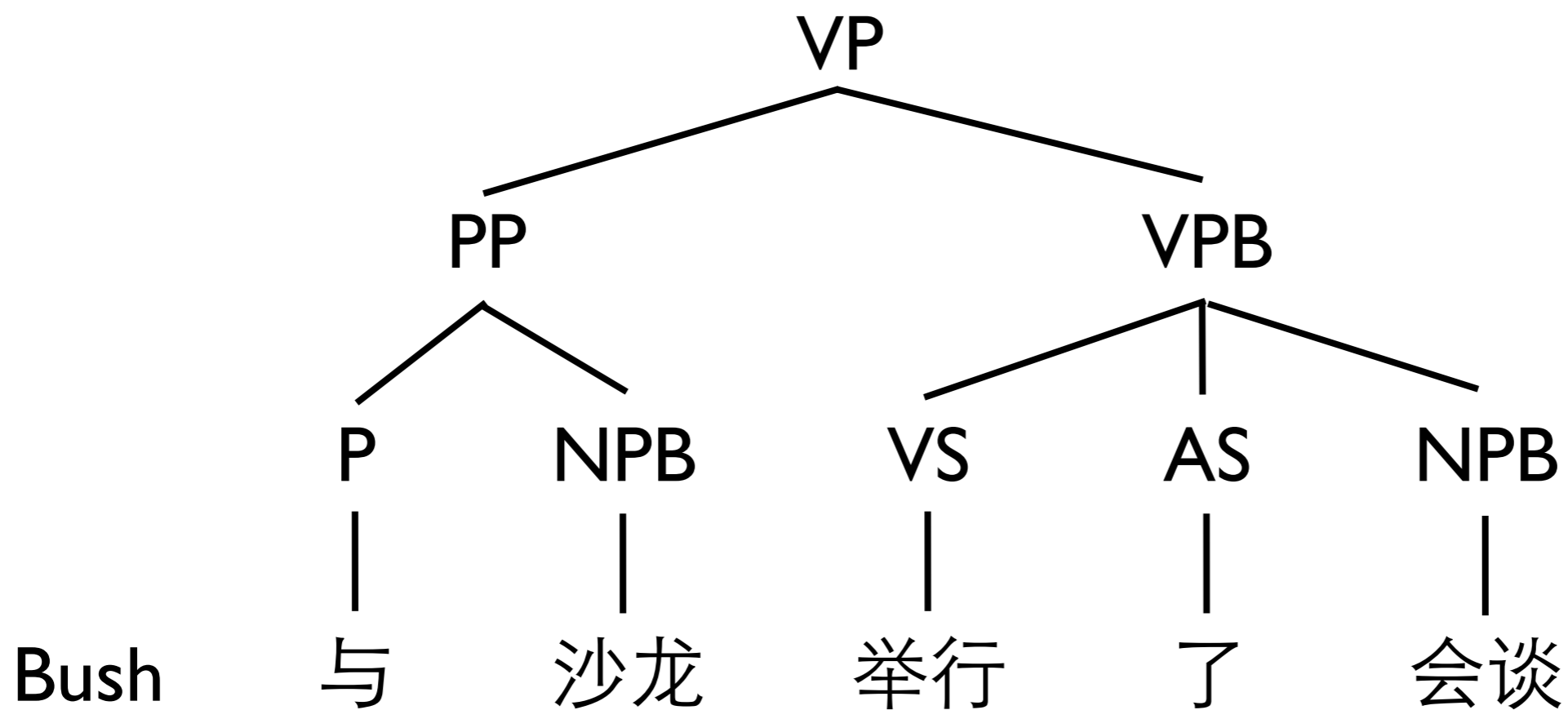
|  
了

NPB

|  
会谈

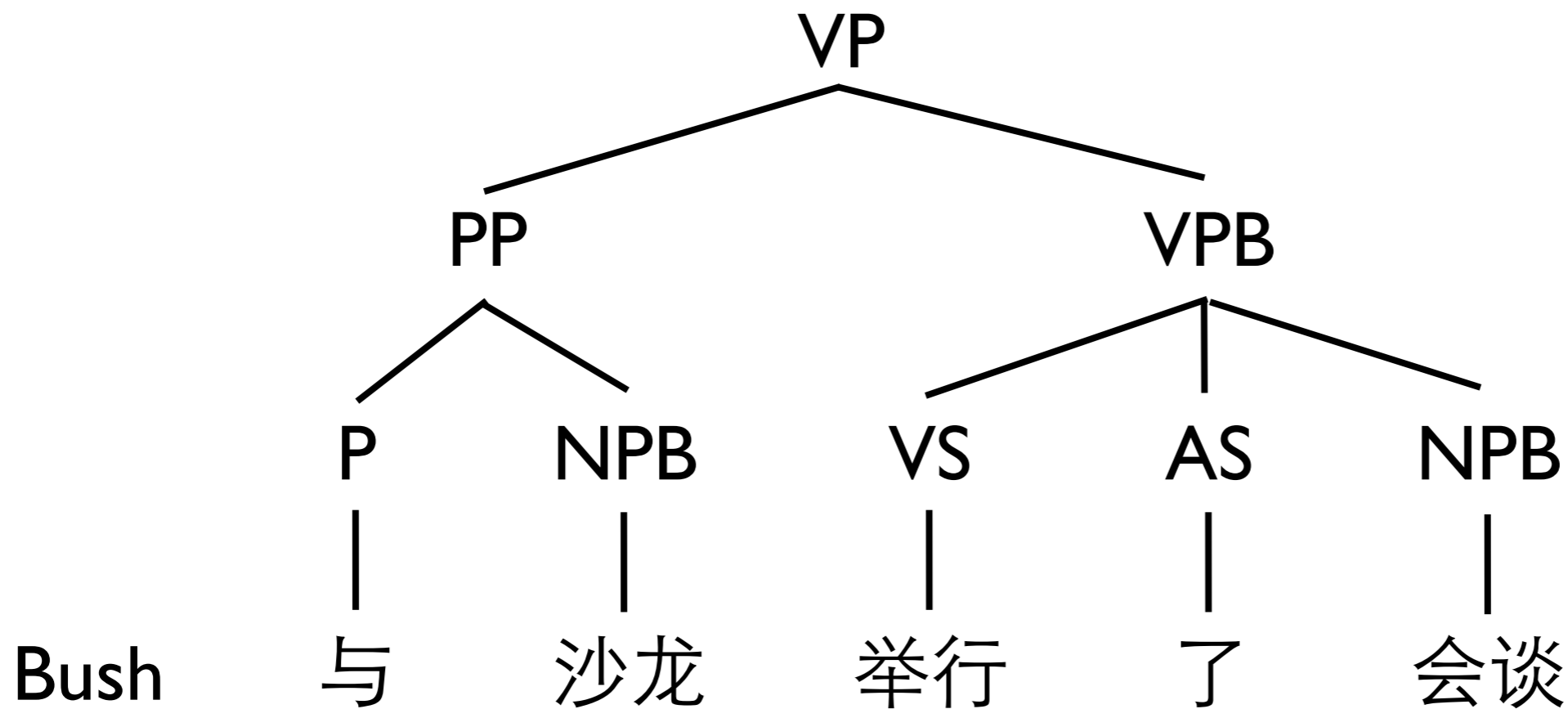
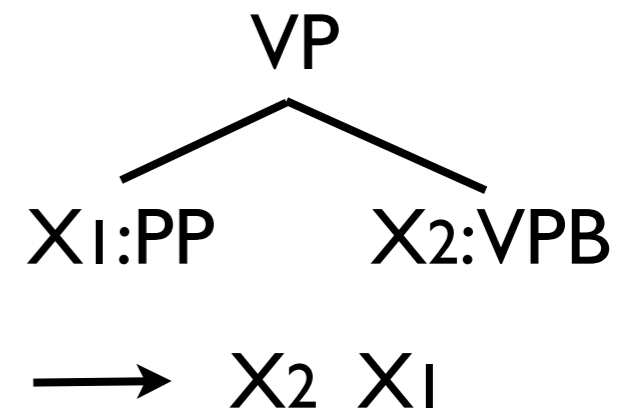
(Liu et al., 2006; Huang et al., 2006)

# 树到串翻译



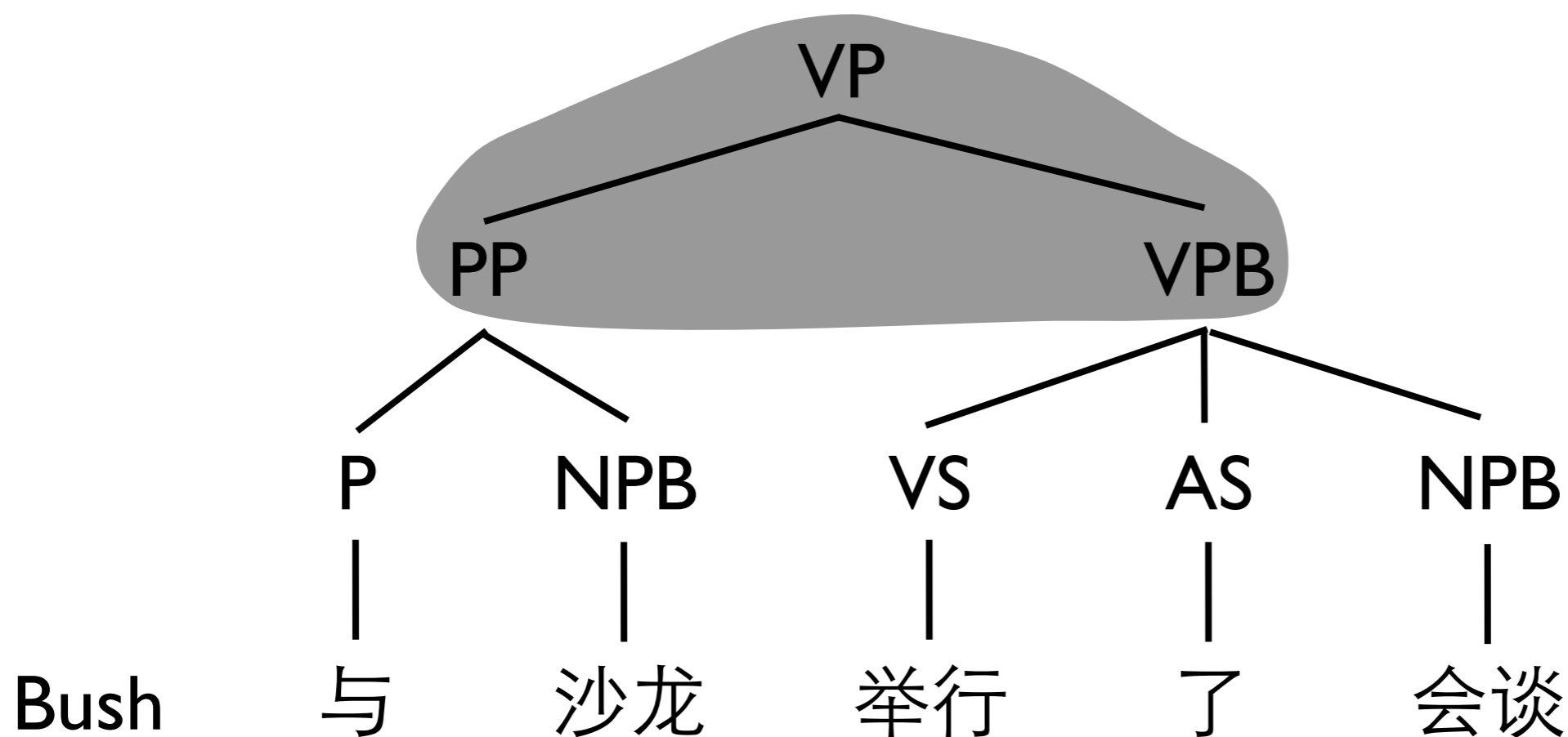
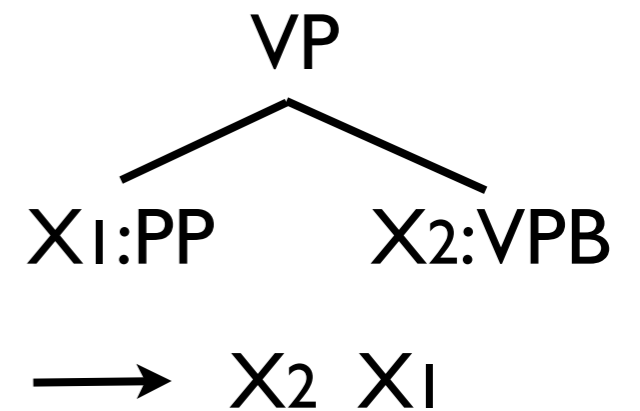
(Liu et al., 2006; Huang et al., 2006)

# 树到串翻译



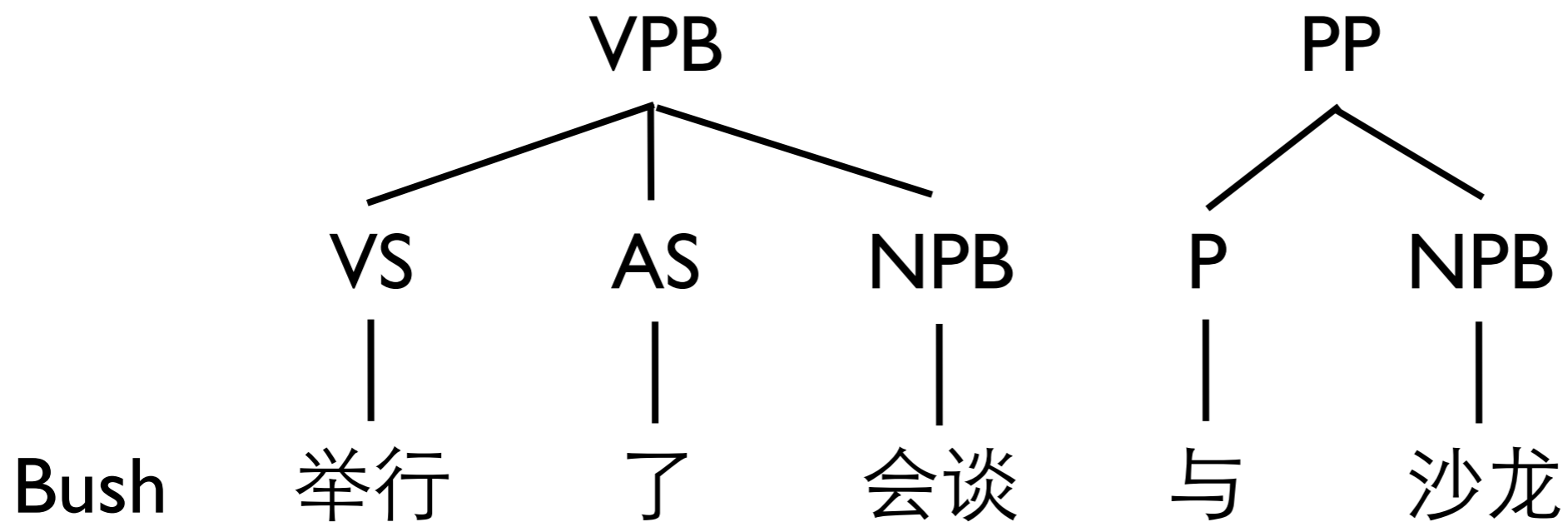
(Liu et al., 2006; Huang et al., 2006)

# 树到串翻译



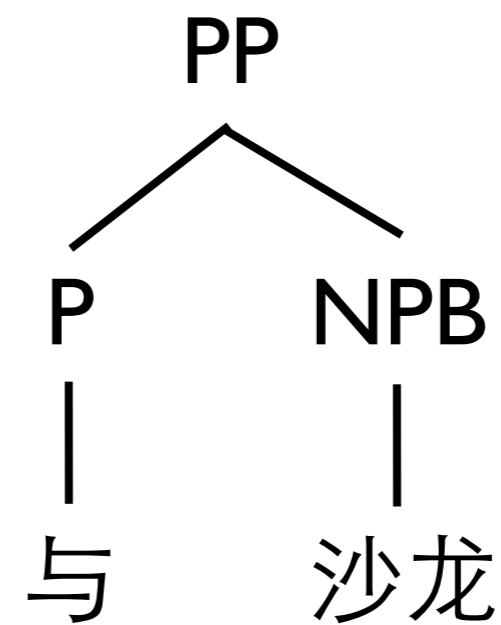
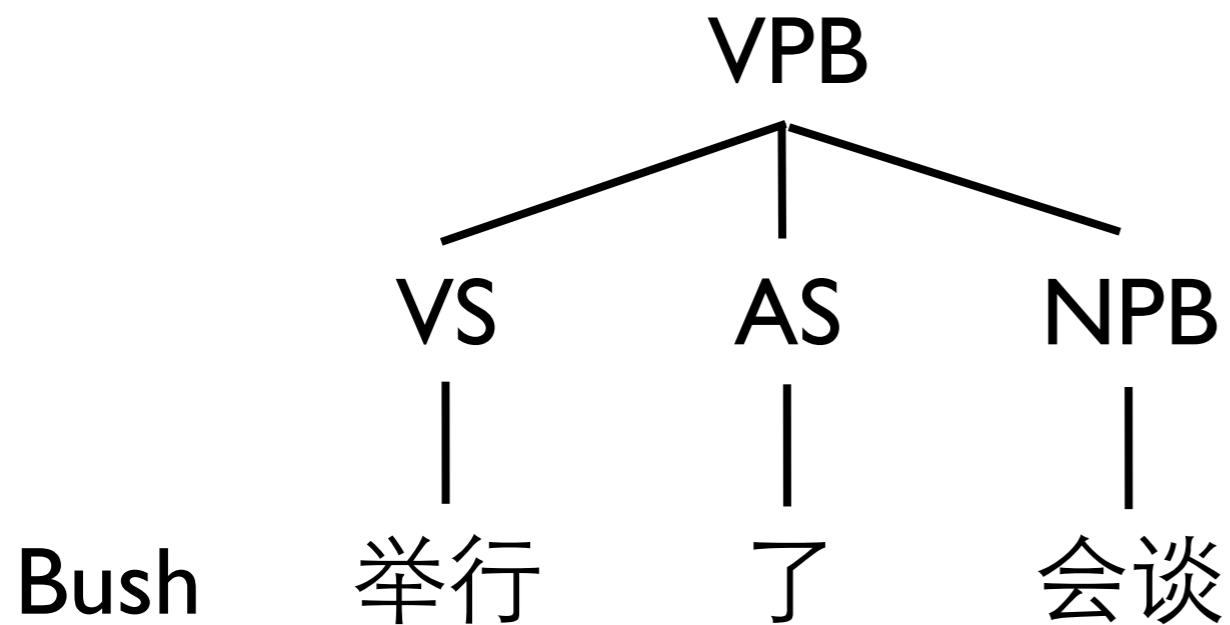
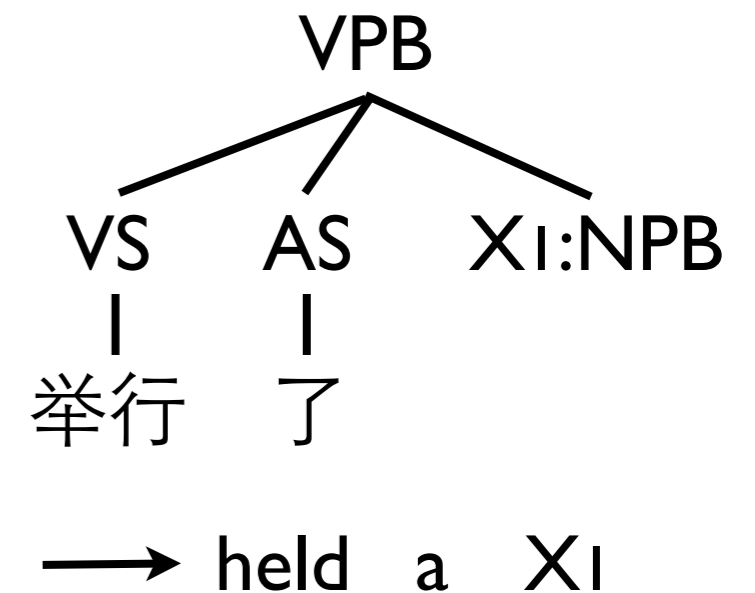
(Liu et al., 2006; Huang et al., 2006)

# 树到串翻译



(Liu et al., 2006; Huang et al., 2006)

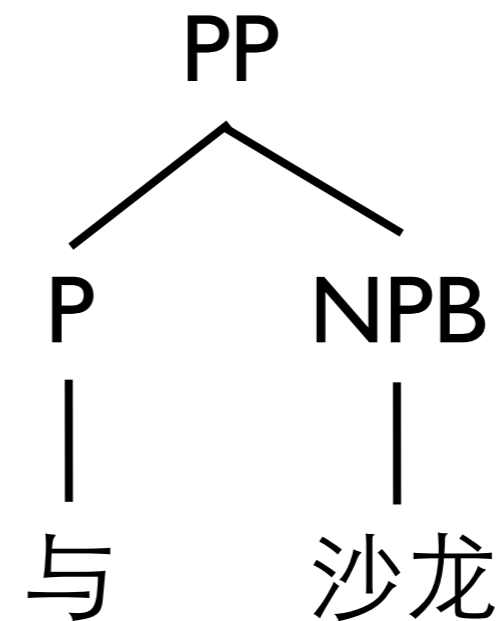
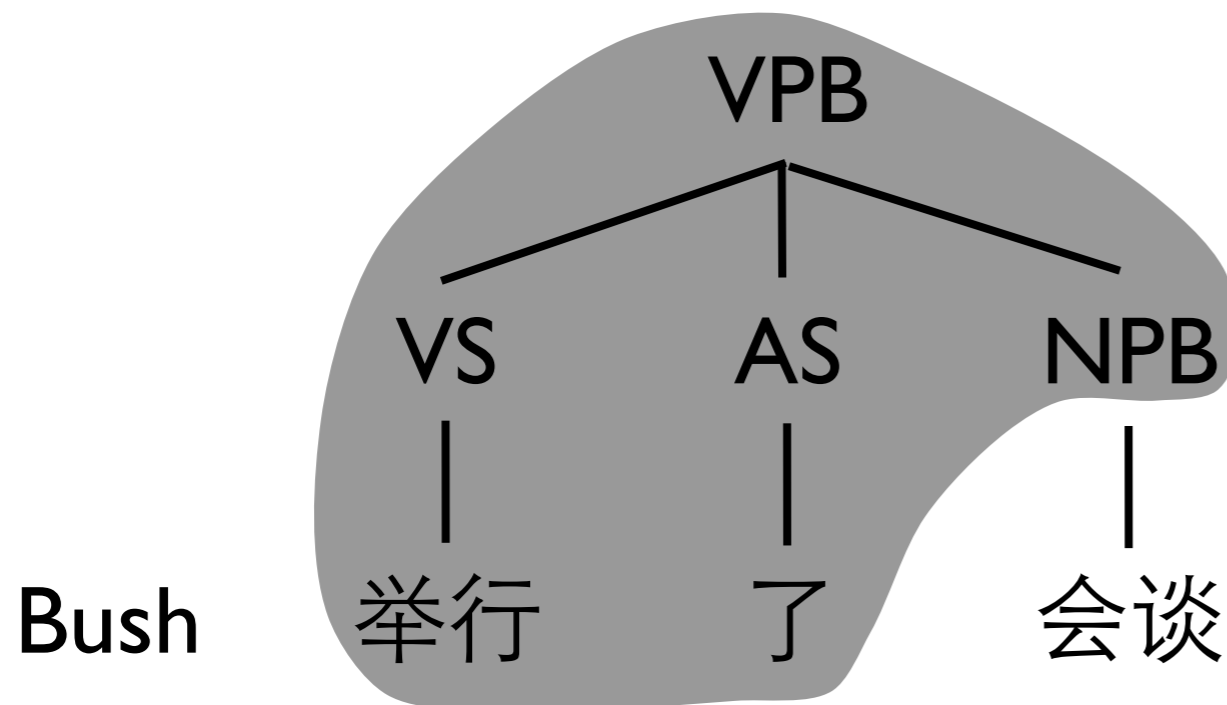
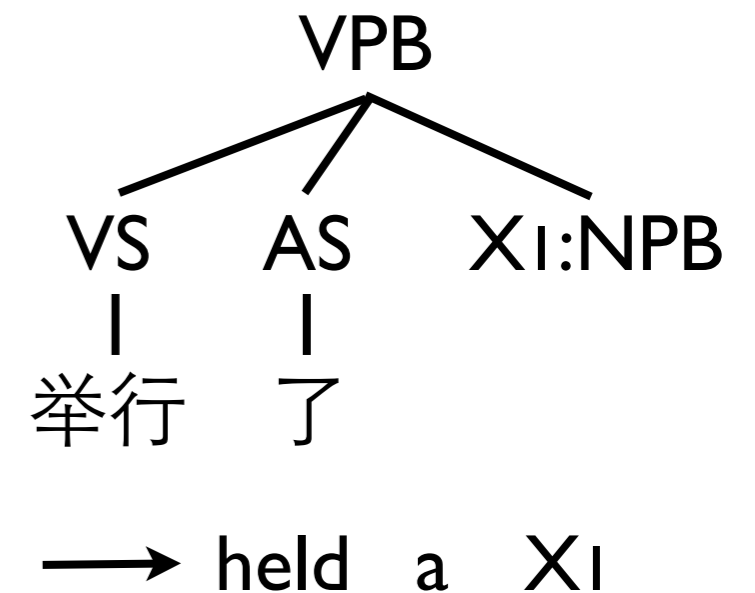
# 树到串翻译



(Liu et al., 2006; Huang et al., 2006)

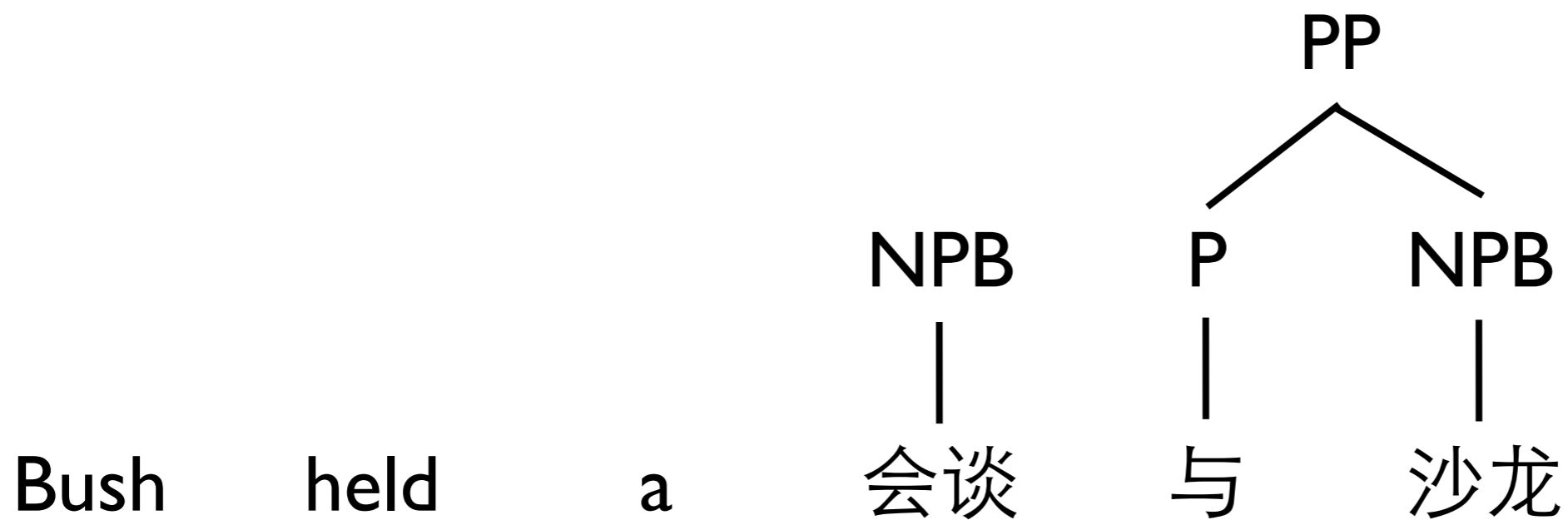


# 树到串翻译



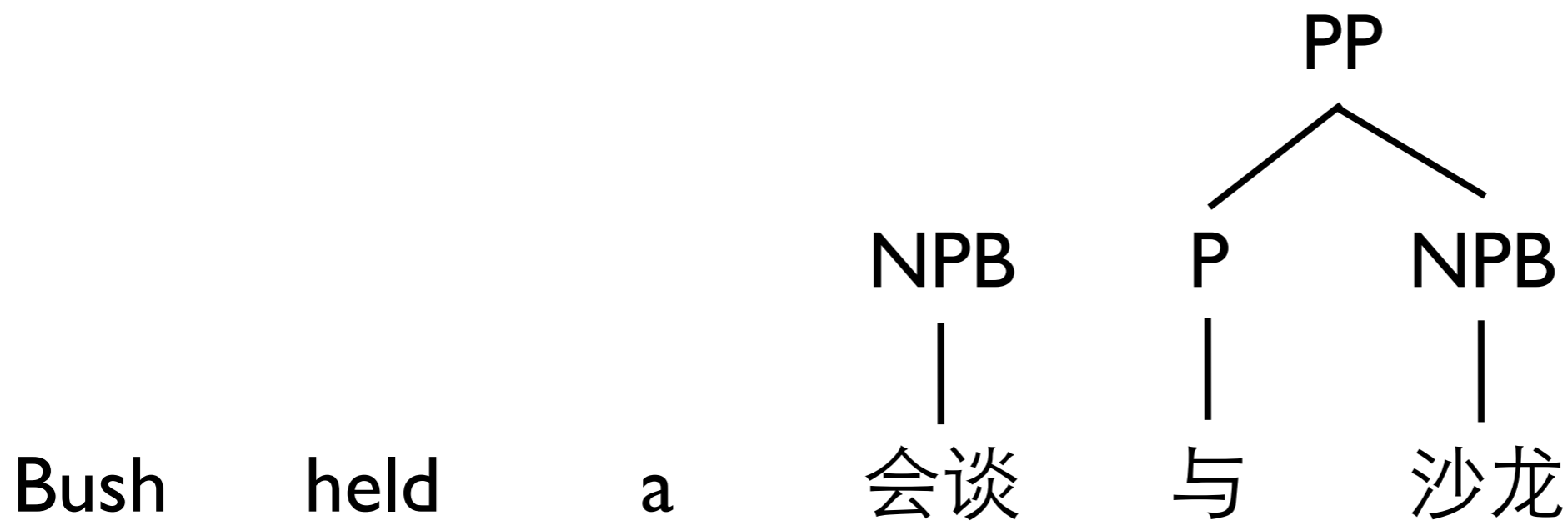
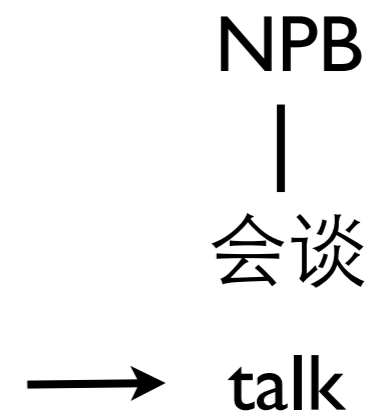
(Liu et al., 2006; Huang et al., 2006)

# 树到串翻译



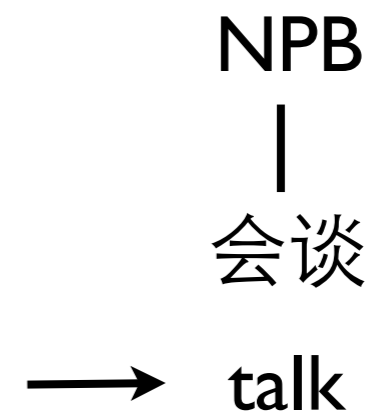
(Liu et al., 2006; Huang et al., 2006)

# 树到串翻译



(Liu et al., 2006; Huang et al., 2006)

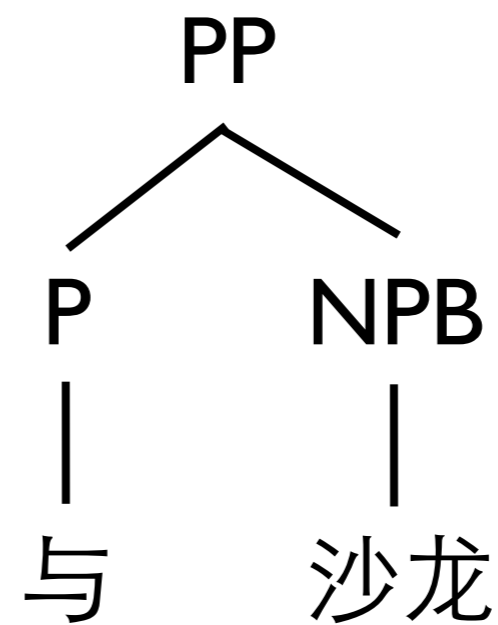
# 树到串翻译



Bush

held

a



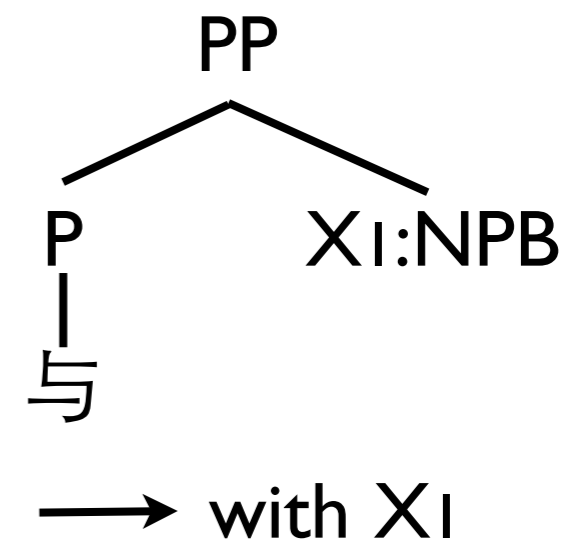
(Liu et al., 2006; Huang et al., 2006)

# 树到串翻译

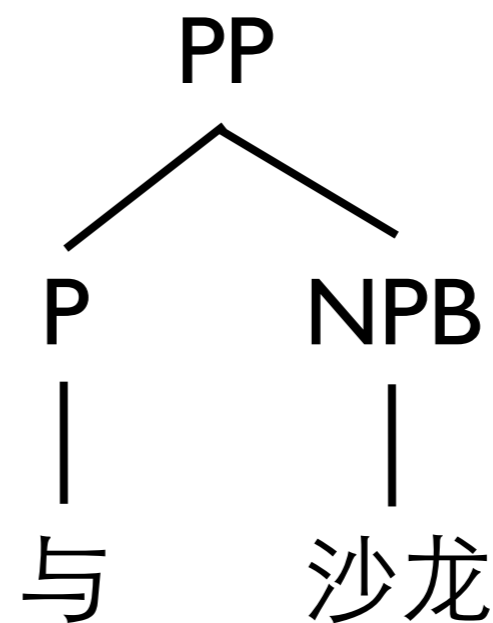


(Liu et al., 2006; Huang et al., 2006)

# 树到串翻译

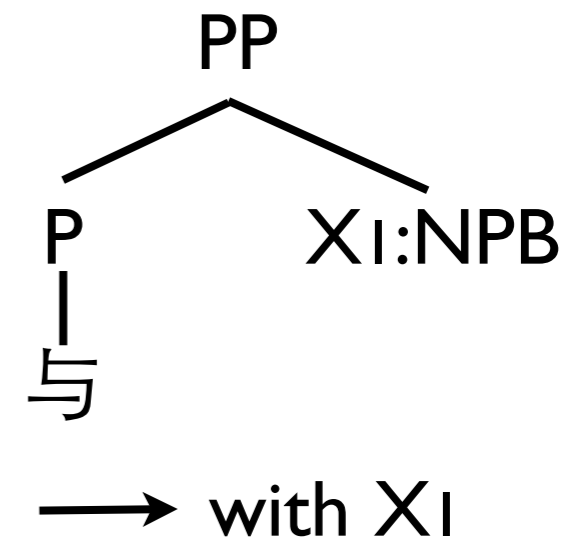


Bush held a talk

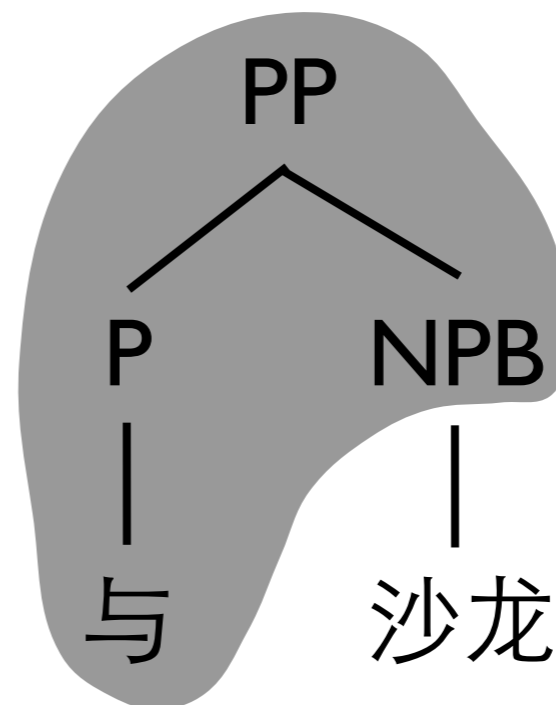


(Liu et al., 2006; Huang et al., 2006)

# 树到串翻译



Bush held a talk



(Liu et al., 2006; Huang et al., 2006)

# 树到串翻译

Bush held a talk with NPB  
沙龙

(Liu et al., 2006; Huang et al., 2006)



# 树到串翻译

NPB  
|  
沙龙  
→ Sharon

Bush held a talk with NPB  
沙龙

(Liu et al., 2006; Huang et al., 2006)

# 树到串翻译

NPB  
|  
沙龙  
→ Sharon

Bush held a talk with

NPB  
|  
沙龙

(Liu et al., 2006; Huang et al., 2006)

# 树到串翻译

Bush held a talk with Sharon

(Liu et al., 2006; Huang et al., 2006)

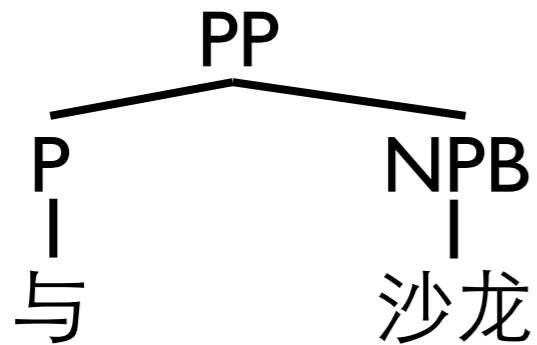
# 表达能力

# 表达能力

短语翻译

# 表达能力

## 短语翻译

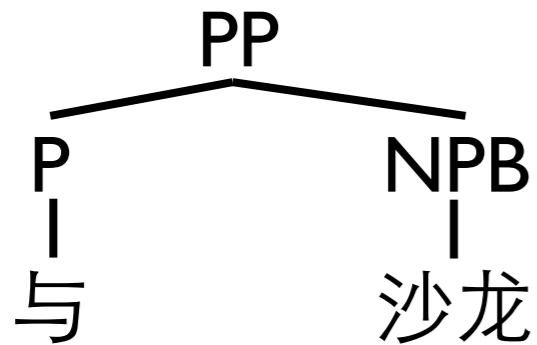


→ with Sharon

# 表达能力

短语翻译

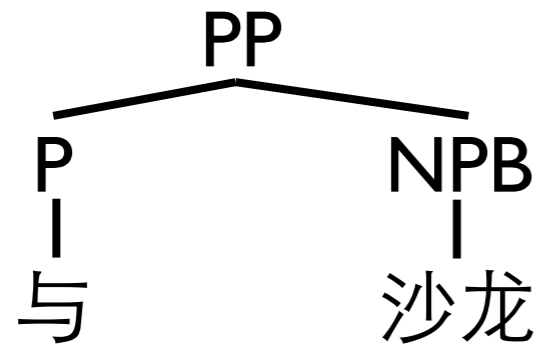
非成分短语



→ with Sharon

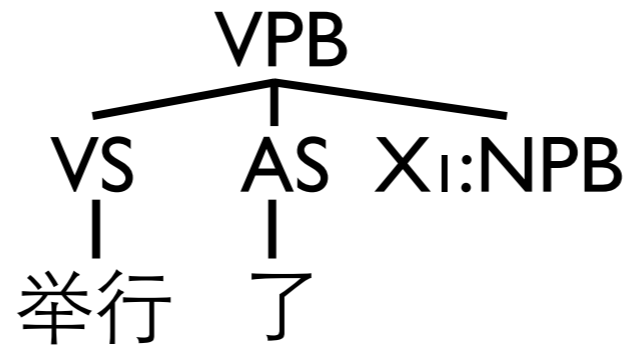
# 表达能力

短语翻译



→ with Sharon

非成分短语

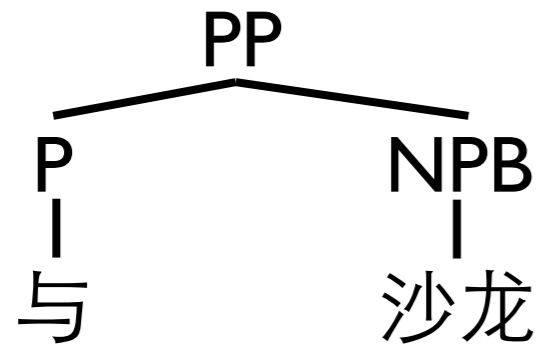


→ held a Xi



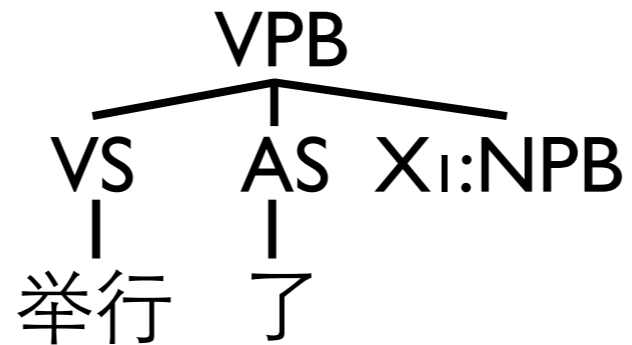
# 表达能力

短语翻译



→ with Sharon

非成分短语

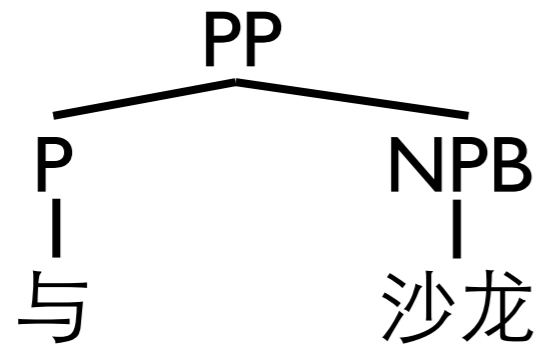


→ held a Xi

非连续短语

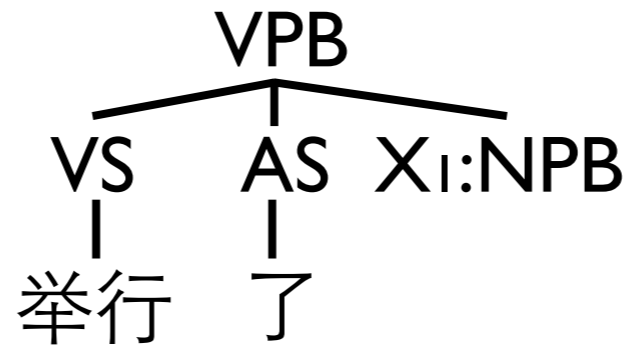
# 表达能力

## 短语翻译



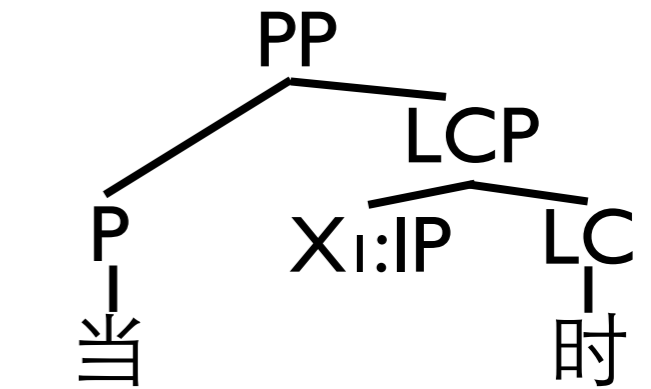
→ with Sharon

## 非成分短语



→ held a Xi

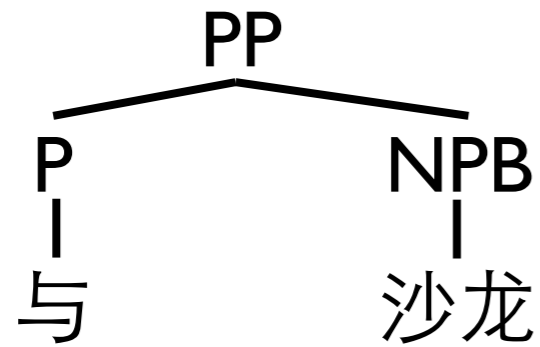
## 非连续短语



→ when Xi

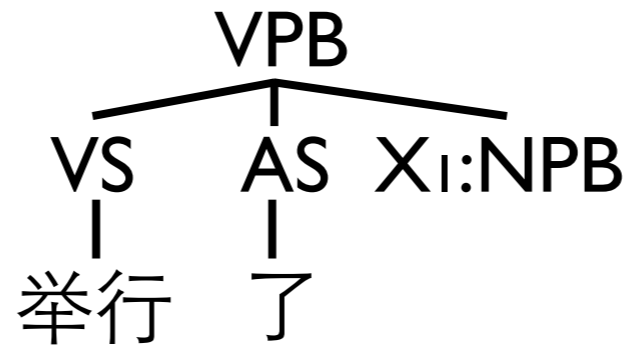
# 表达能力

## 短语翻译



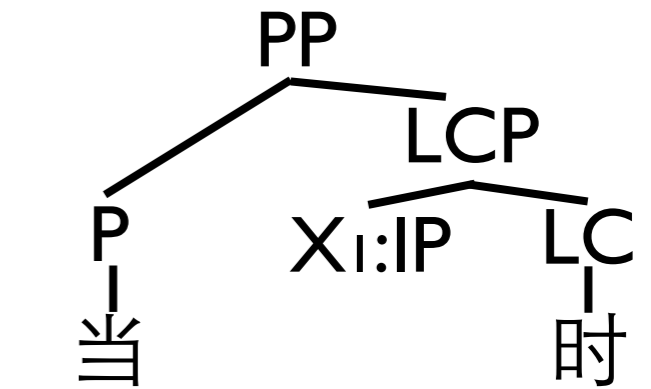
→ with Sharon

## 非成分短语



→ held a Xi

## 非连续短语

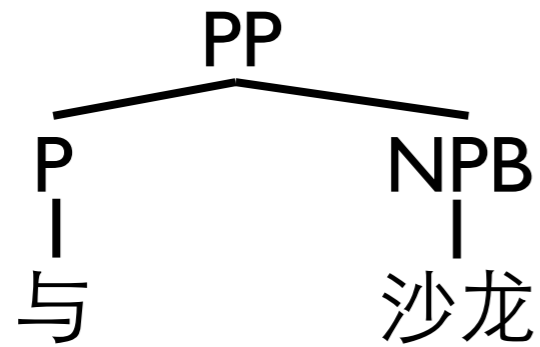


→ when Xi

## 删词

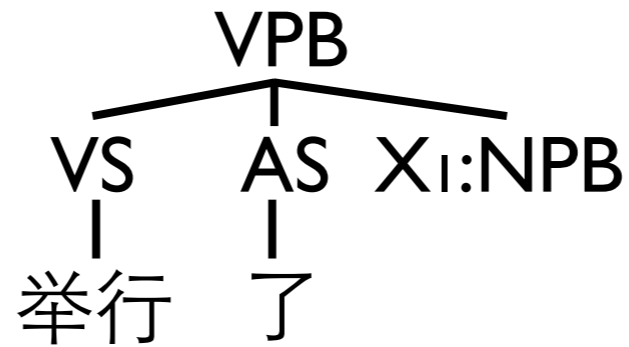
# 表达能力

## 短语翻译



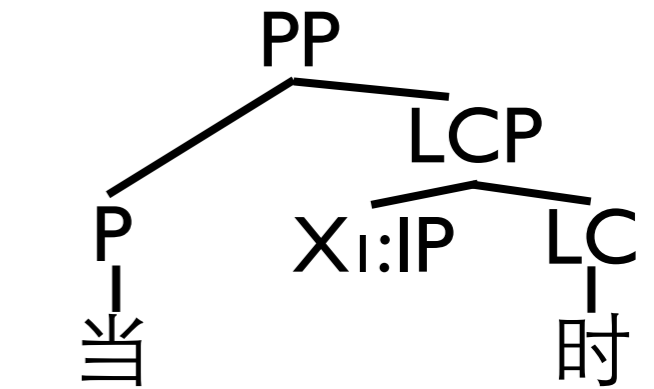
→ with Sharon

## 非成分短语



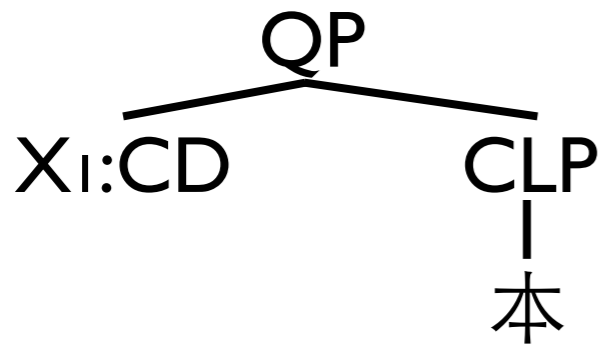
→ held a Xi

## 非连续短语



→ when Xi

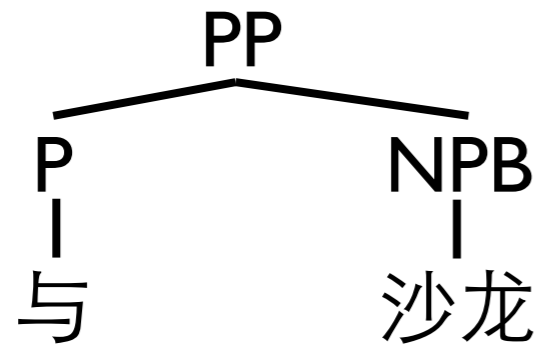
## 删词



→ Xi

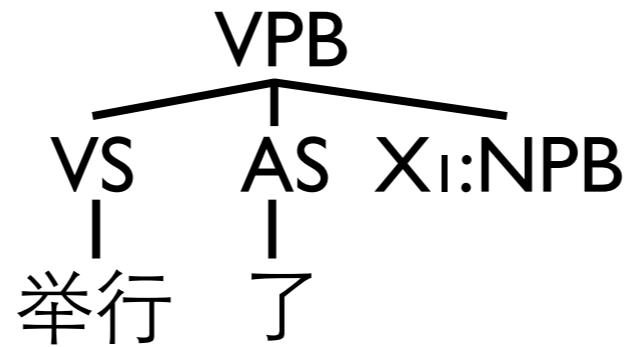
# 表达能力

## 短语翻译



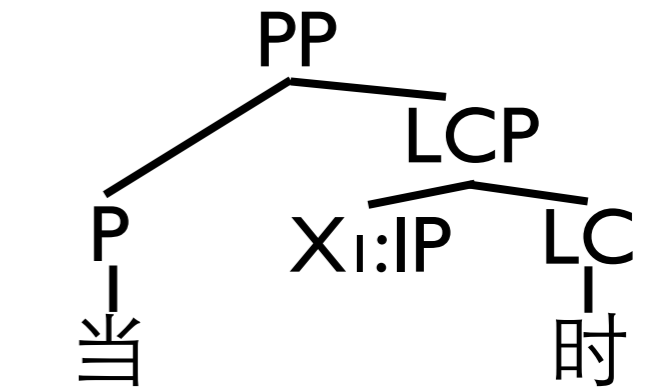
→ with Sharon

## 非成分短语



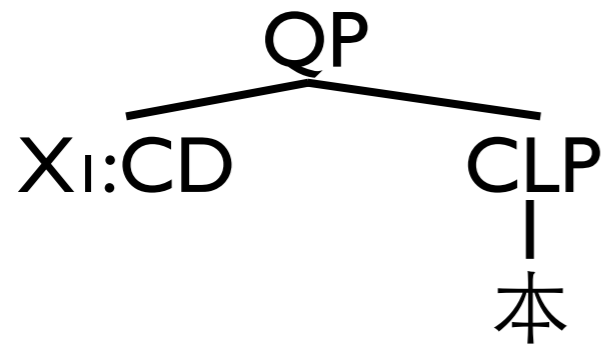
→ held a Xi

## 非连续短语



→ when Xi

## 删词

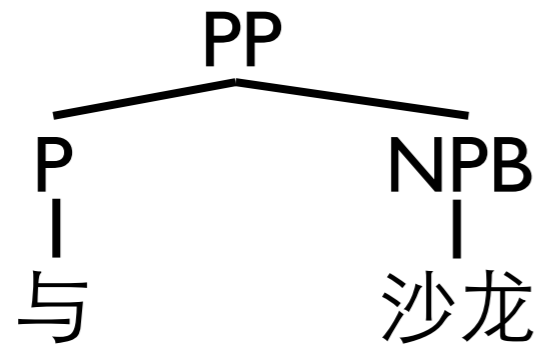


→ Xi

## 多层调序

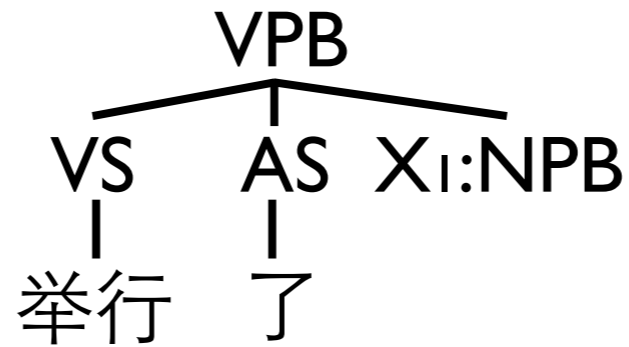
# 表达能力

## 短语翻译



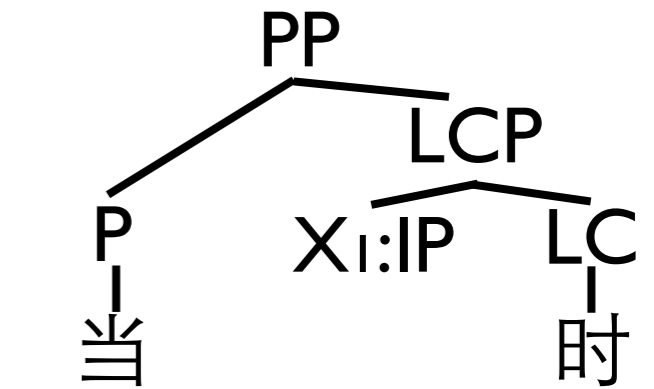
→ with Sharon

## 非成分短语



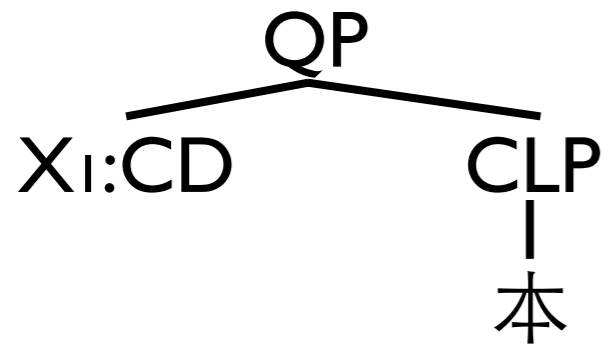
→ held a X<sub>1</sub>

## 非连续短语



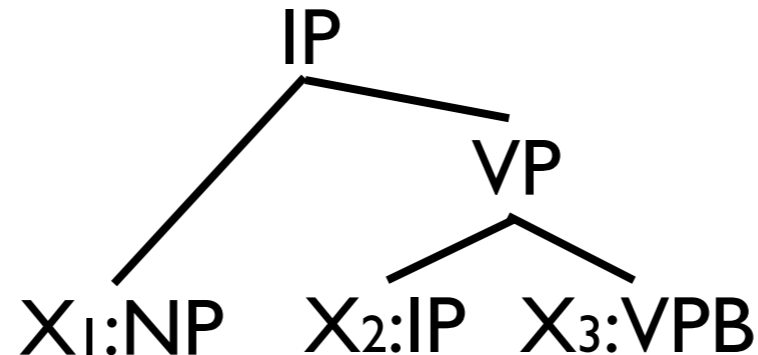
→ when X<sub>1</sub>

## 删词



→ X<sub>1</sub>

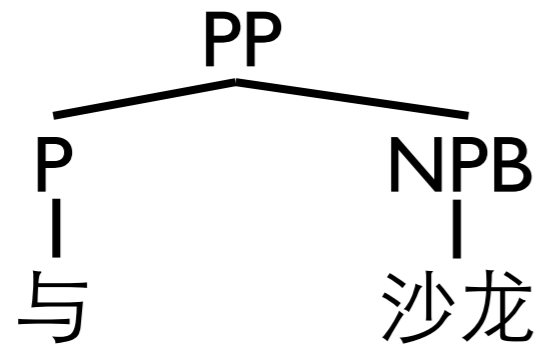
## 多层调序



→ X<sub>1</sub> X<sub>3</sub> X<sub>2</sub>

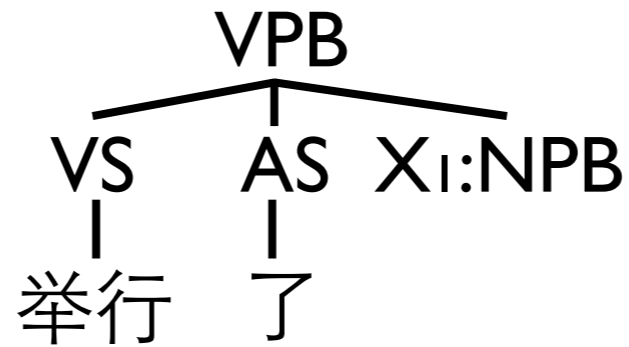
# 表达能力

## 短语翻译



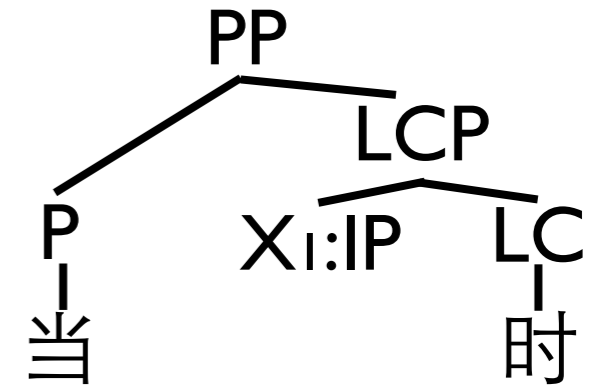
→ with Sharon

## 非成分短语



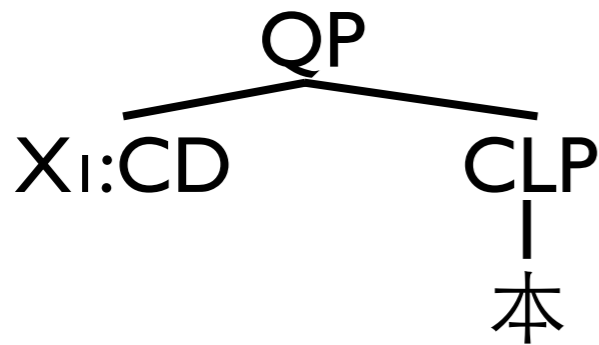
→ held a  $X_1$

## 非连续短语



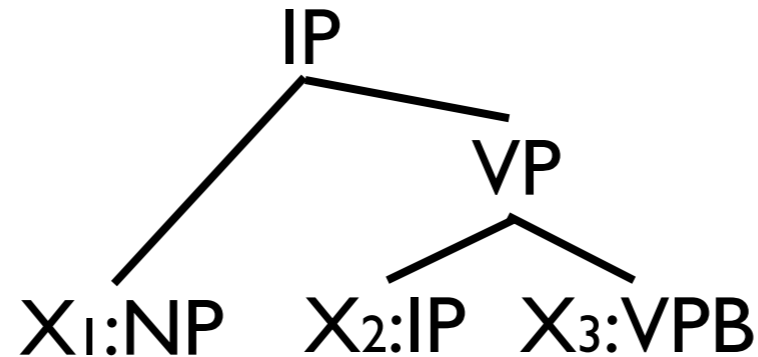
→ when  $X_1$

## 删词



→  $X_1$

## 多层调序

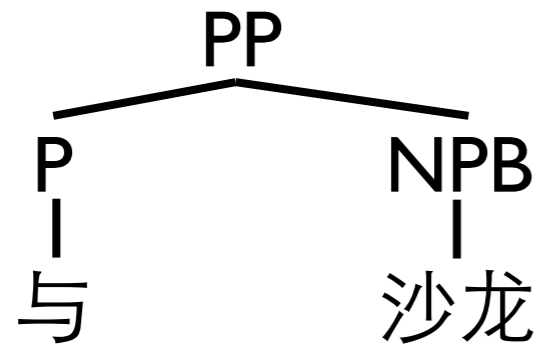


→  $X_1$   $X_3$   $X_2$

## 词汇化调序

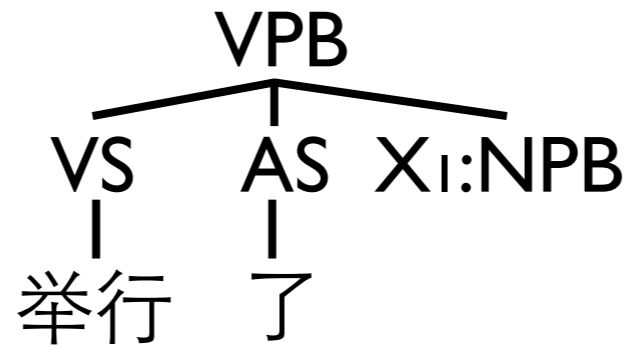
# 表达能力

## 短语翻译



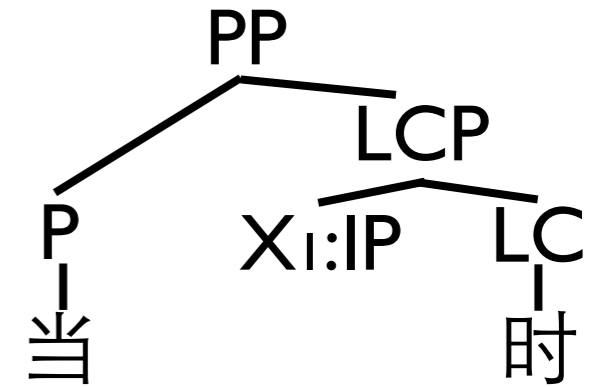
→ with Sharon

## 非成分短语



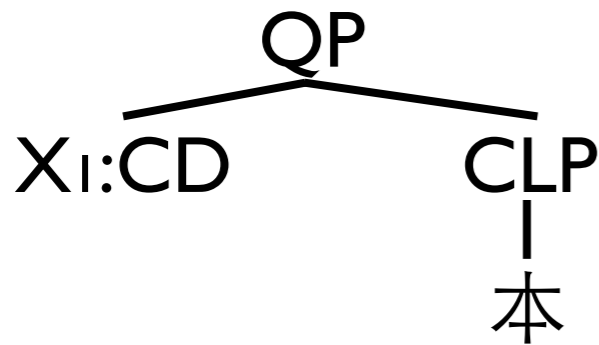
→ held a  $X_1$

## 非连续短语



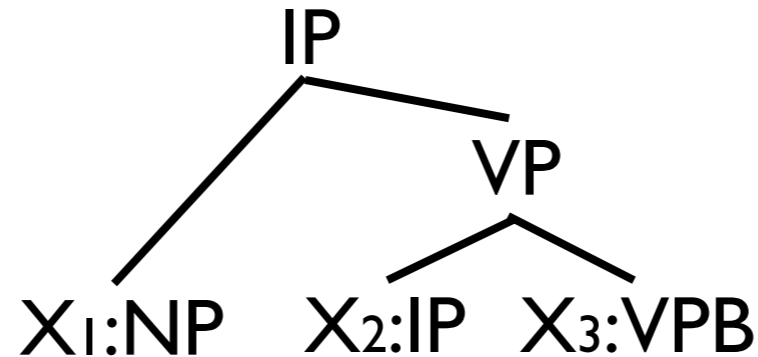
→ when  $X_1$

## 删词



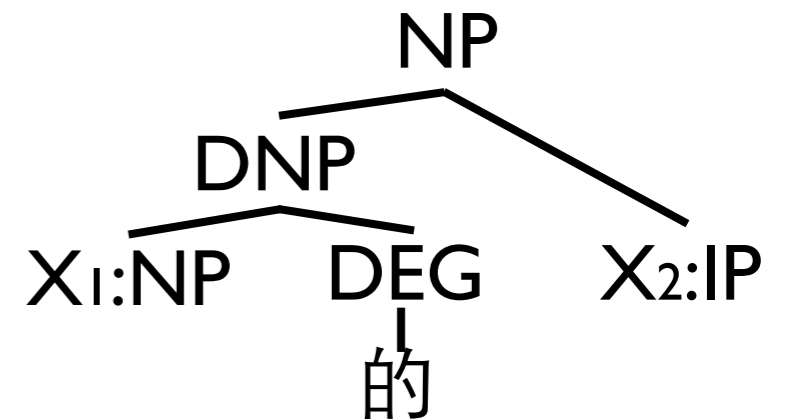
→  $X_1$

## 多层调序



→  $X_1$   $X_3$   $X_2$

## 词汇化调序



→  $X_2$  of  $X_1$



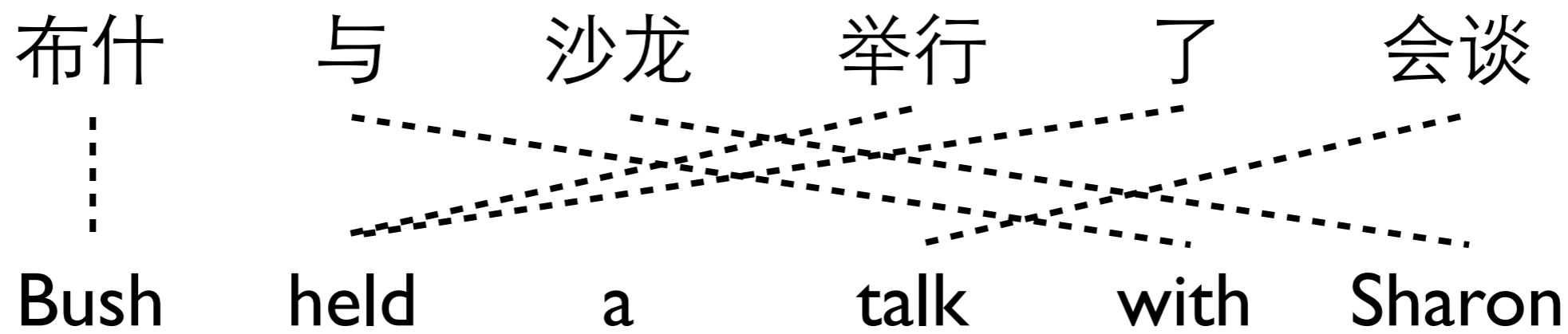
# 规则抽取

布什 与 沙龙 举行 了 会谈

Bush held a talk with Sharon

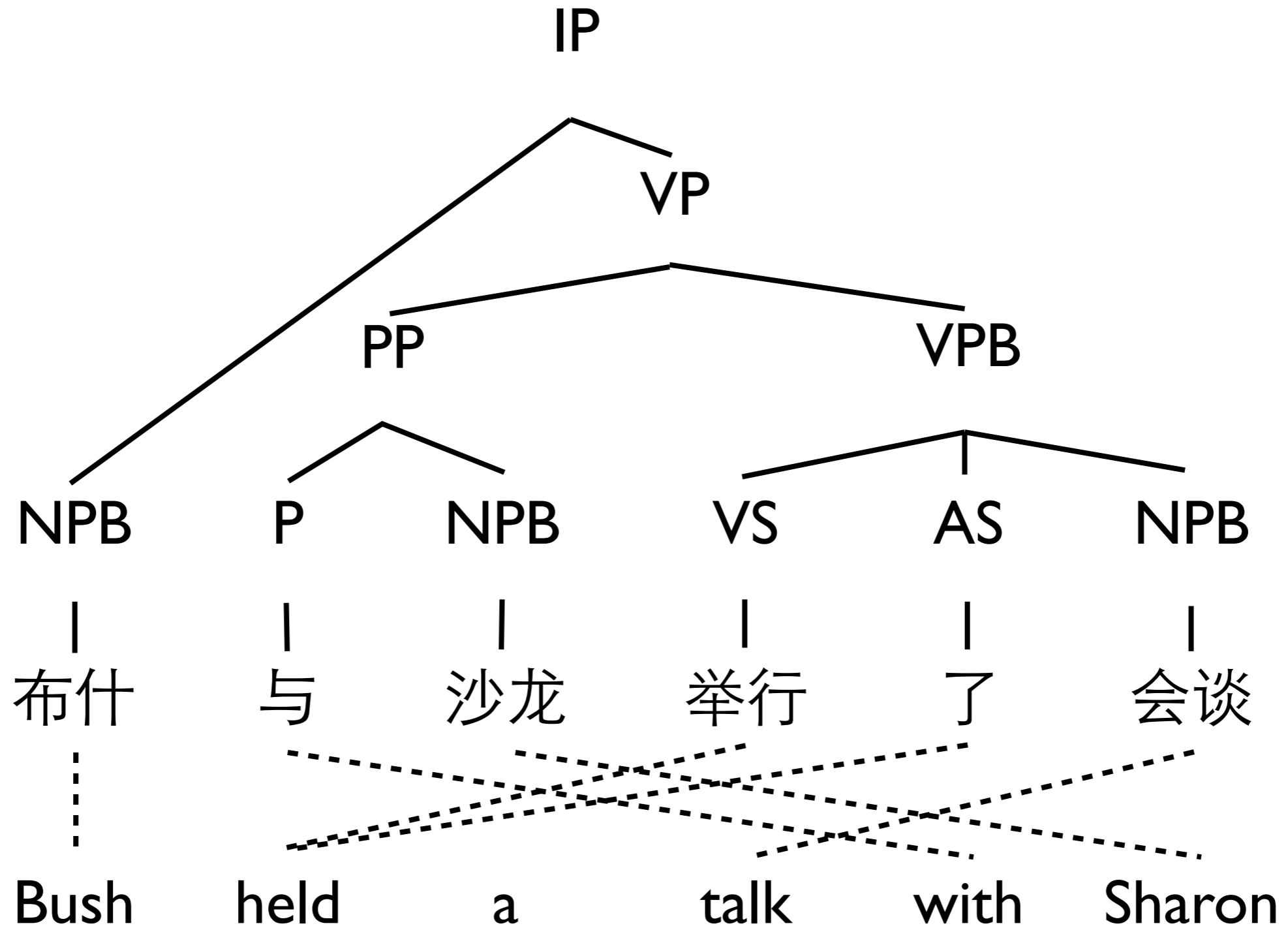
(Galley et al., 2004)

# 规则抽取



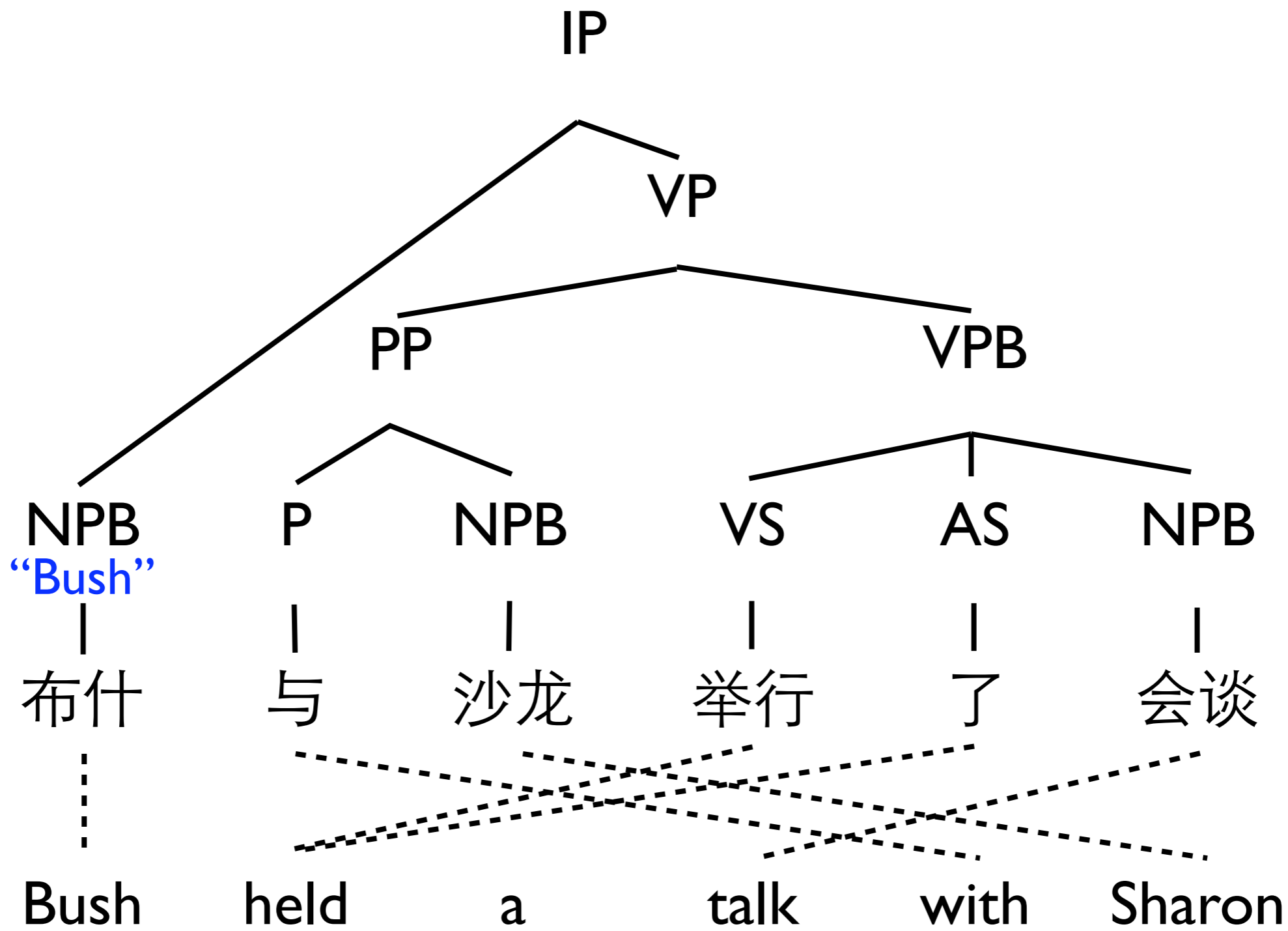
(Galley et al., 2004)

# 规则抽取



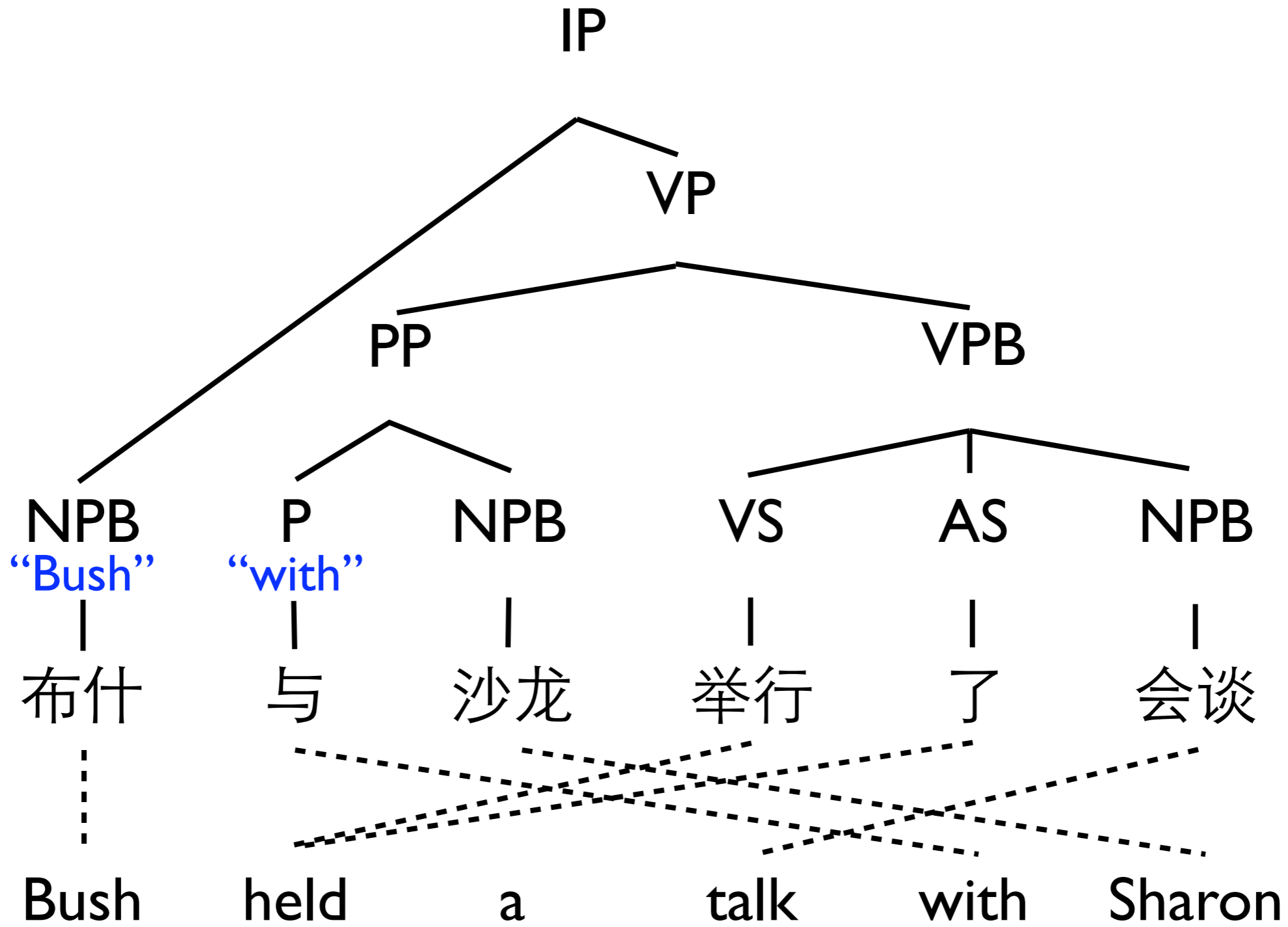
(Galley et al., 2004)

# 规则抽取



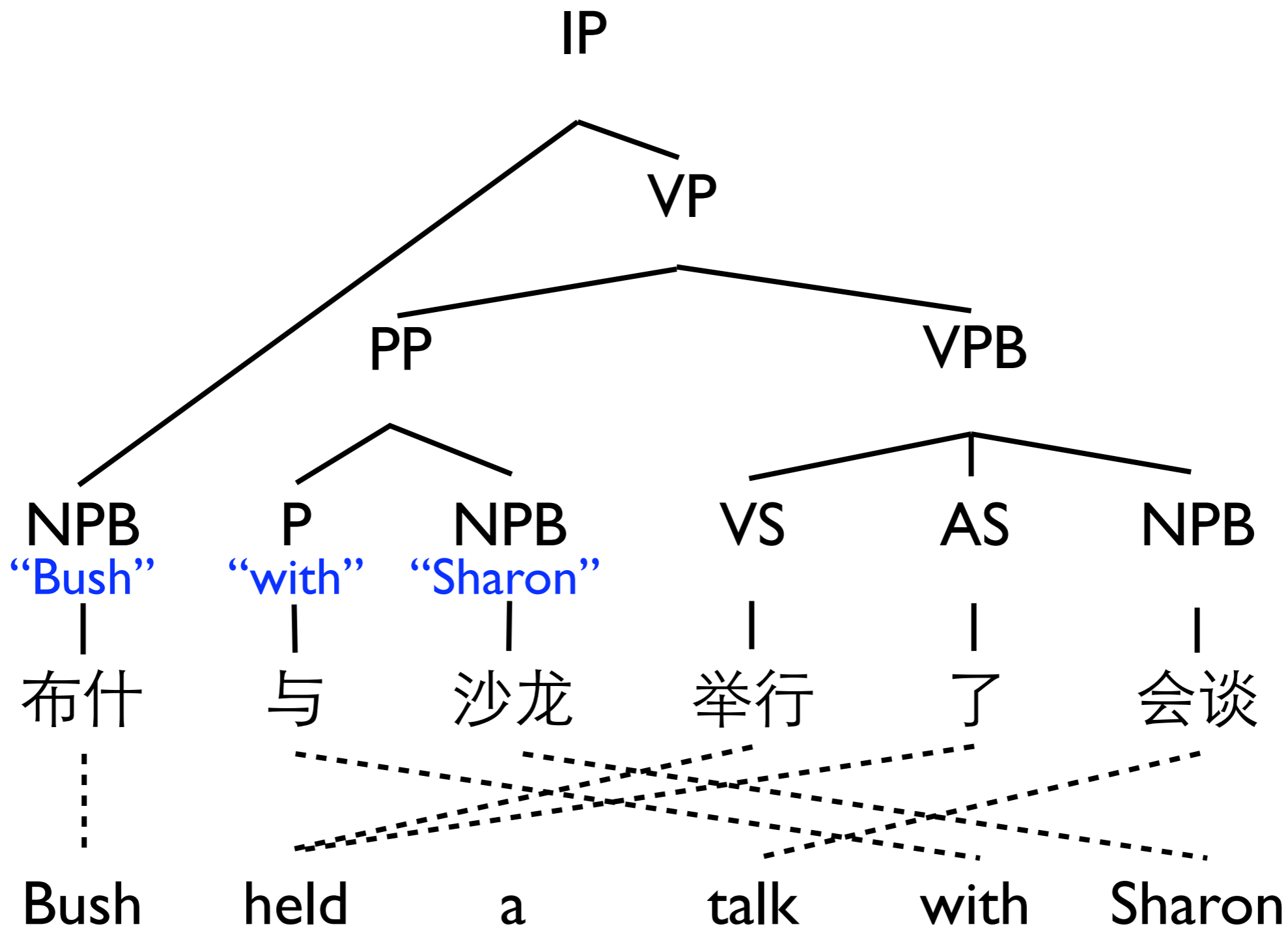
(Galley et al., 2004)

# 规则抽取



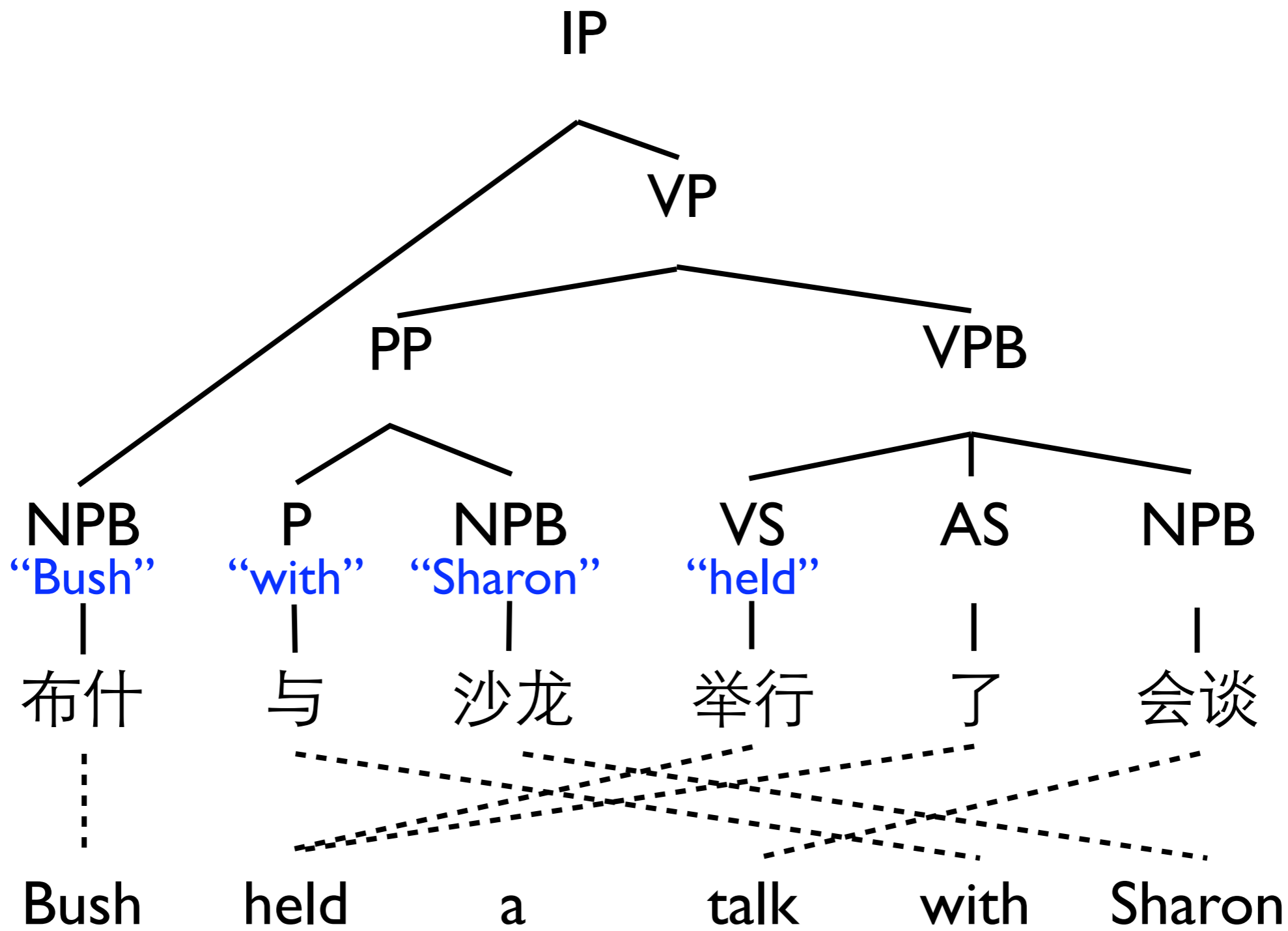
(Galley et al., 2004)

# 规则抽取



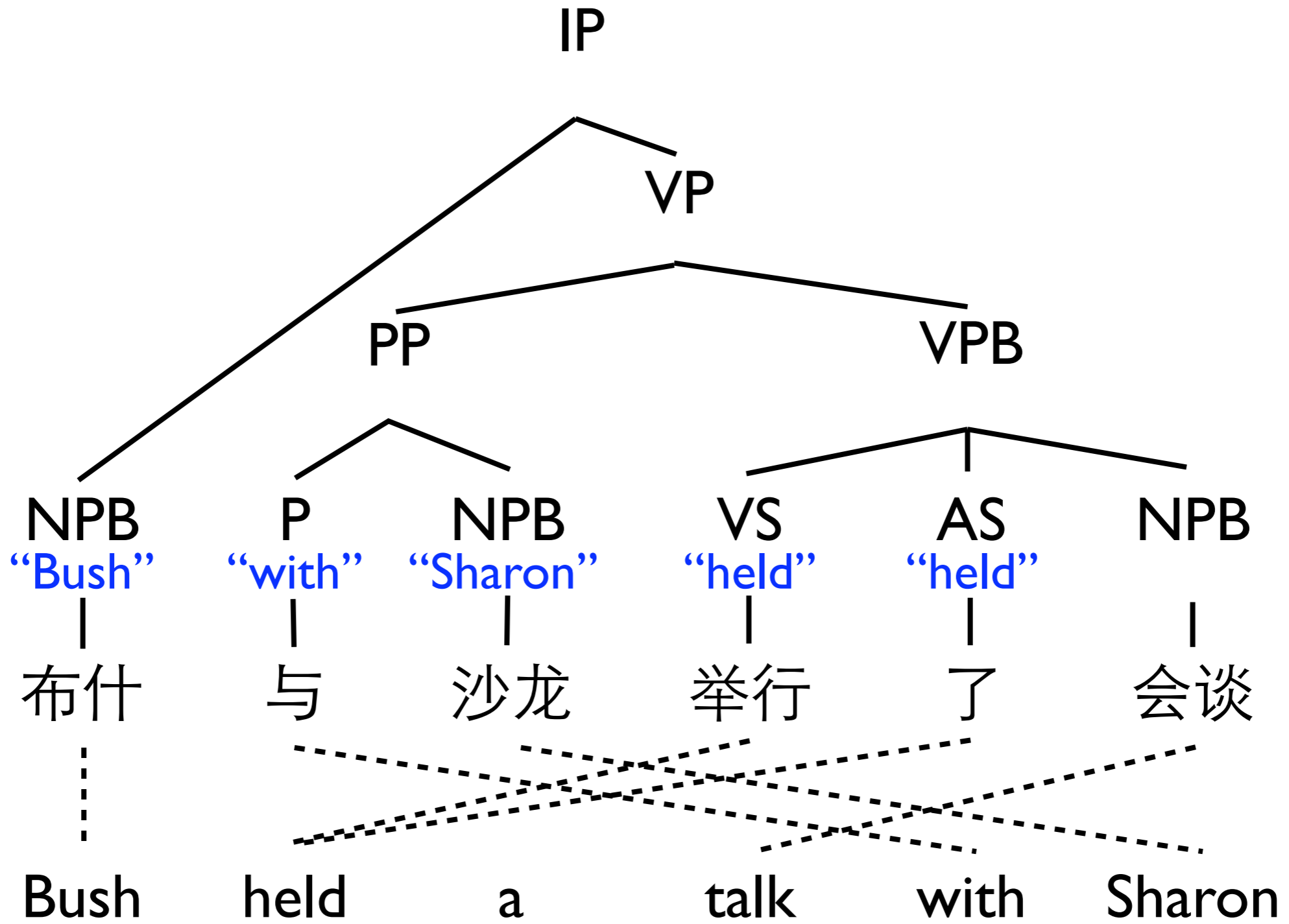
(Galley et al., 2004)

# 规则抽取



(Galley et al., 2004)

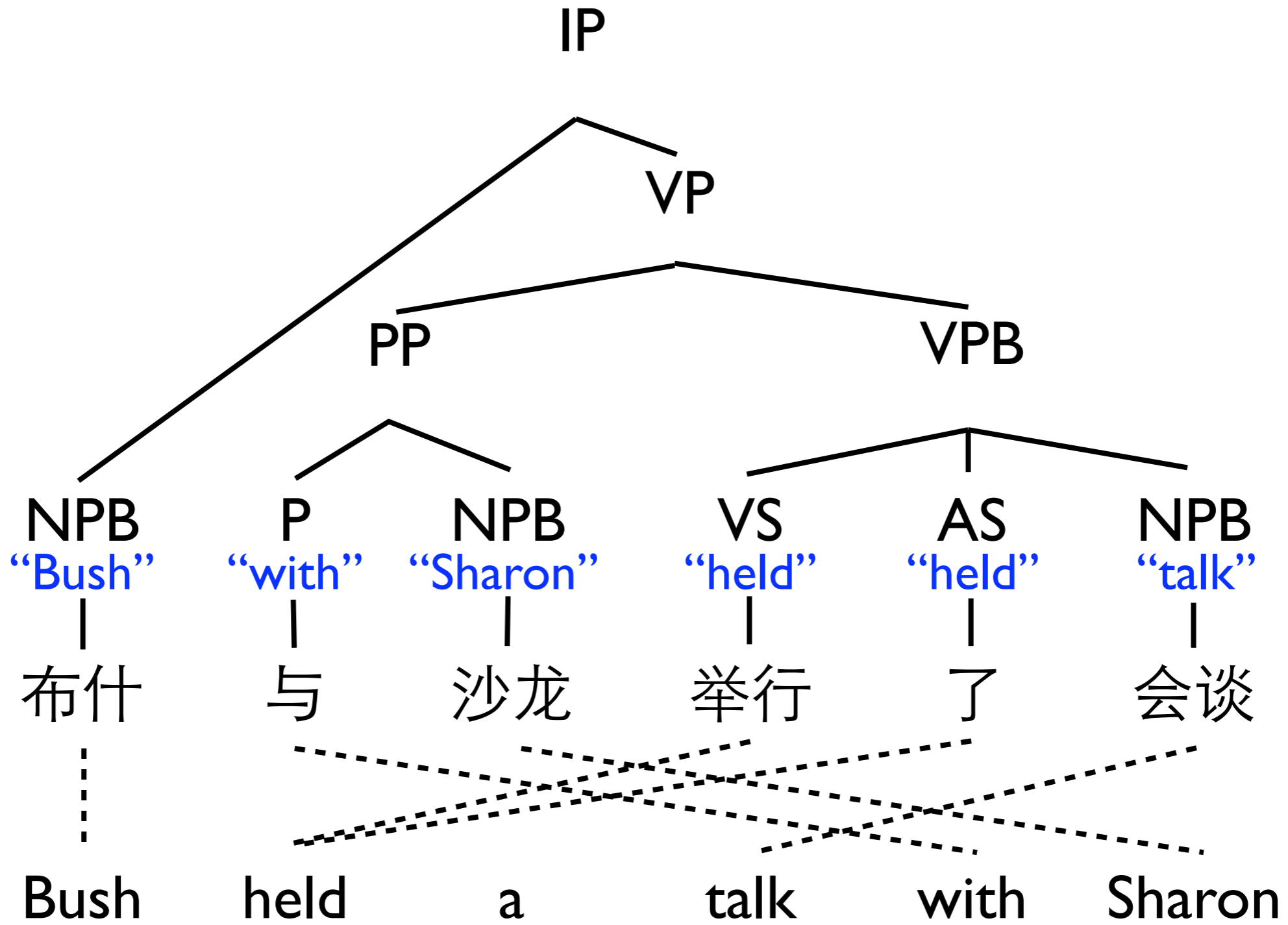
# 规则抽取



(Galley et al., 2004)

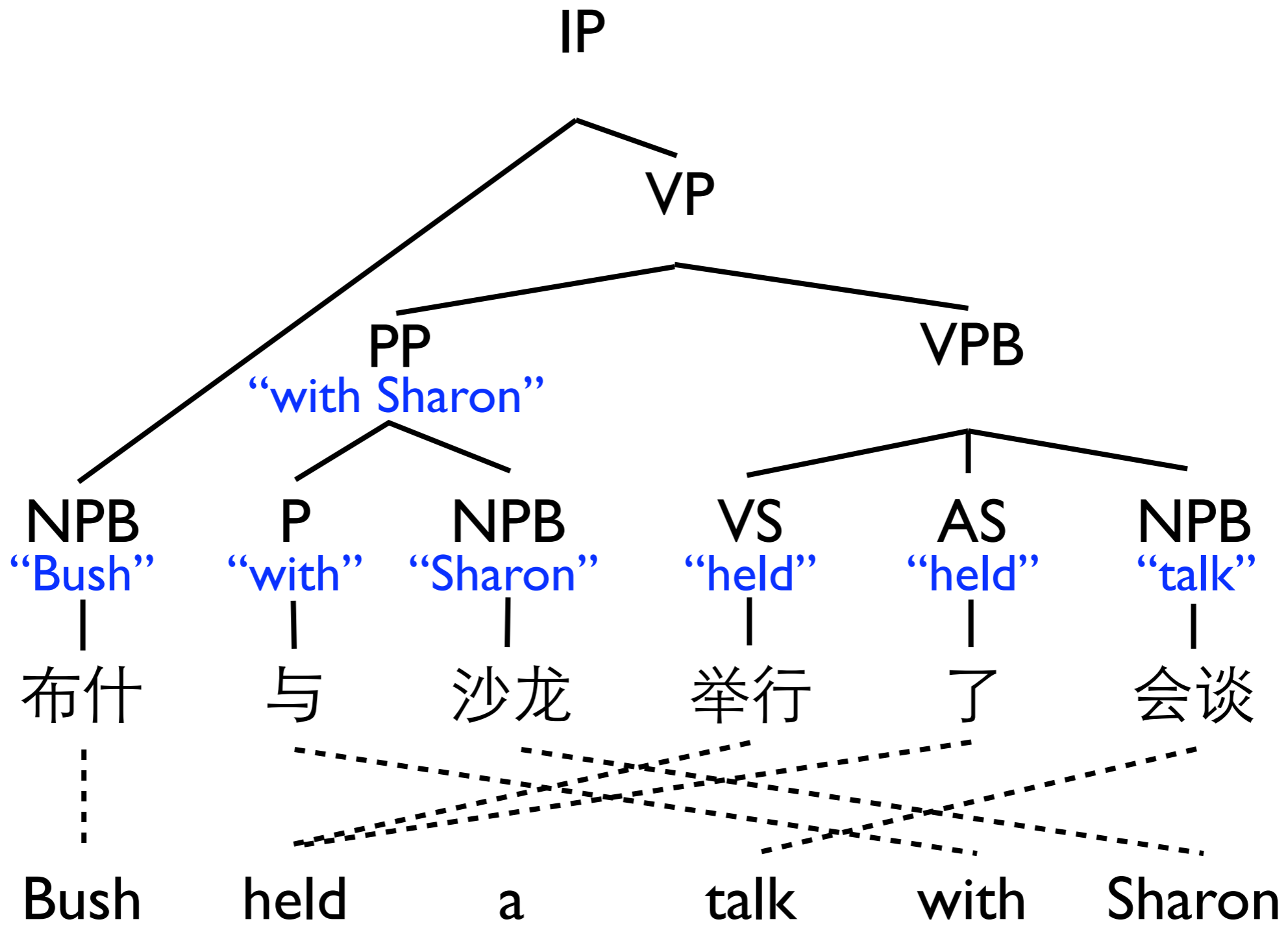


# 规则抽取



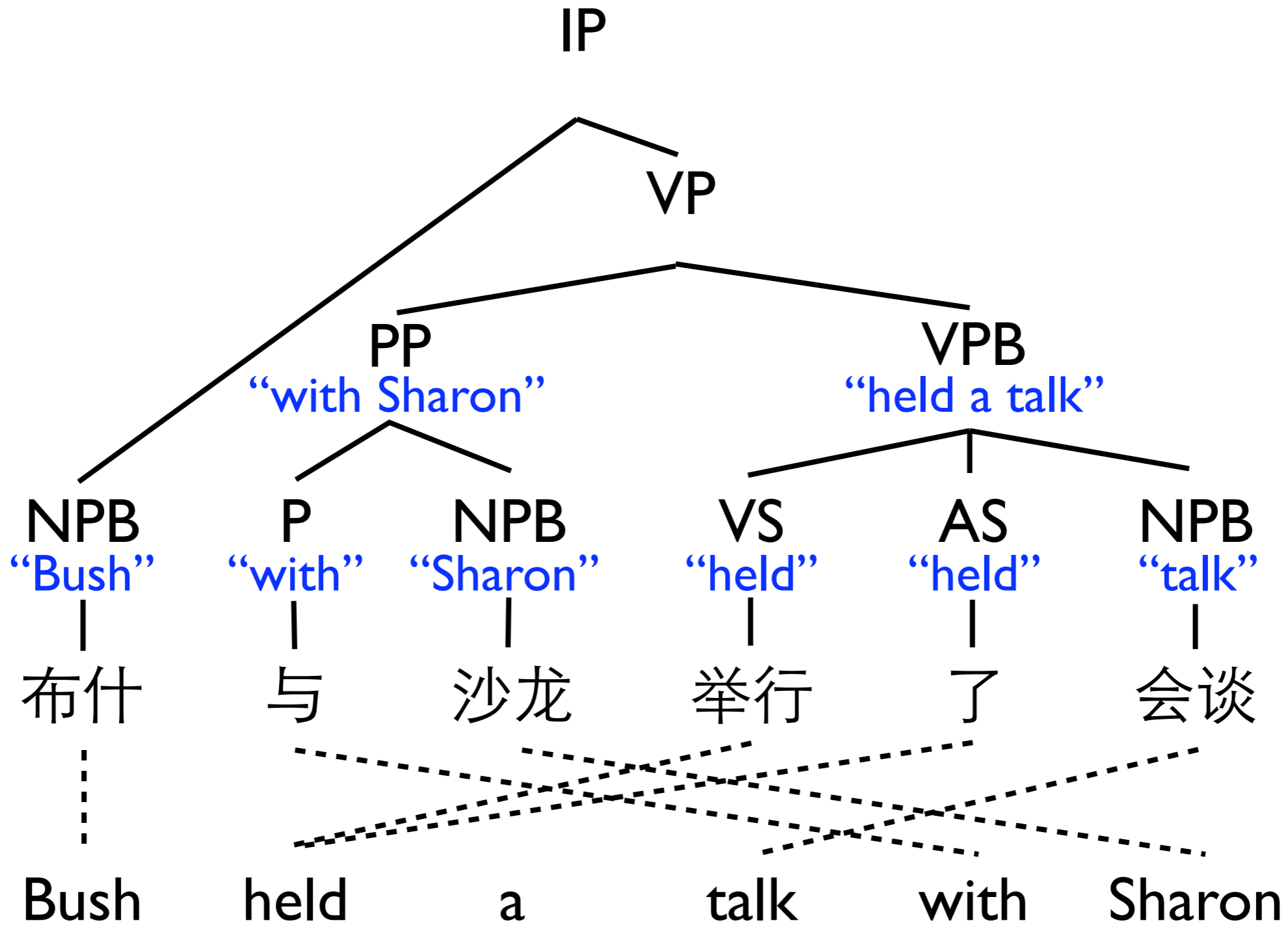
(Galley et al., 2004)

# 规则抽取



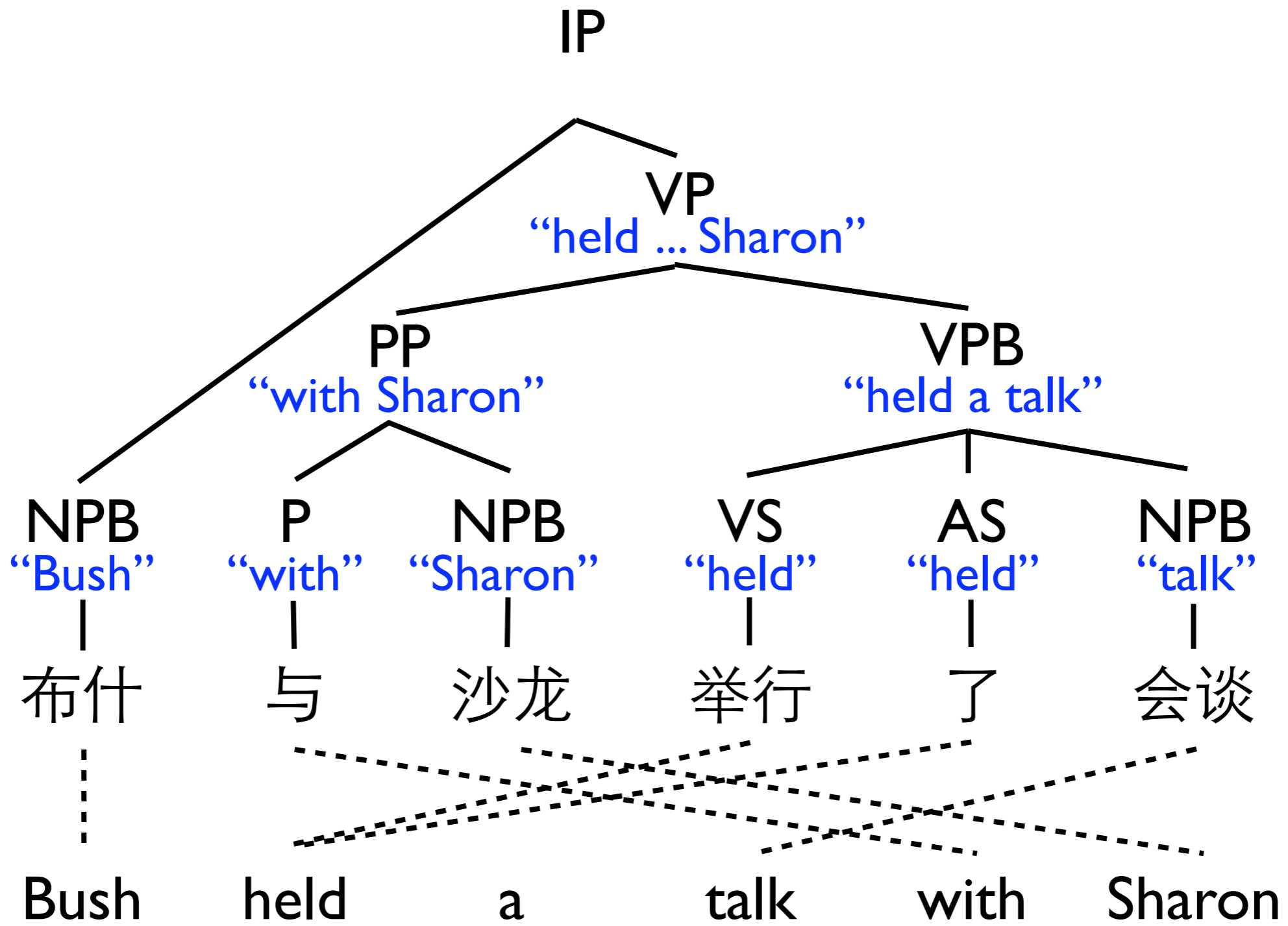
(Galley et al., 2004)

# 规则抽取



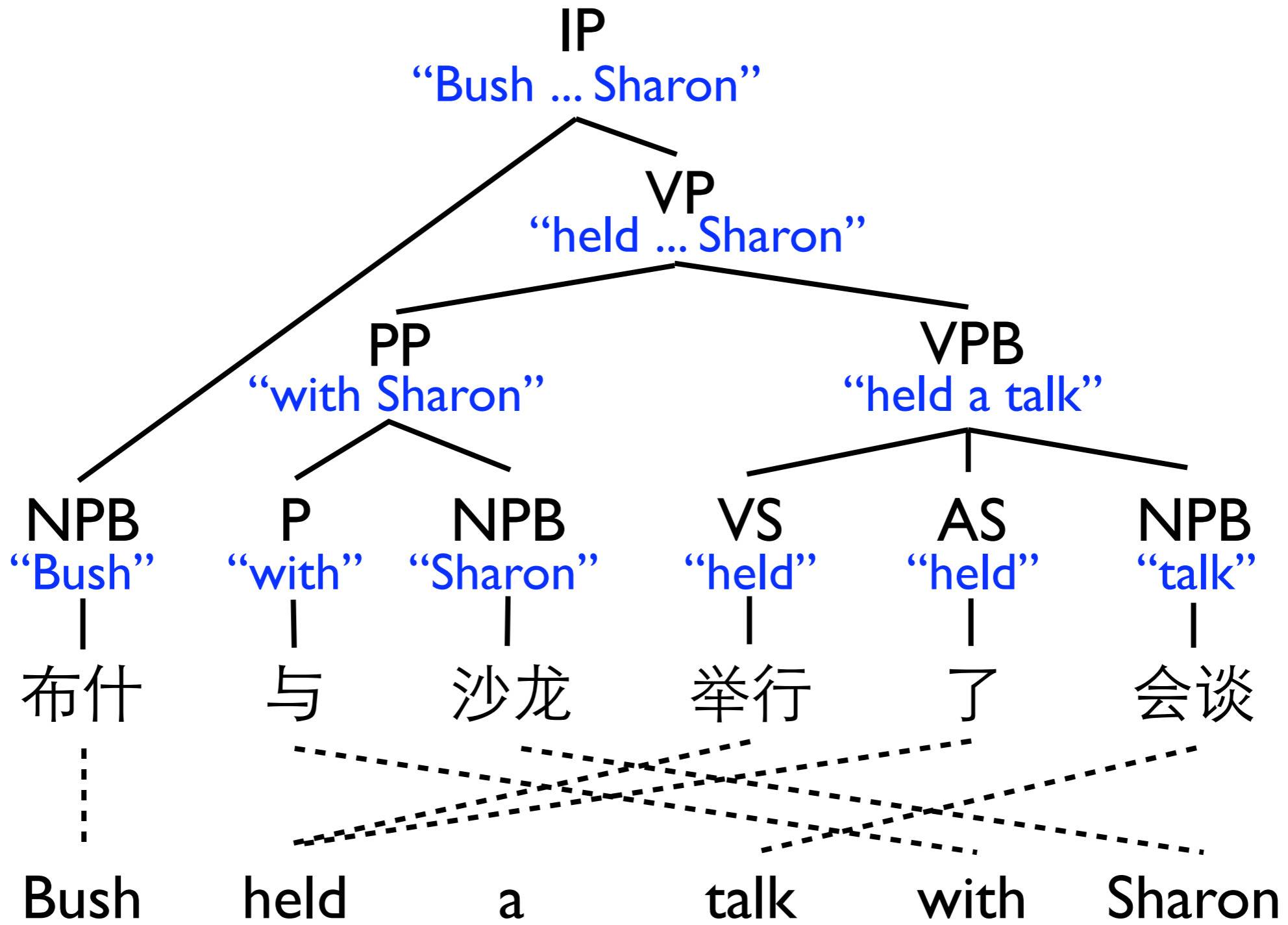
(Galley et al., 2004)

# 规则抽取



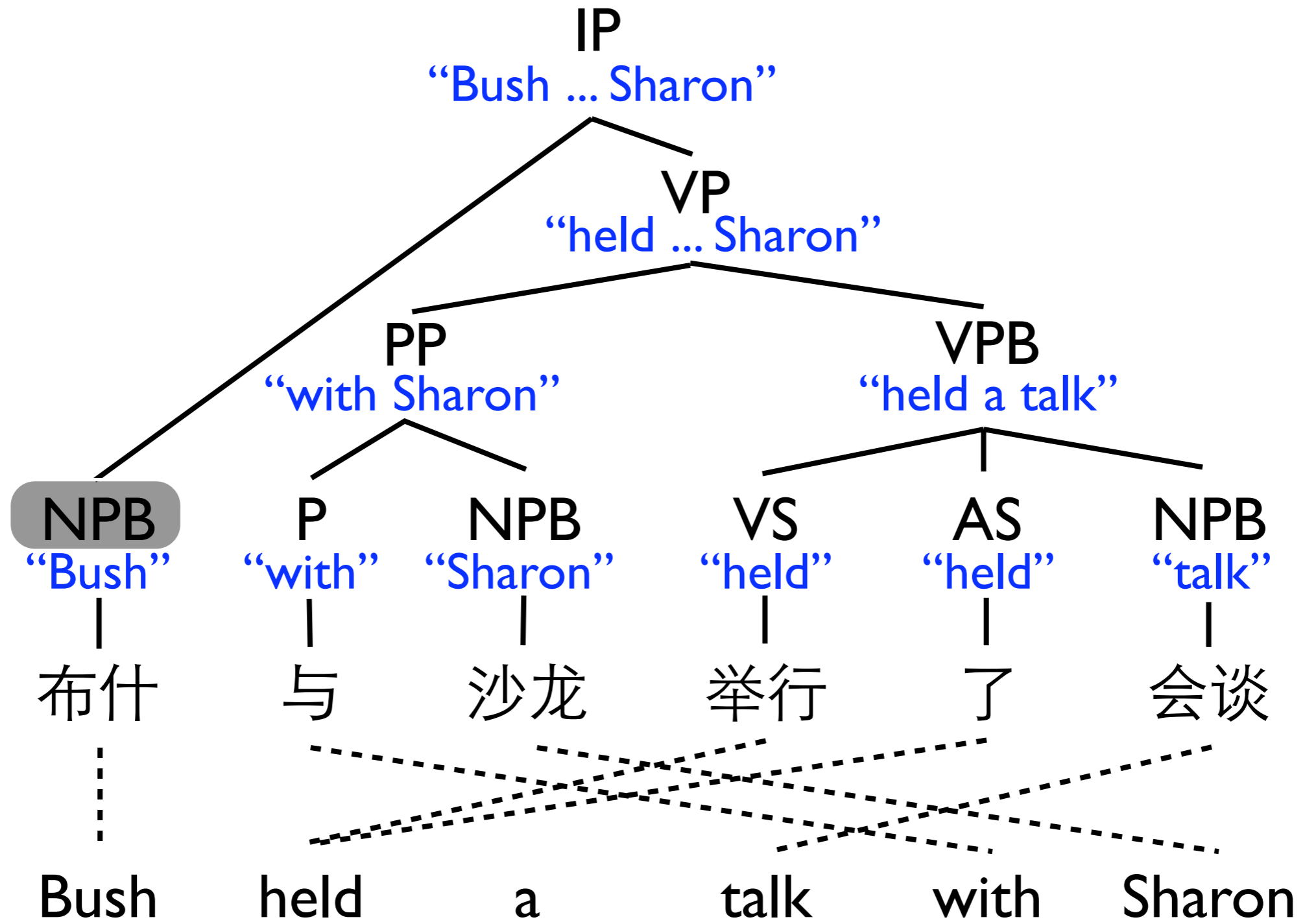
(Galley et al., 2004)

# 规则抽取



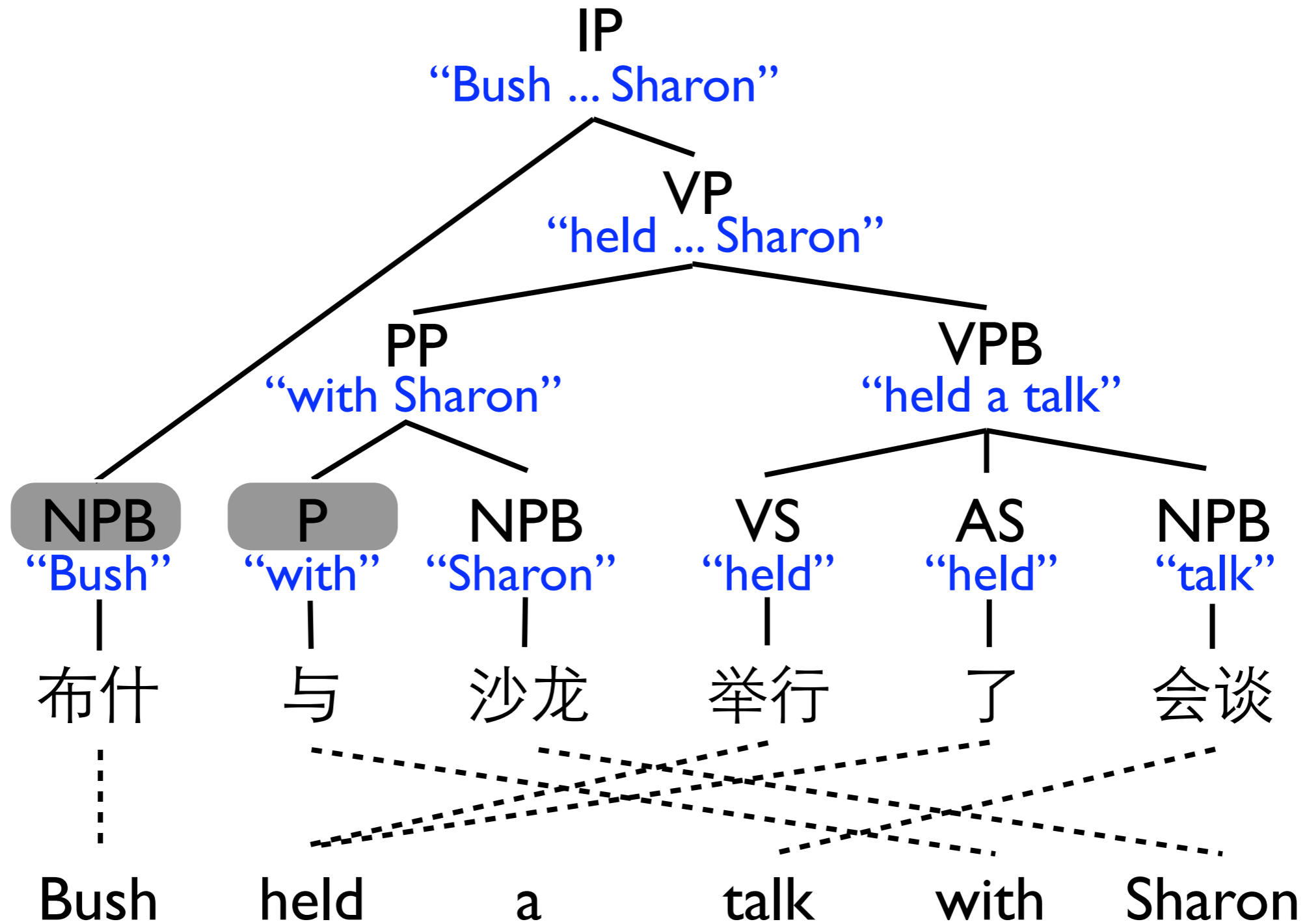
(Galley et al., 2004)

# 规则抽取



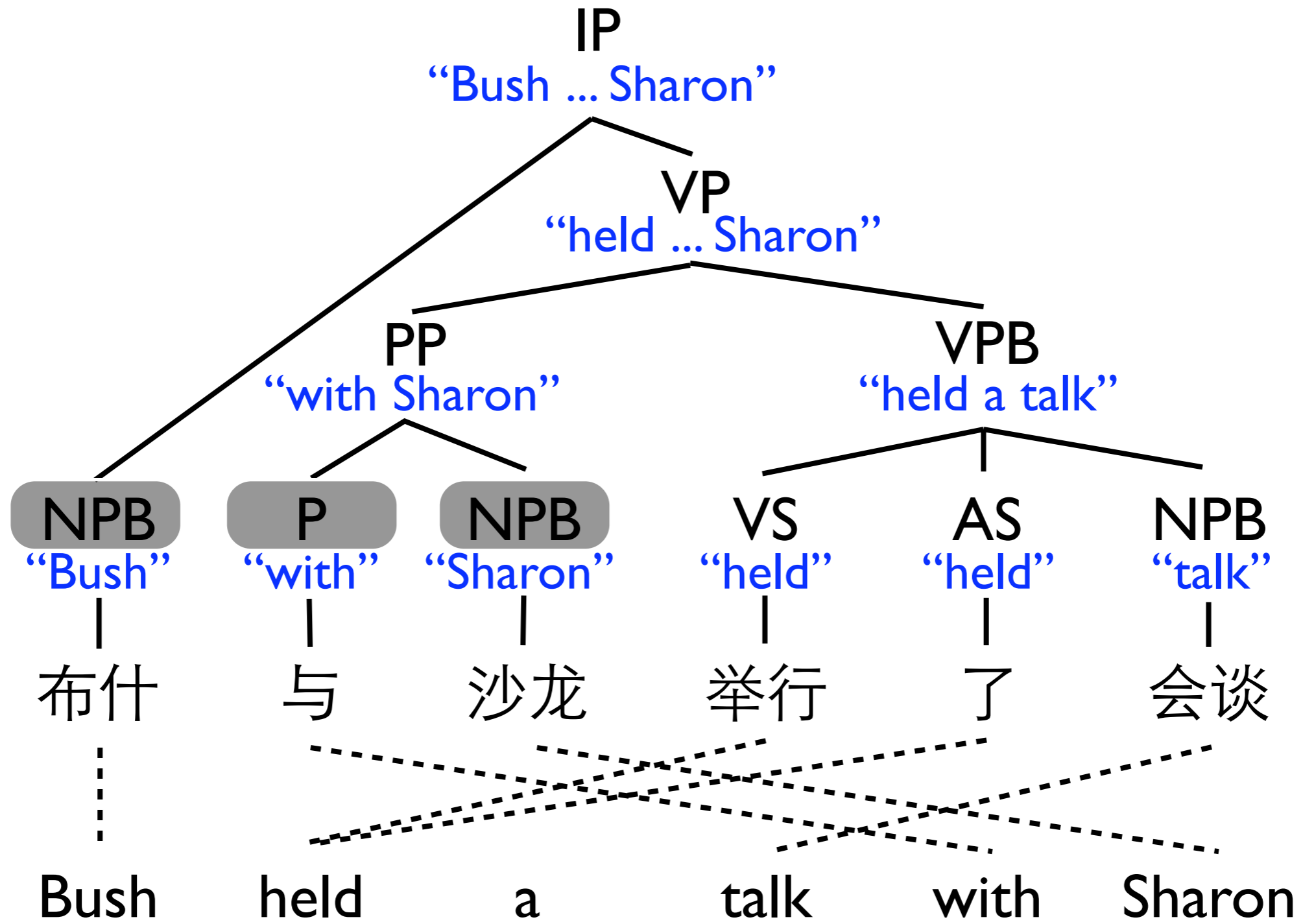
(Galley et al., 2004)

# 规则抽取



(Galley et al., 2004)

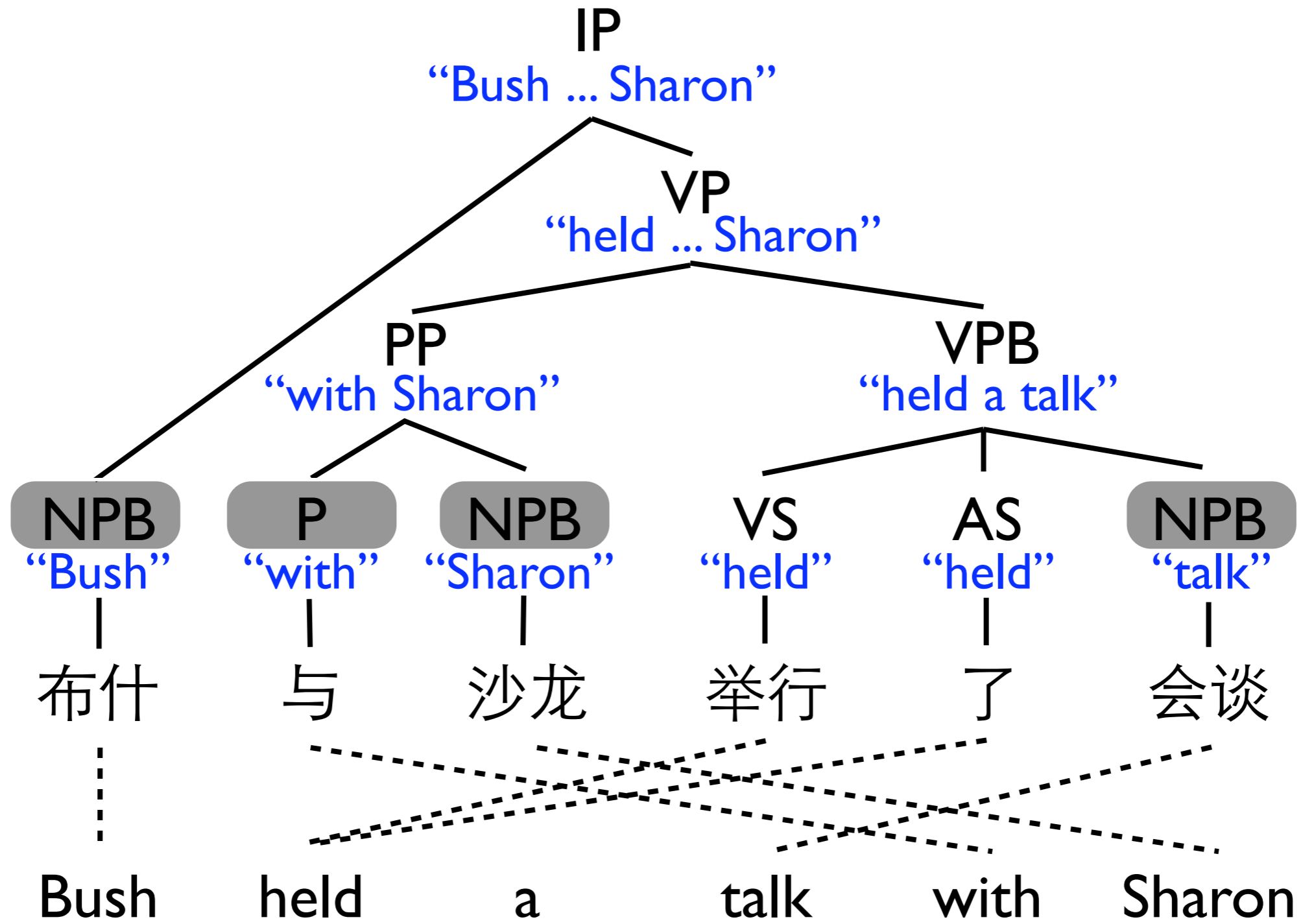
# 规则抽取



(Galley et al., 2004)

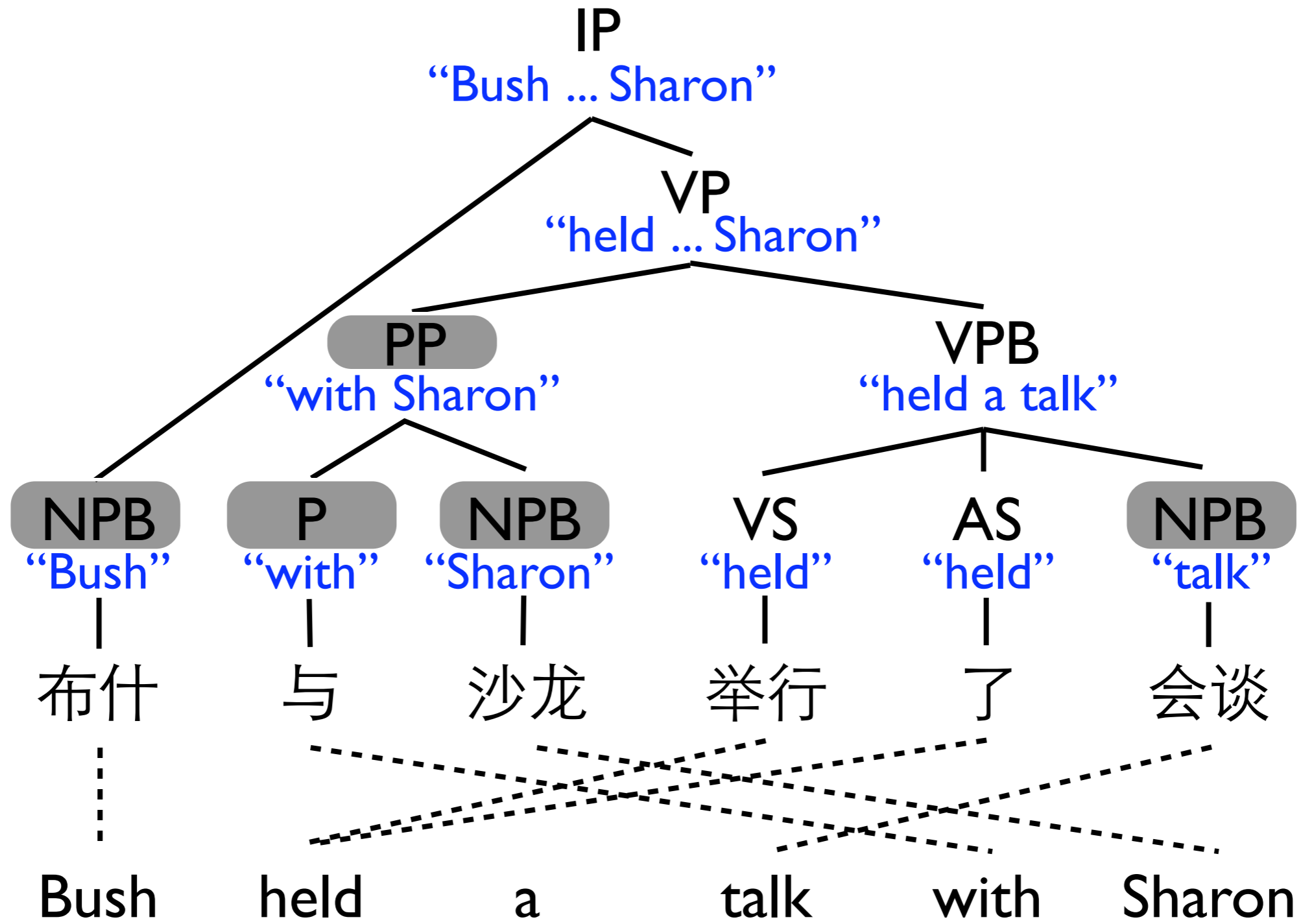


# 规则抽取



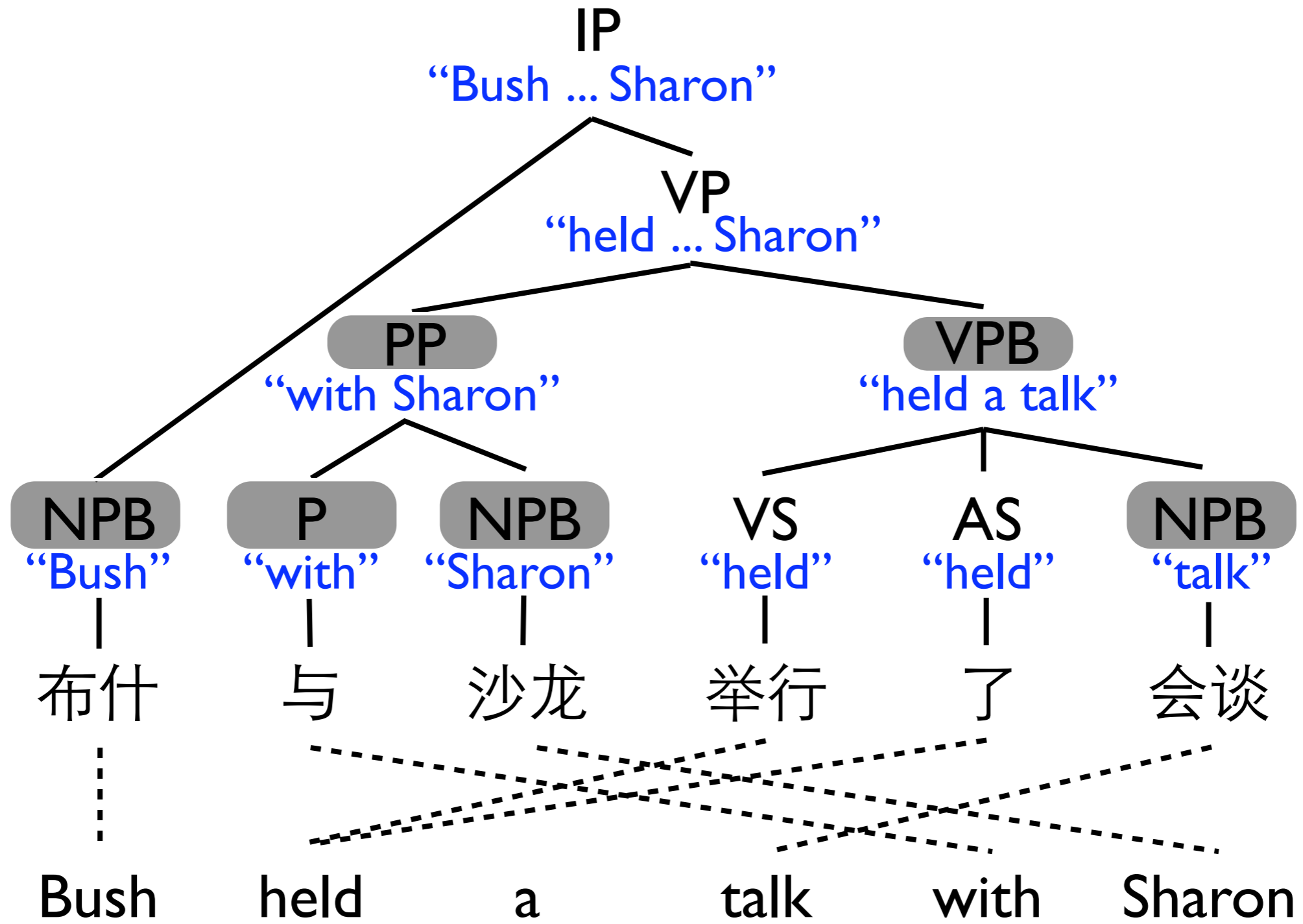
(Galley et al., 2004)

# 规则抽取



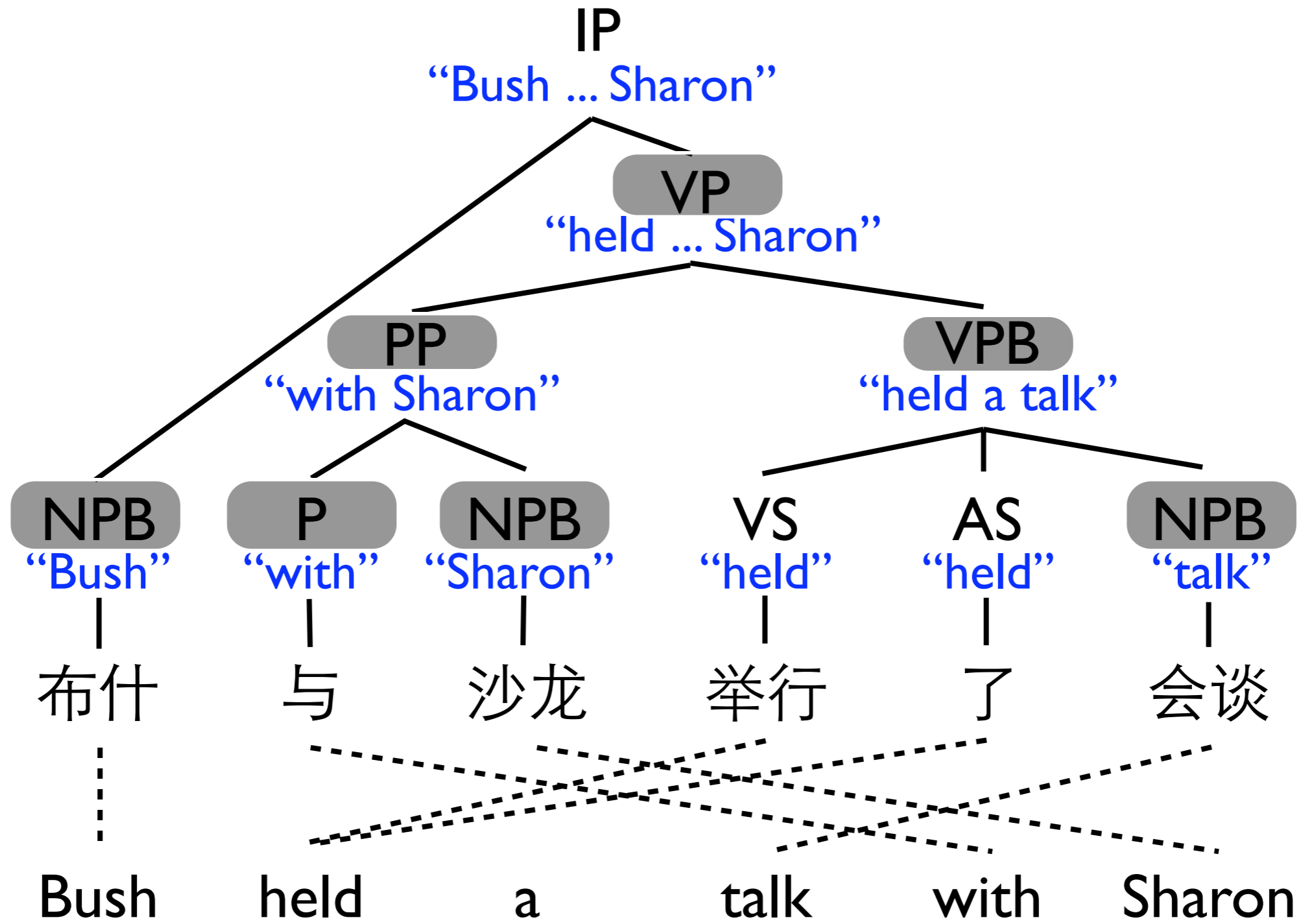
(Galley et al., 2004)

# 规则抽取



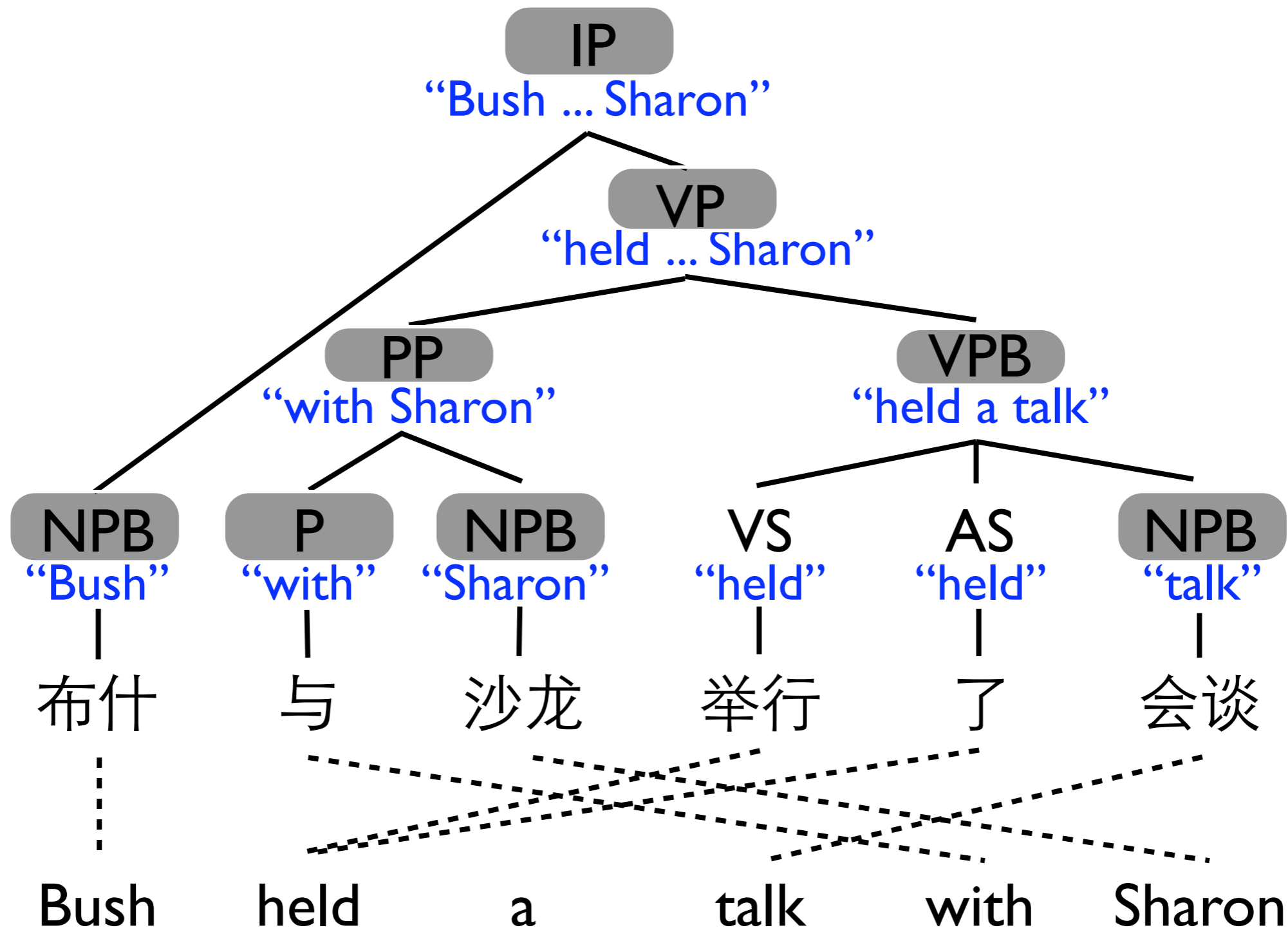
(Galley et al., 2004)

# 规则抽取



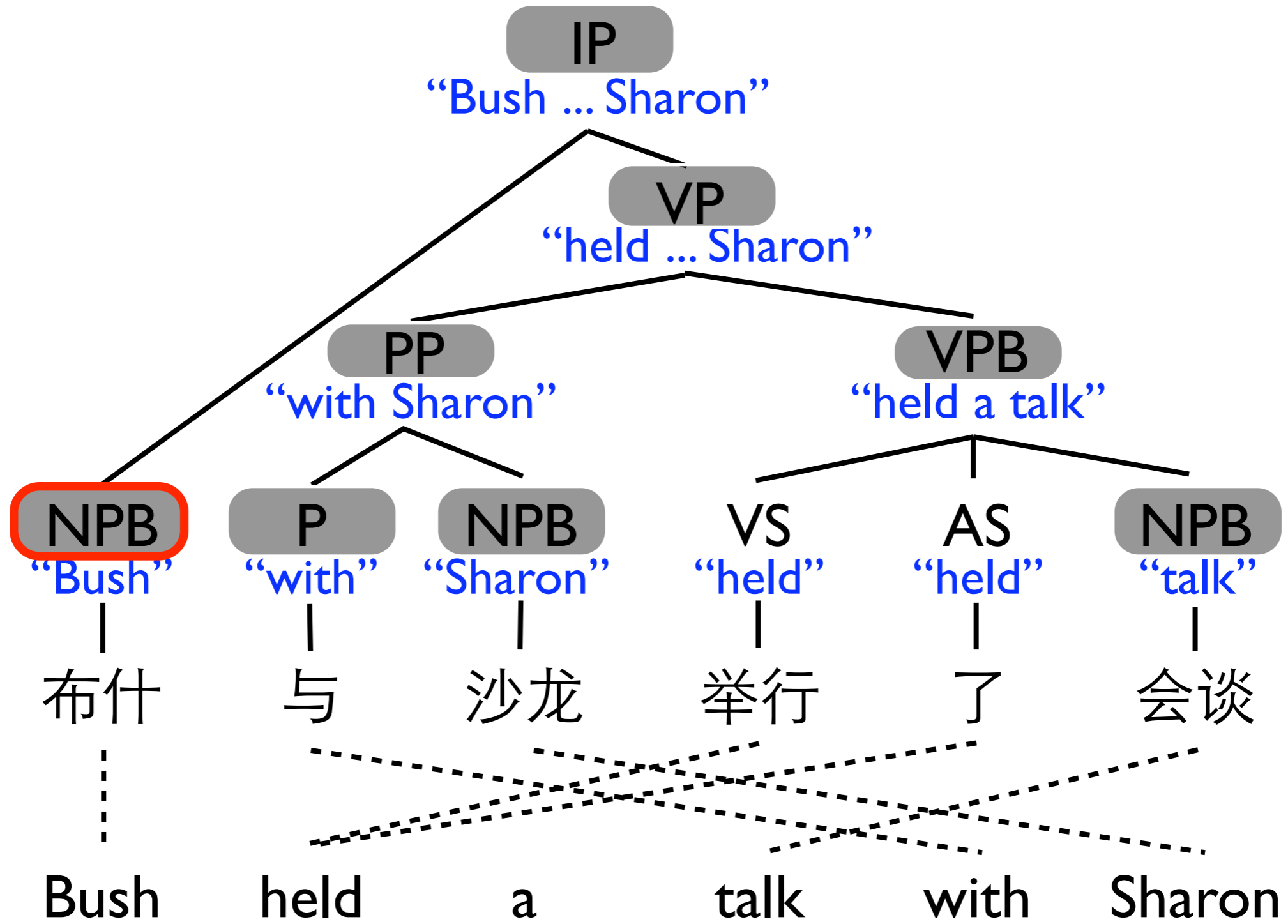
(Galley et al., 2004)

# 规则抽取



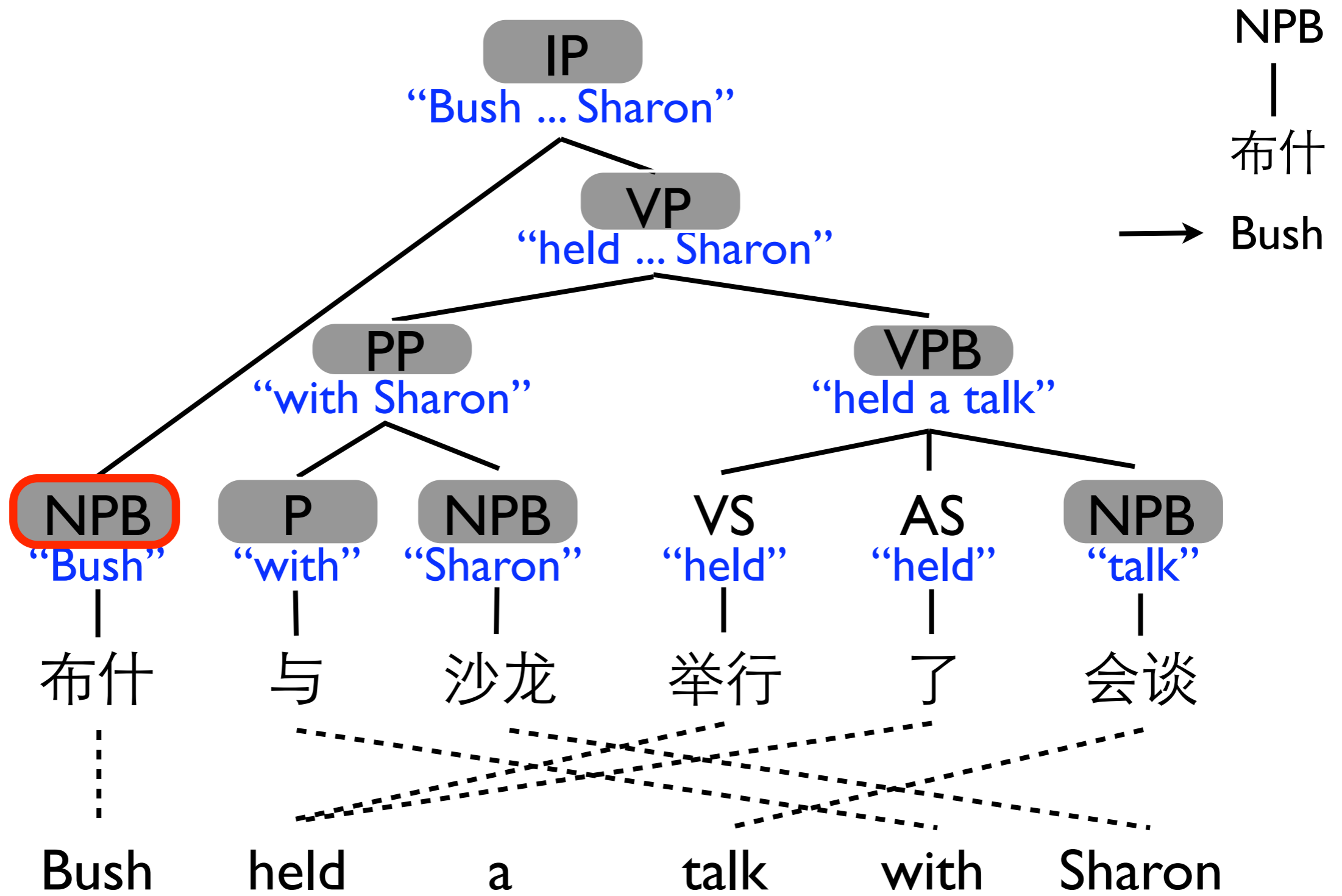
(Galley et al., 2004)

# 规则抽取



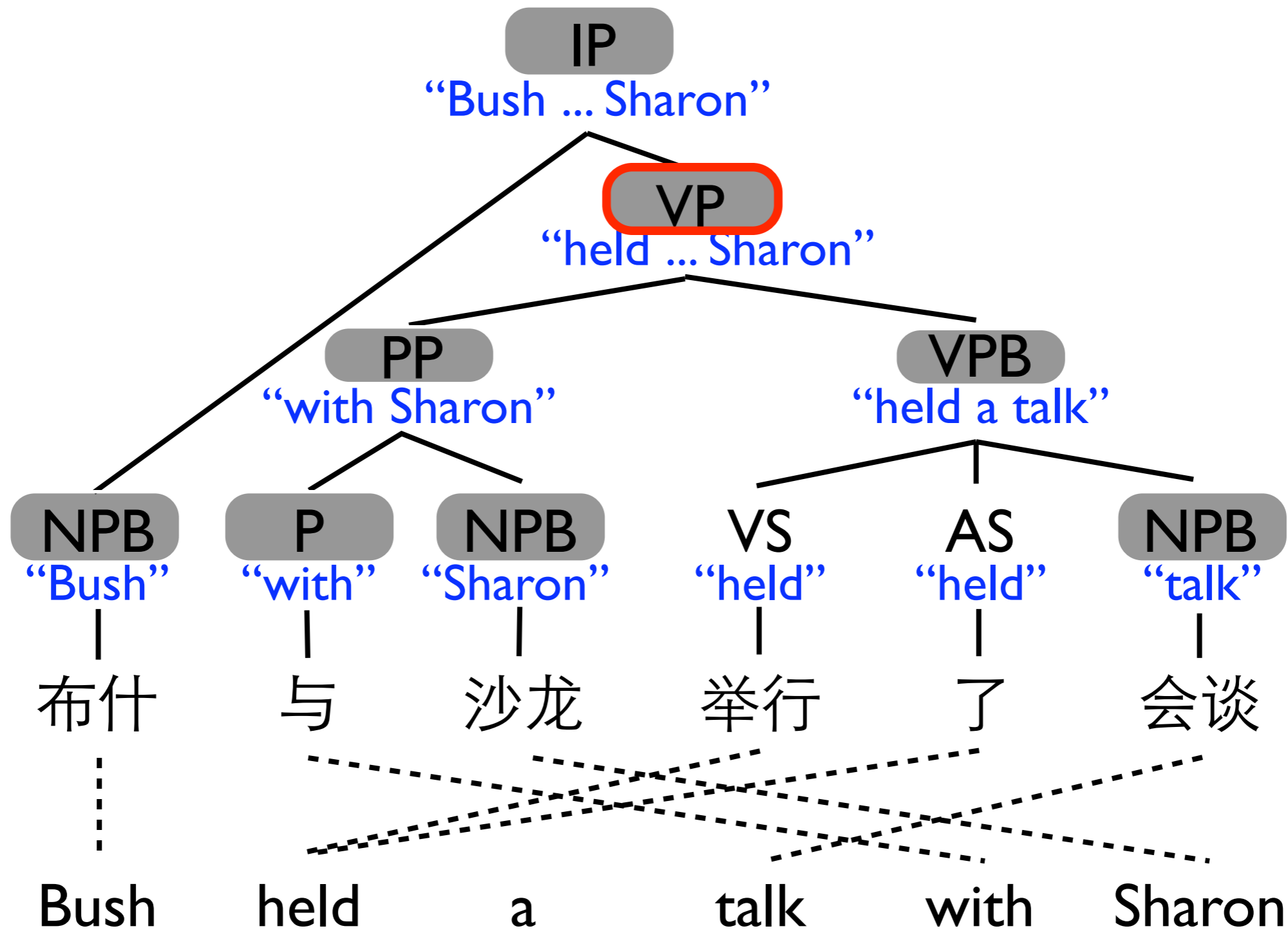
(Galley et al., 2004)

# 规则抽取



(Galley et al., 2004)

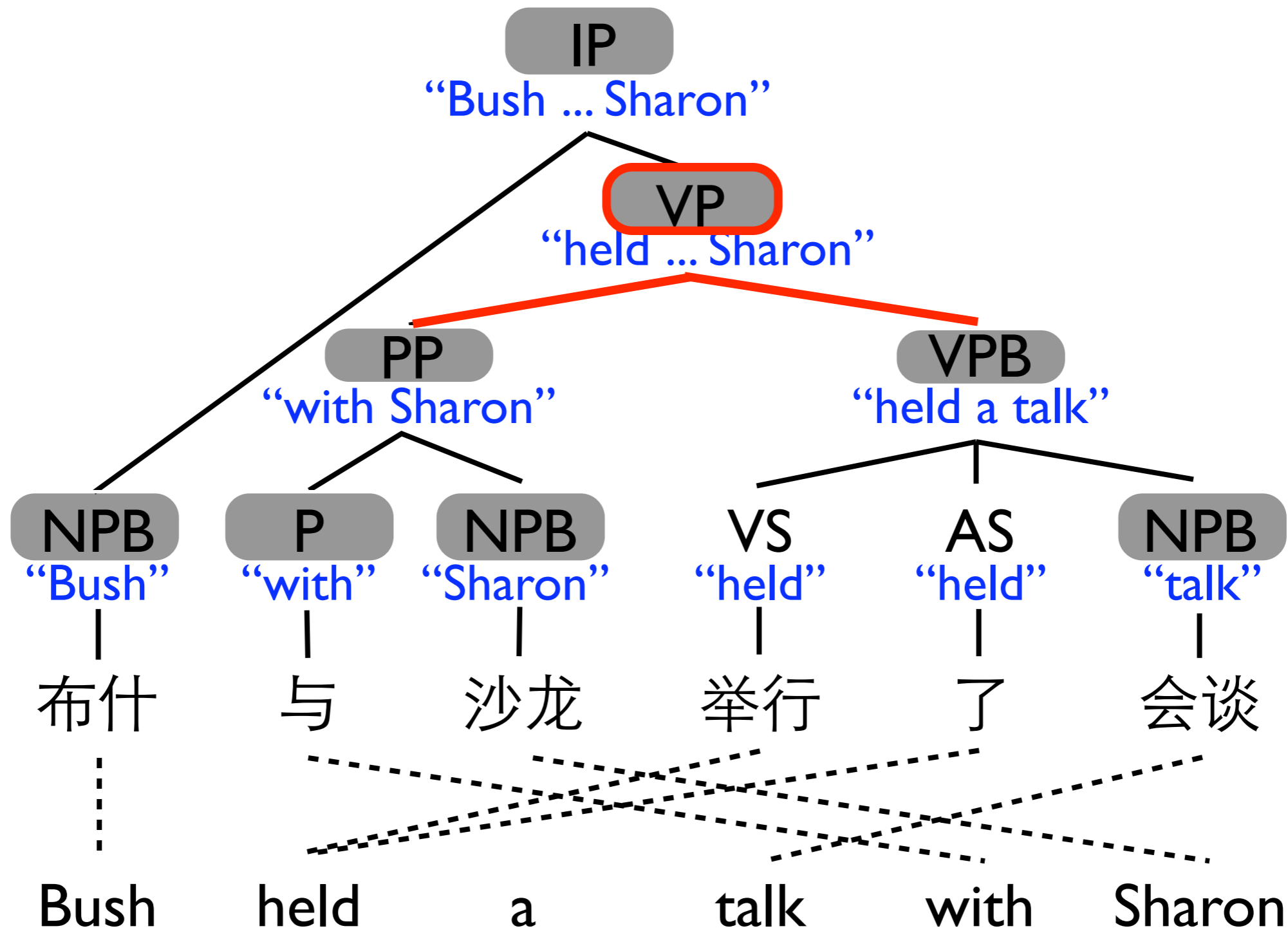
# 规则抽取



(Galley et al., 2004)

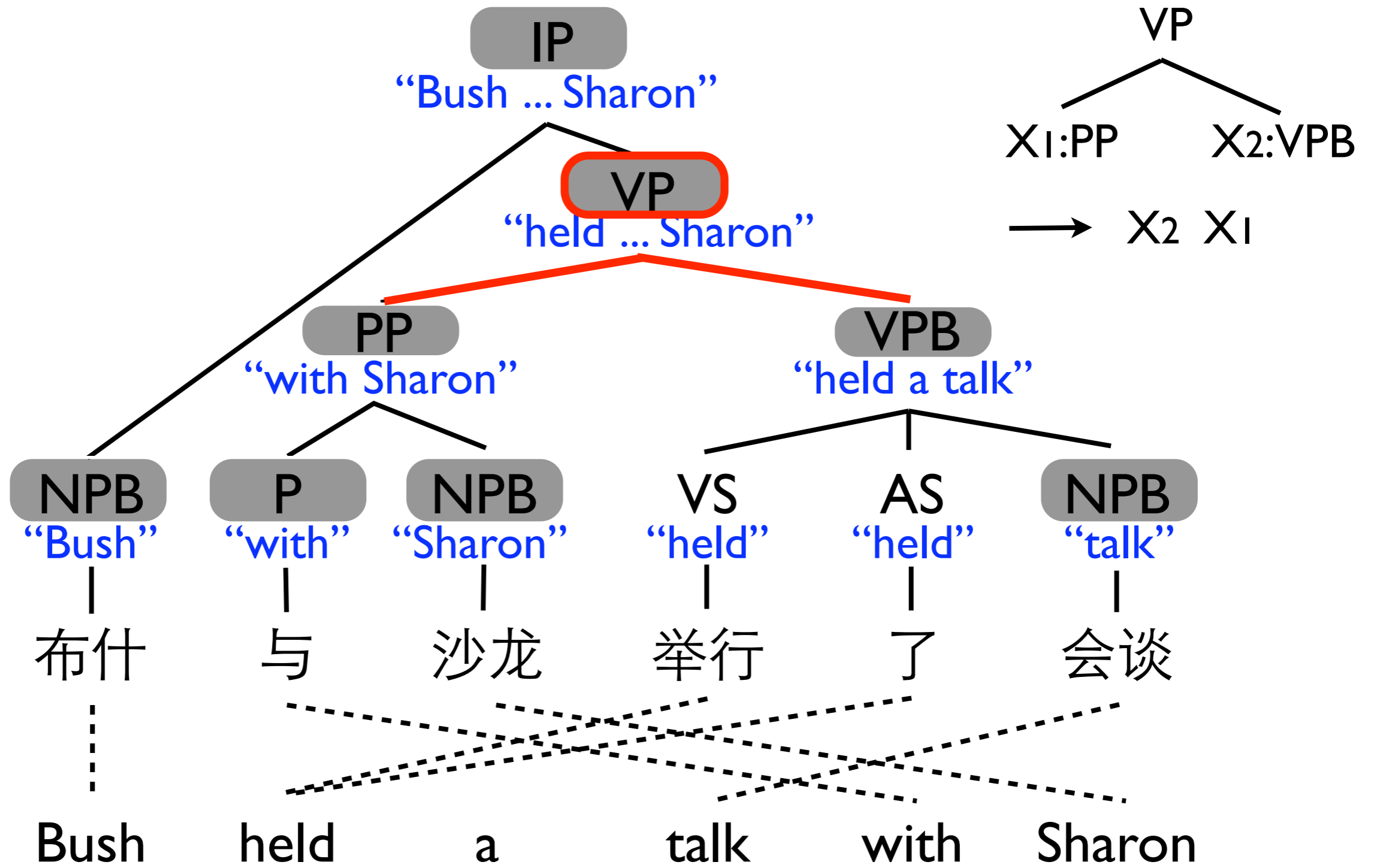


# 规则抽取



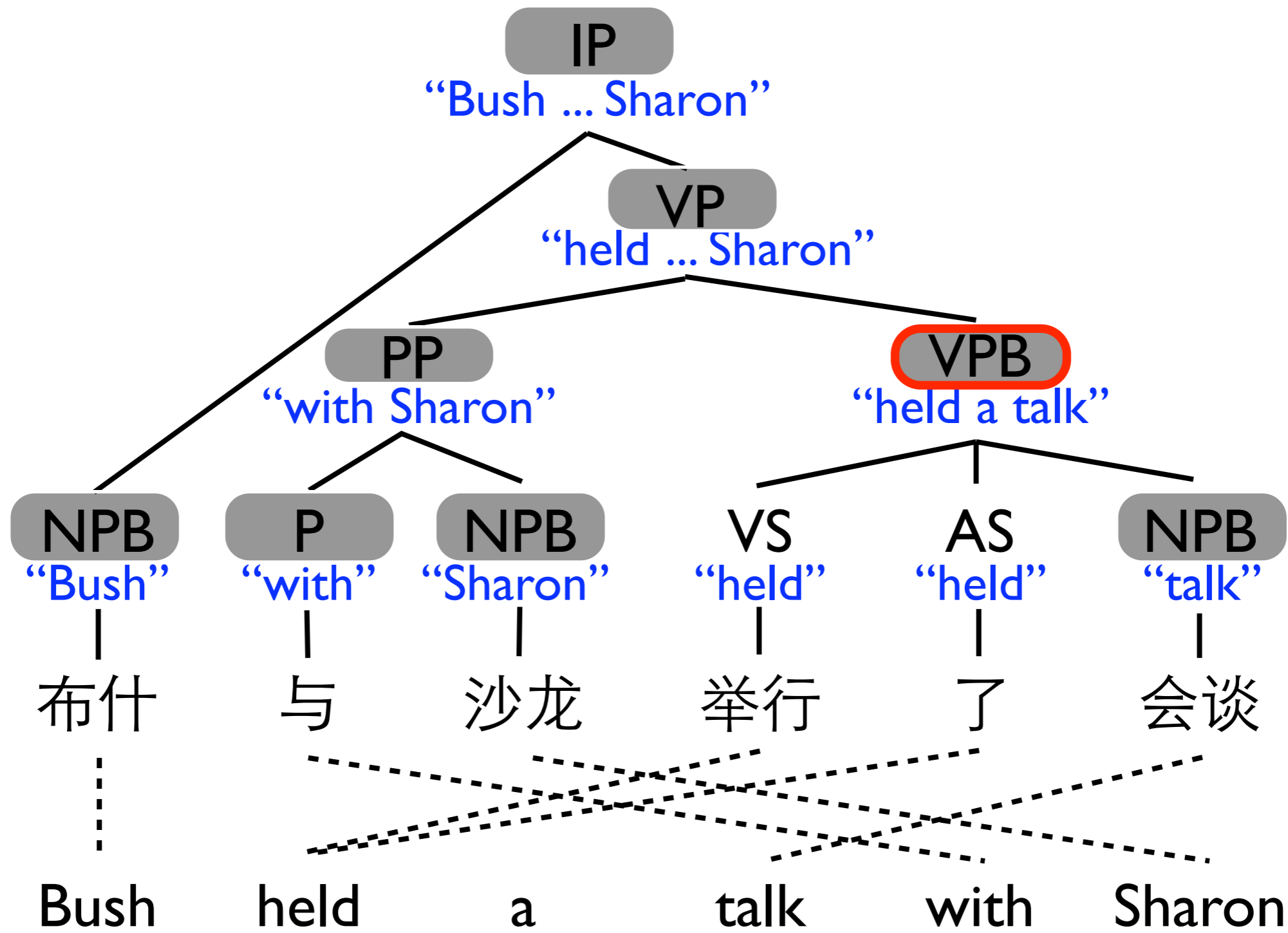
(Galley et al., 2004)

# 规则抽取



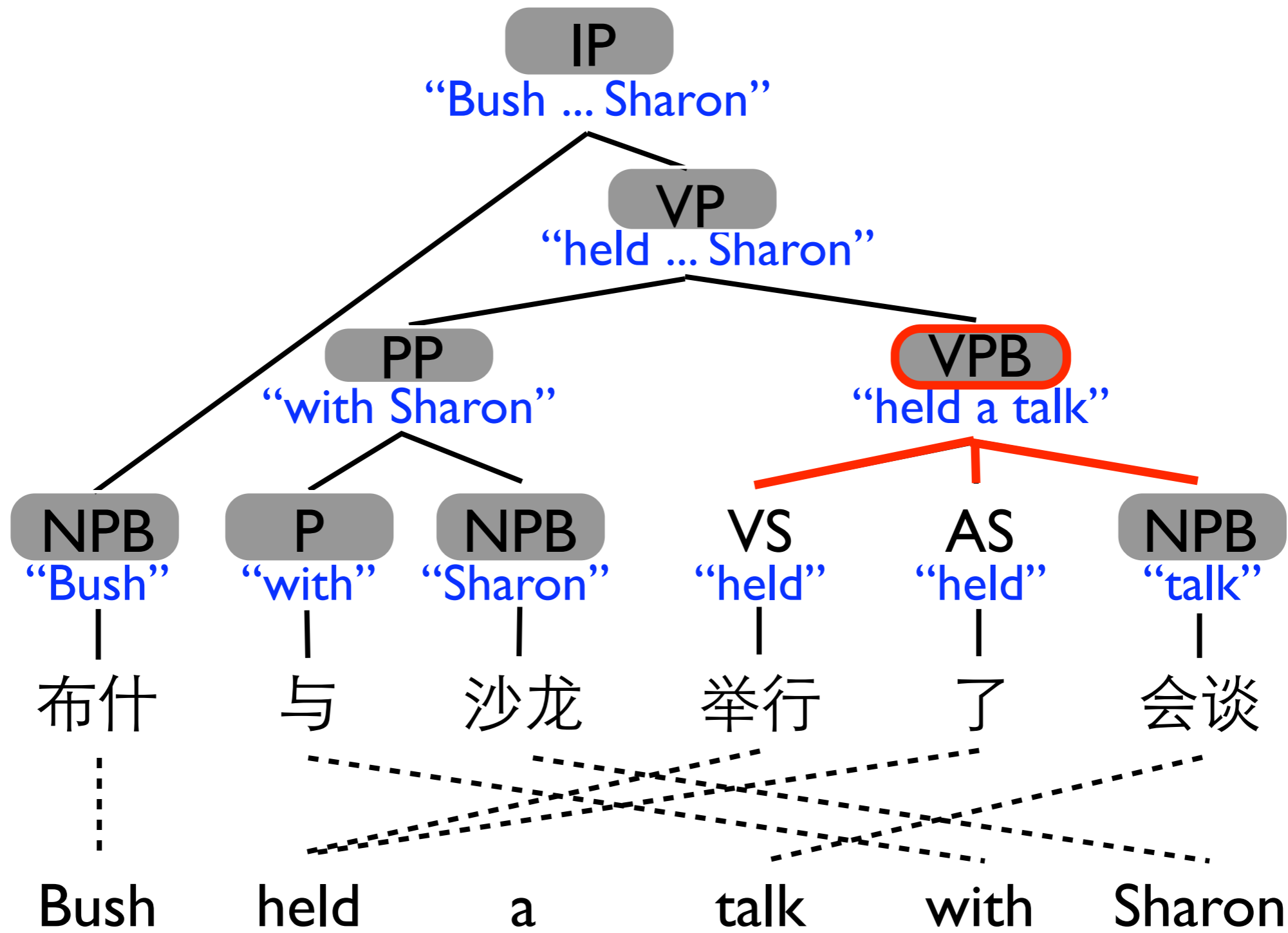
(Galley et al., 2004)

# 规则抽取



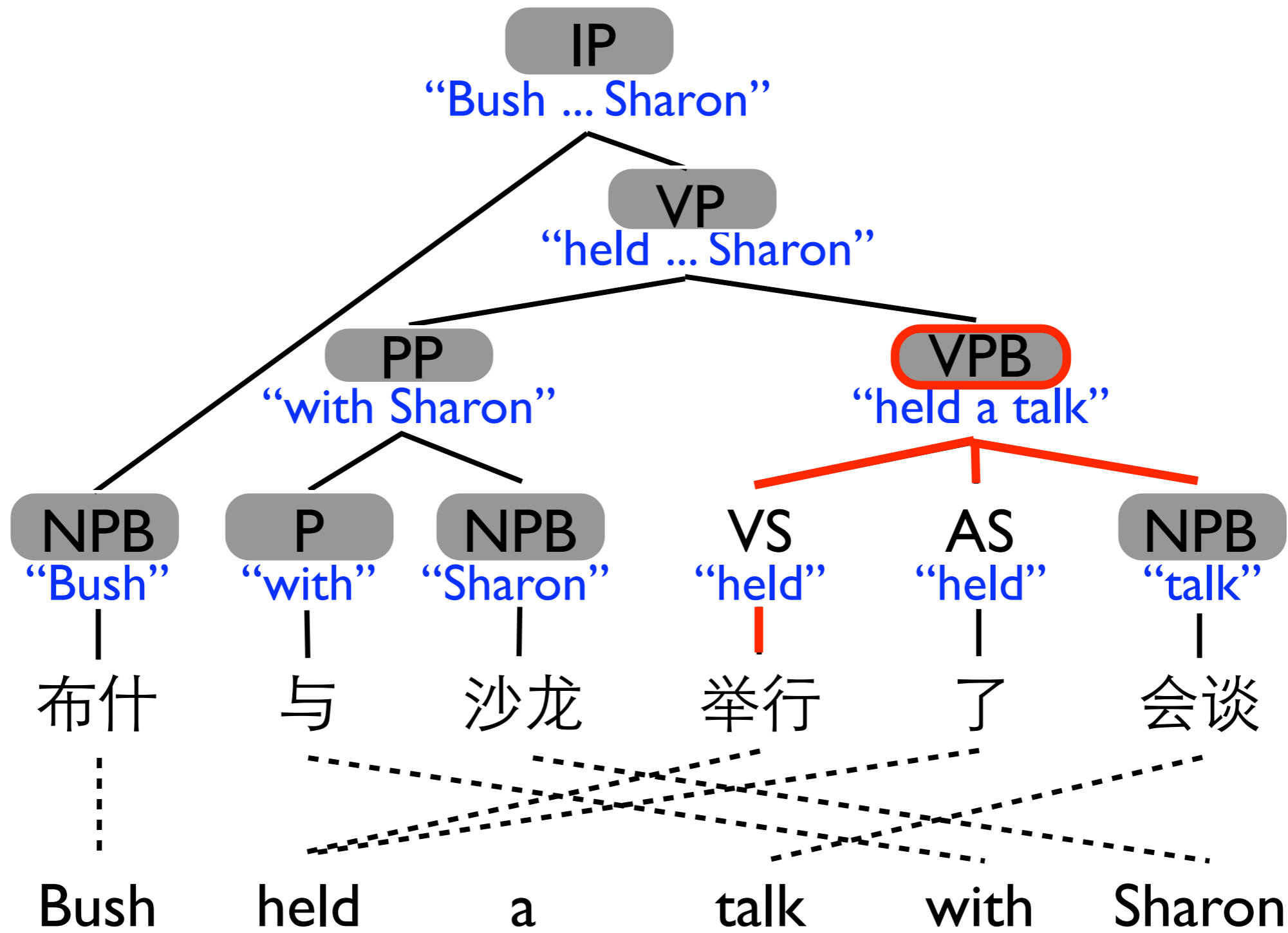
(Galley et al., 2004)

# 规则抽取



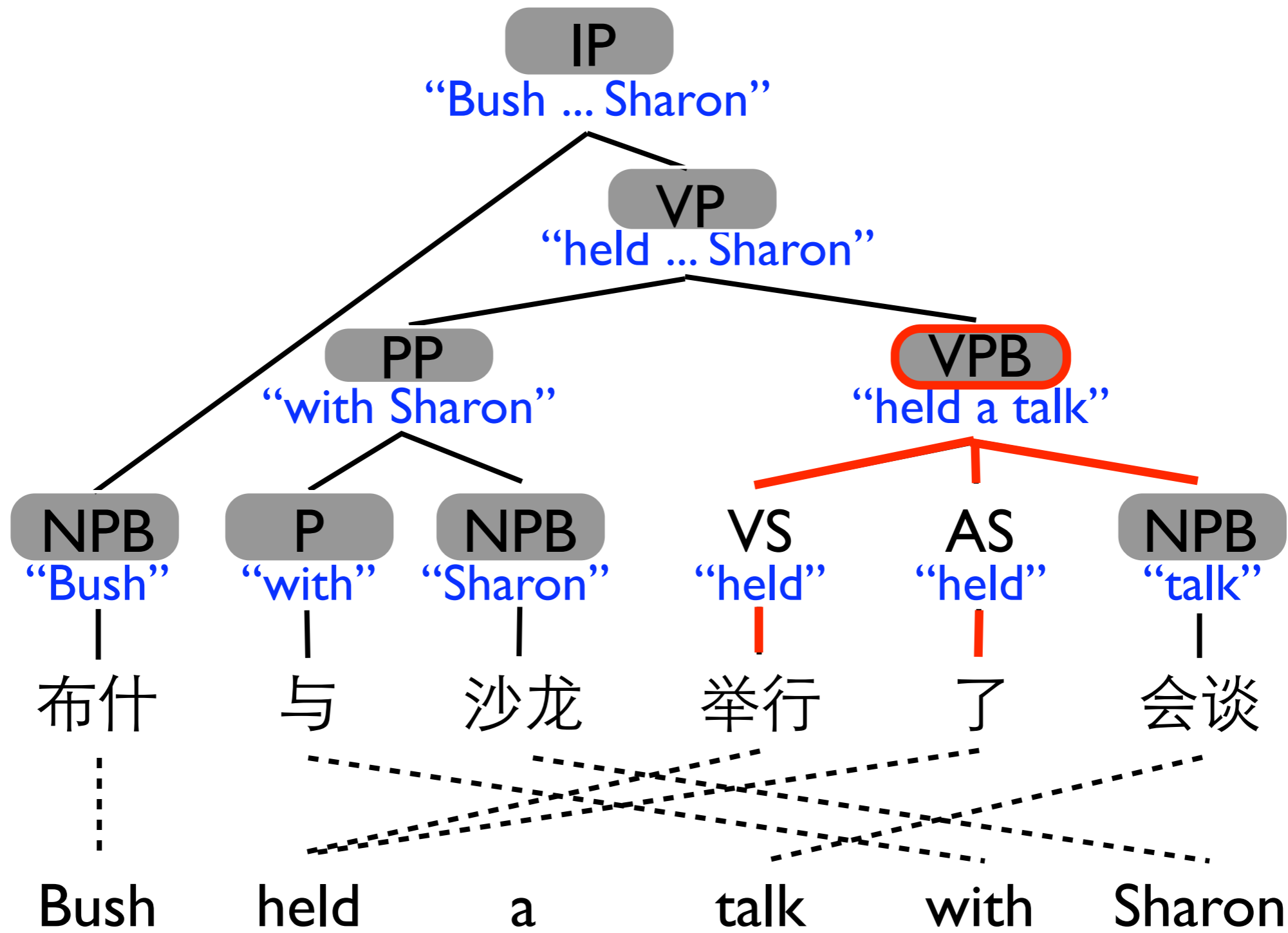
(Galley et al., 2004)

# 规则抽取



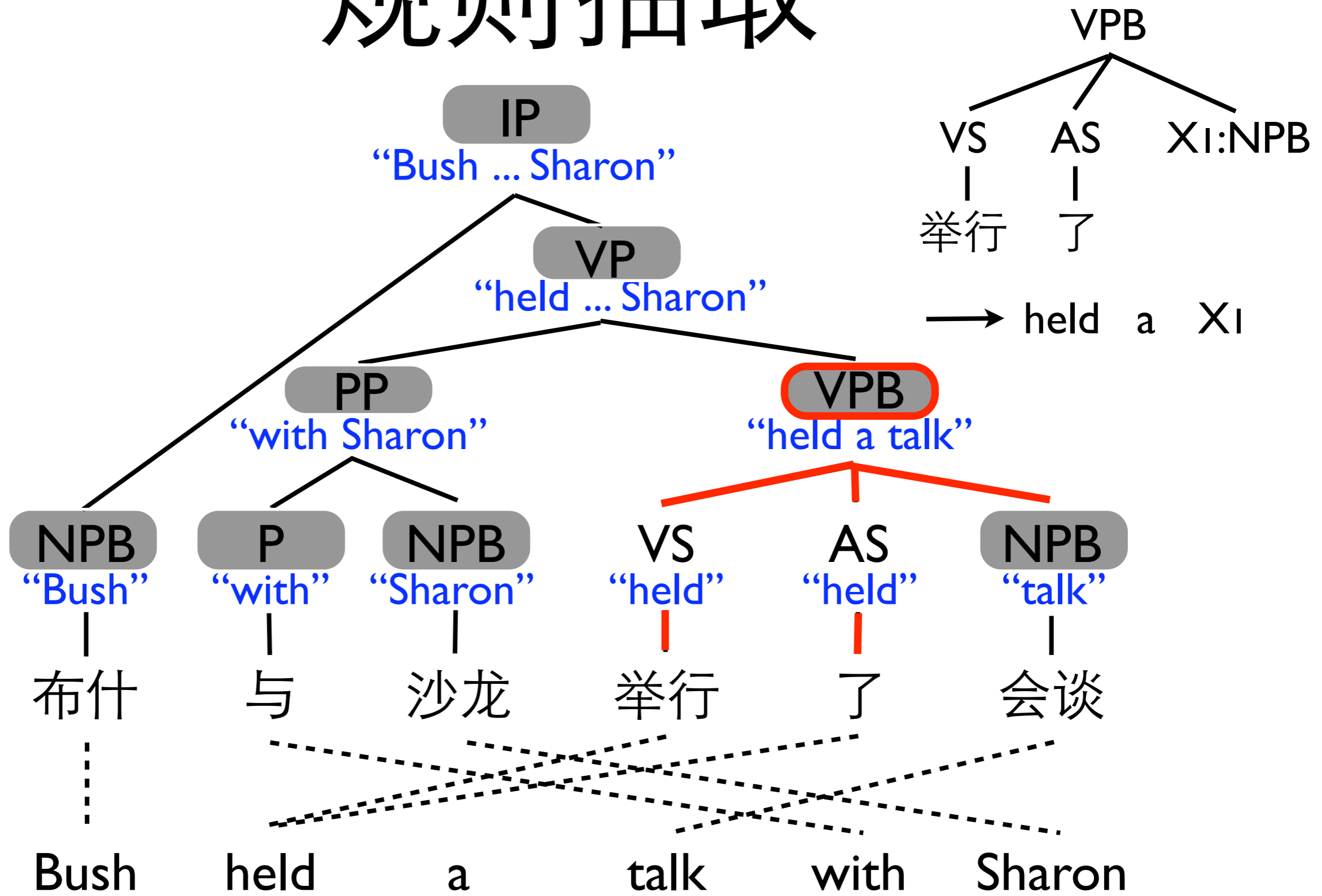
(Galley et al., 2004)

# 规则抽取



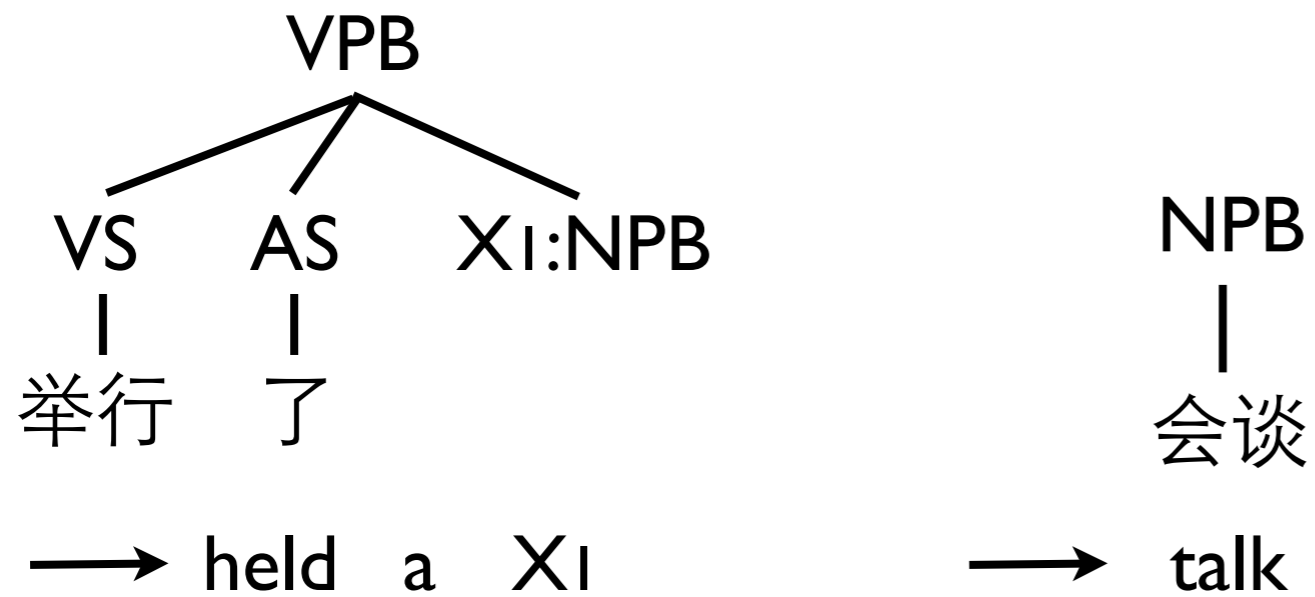
(Galley et al., 2004)

# 规则抽取



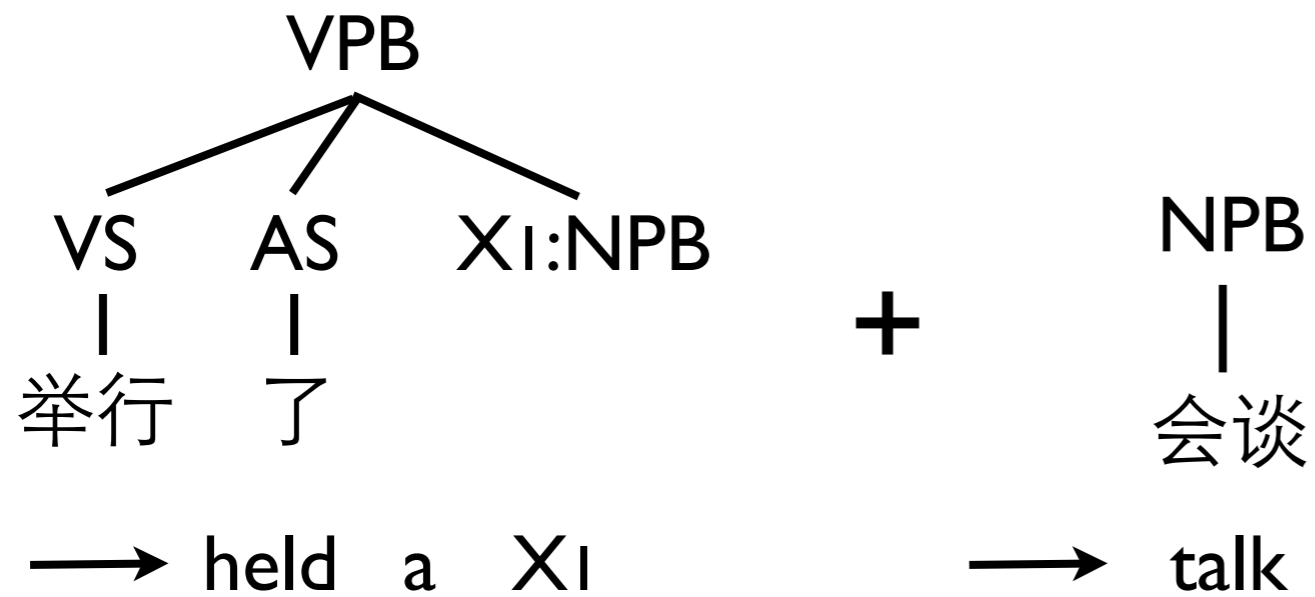
(Galley et al., 2004)

# 复合规则

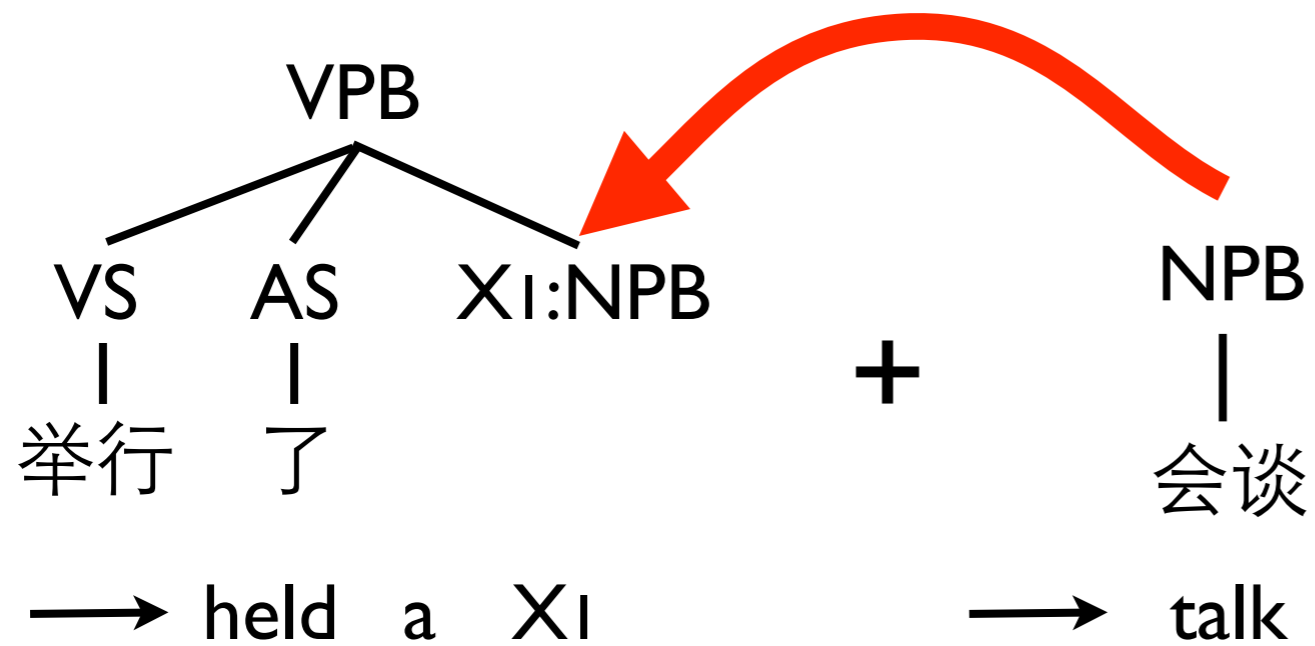




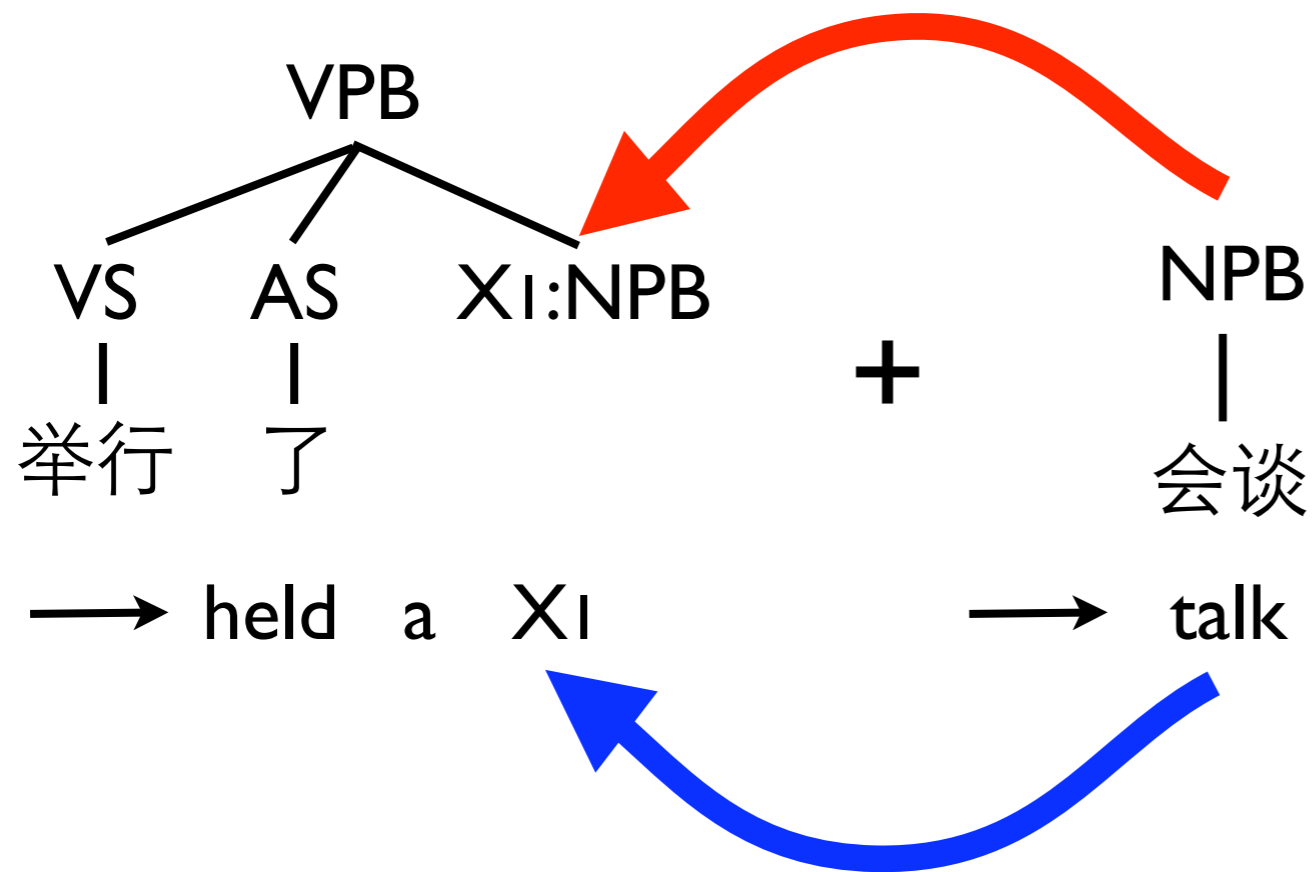
# 复合规则



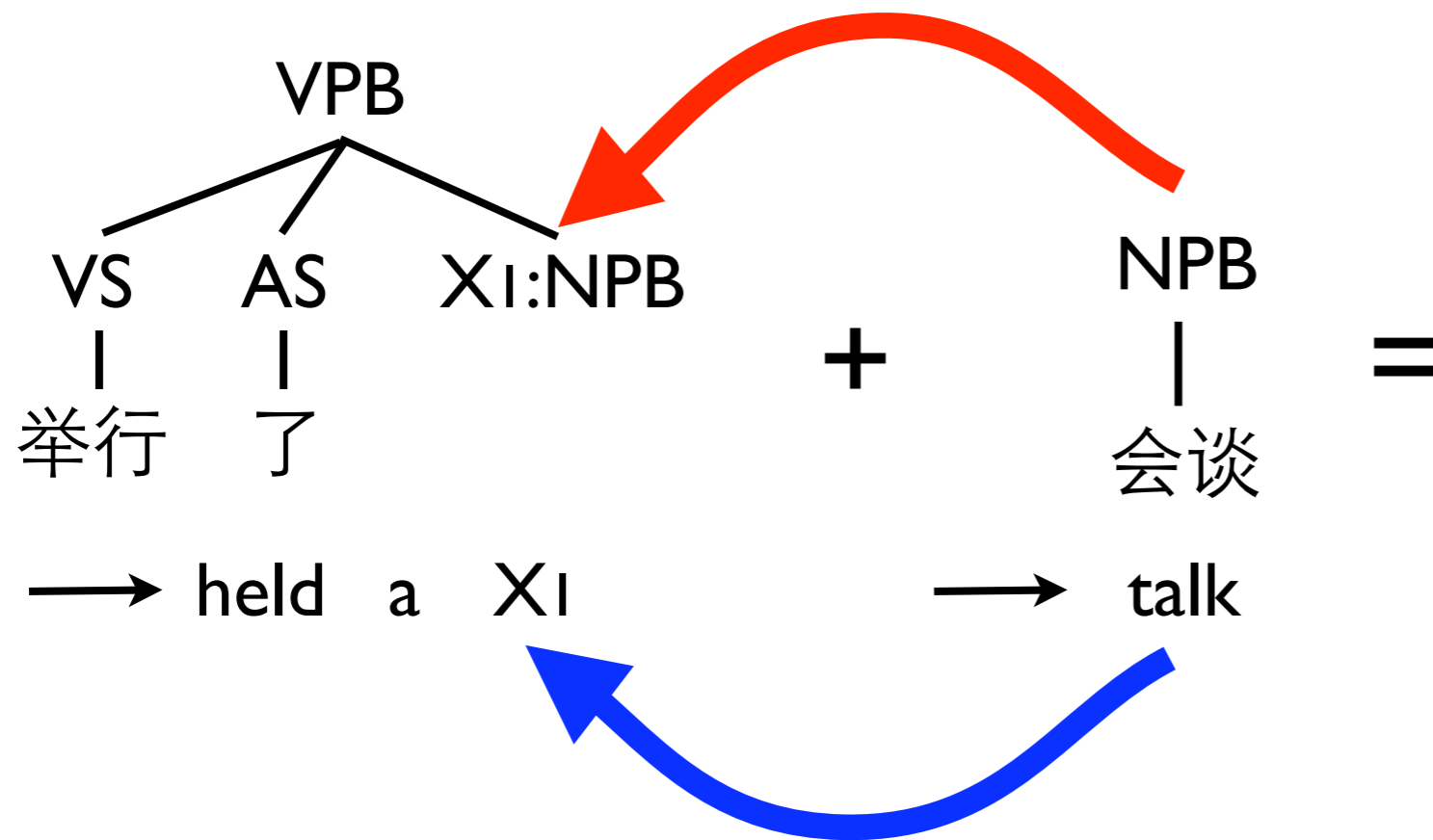
# 复合规则



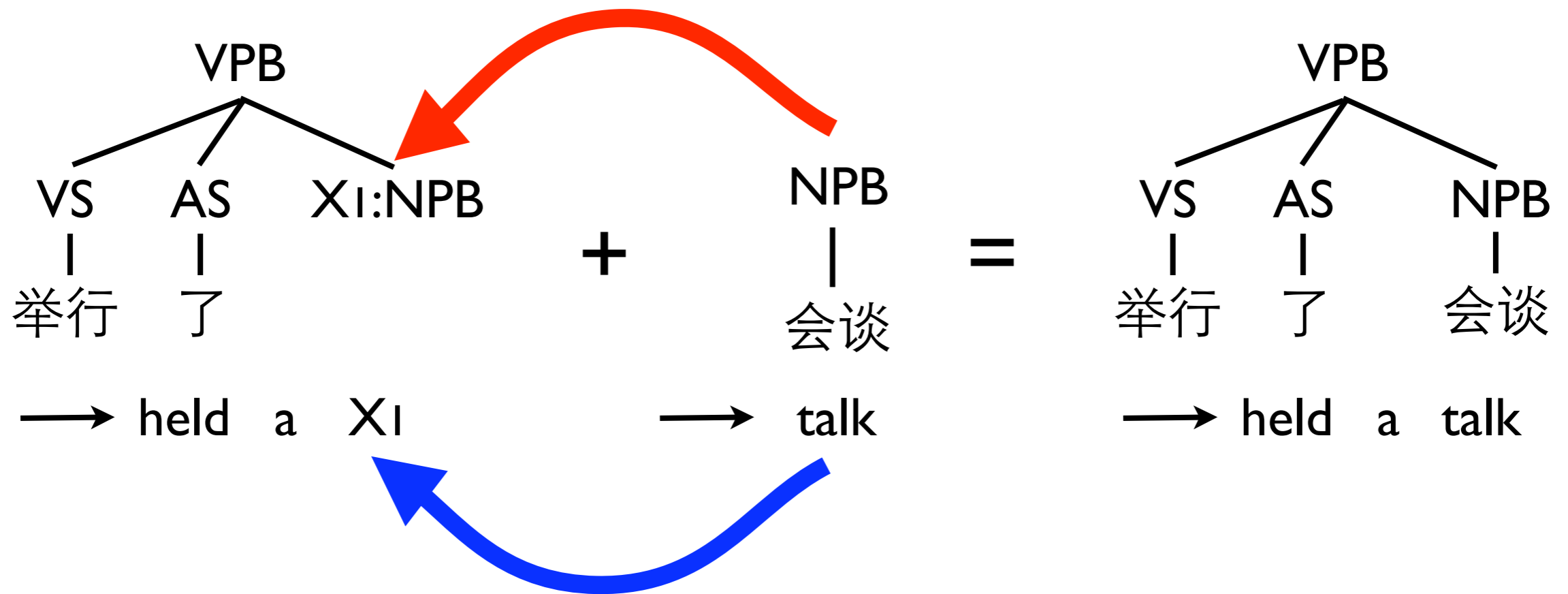
# 复合规则



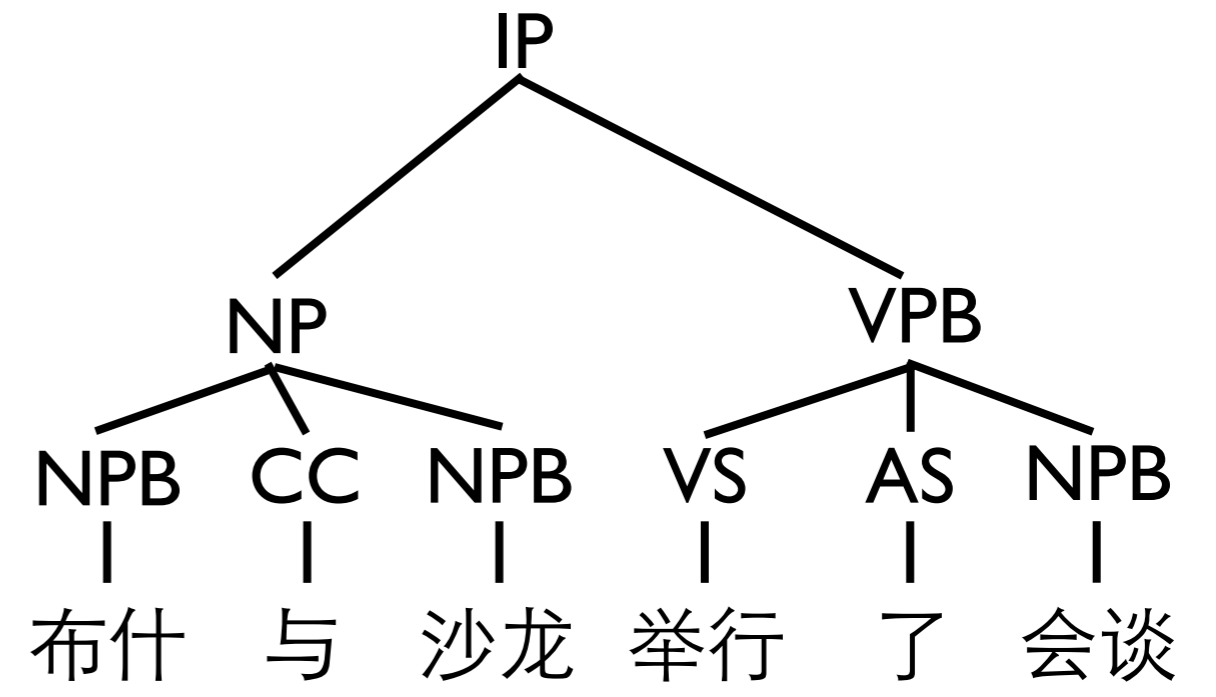
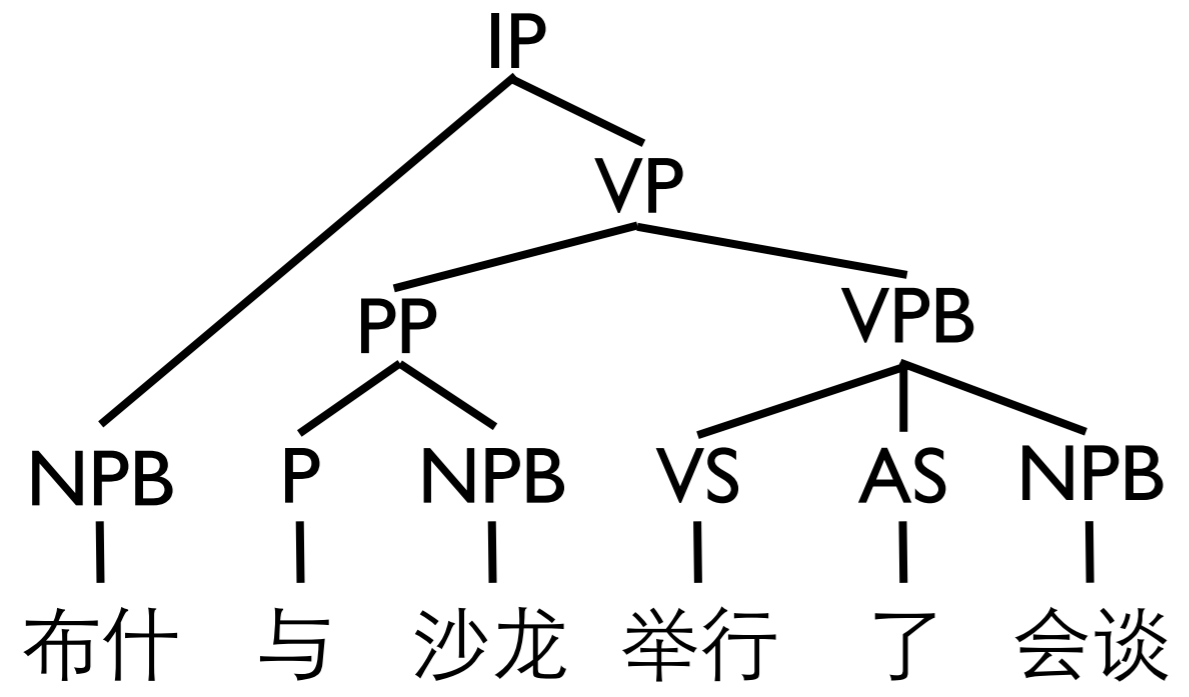
# 复合规则



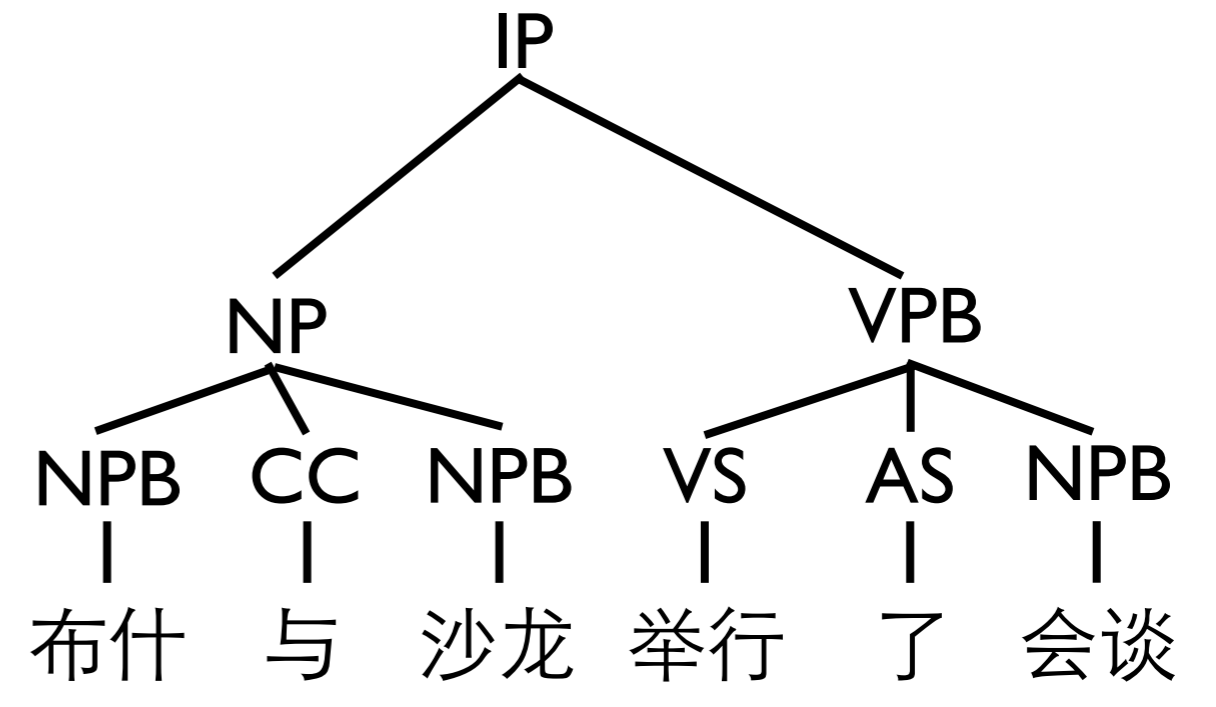
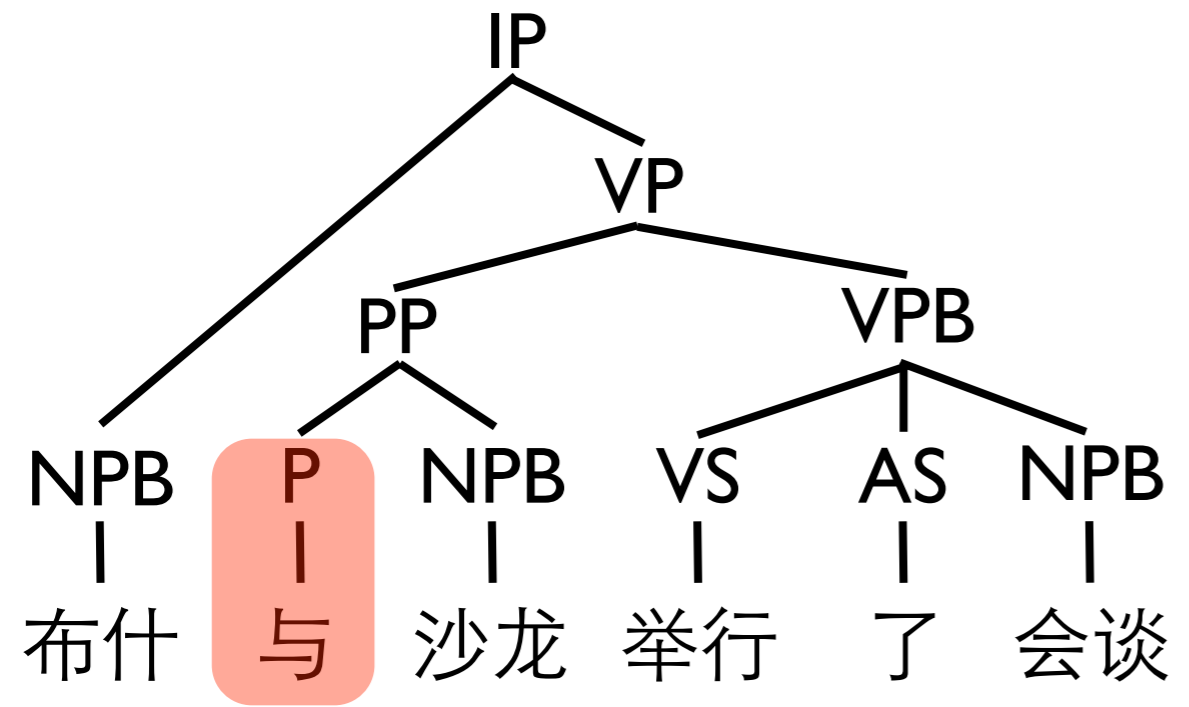
# 复合规则



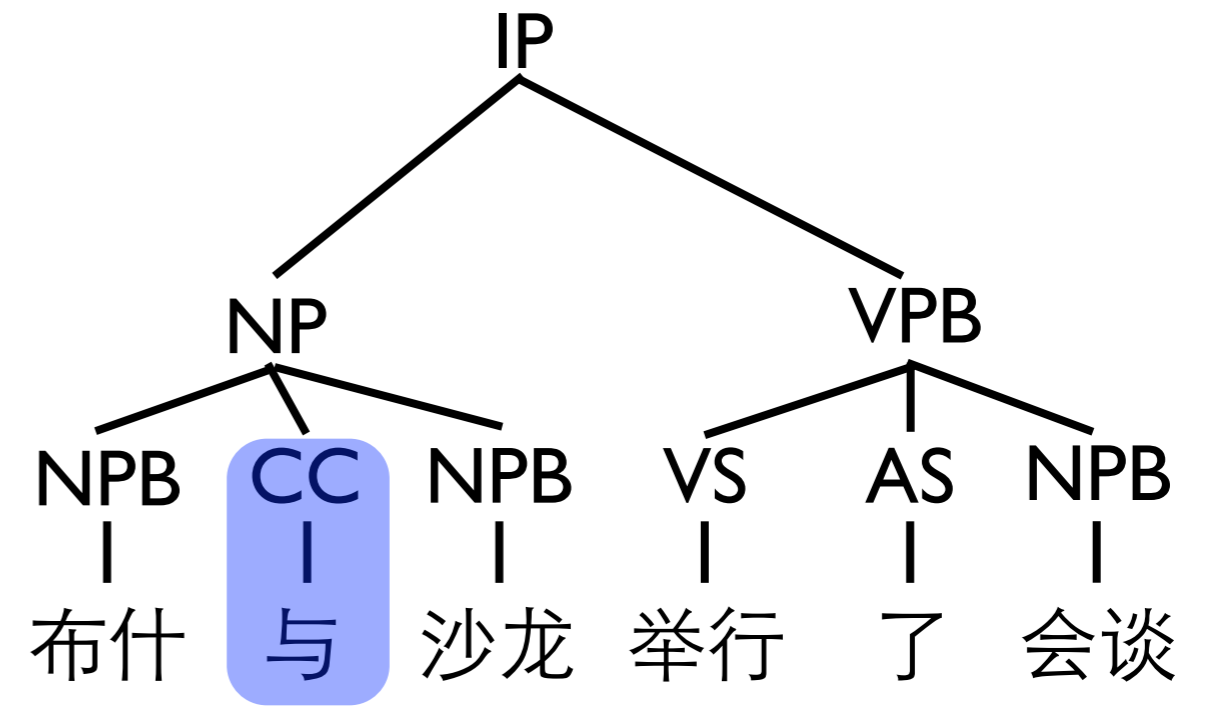
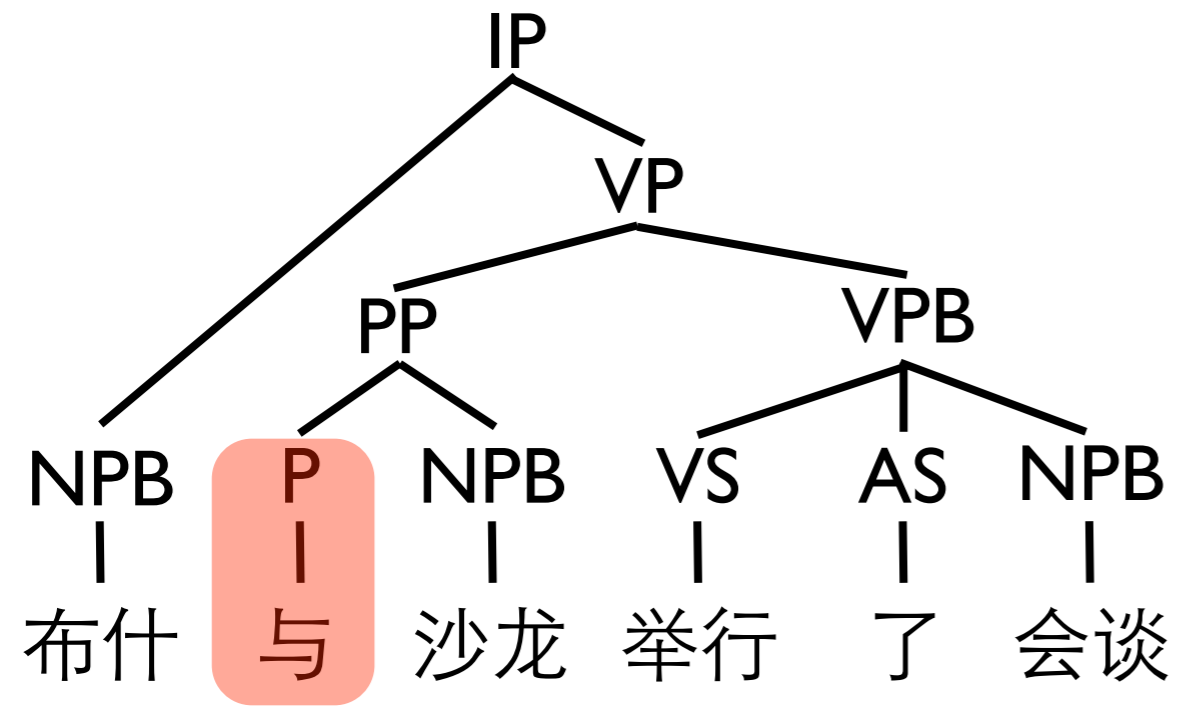
# 结构歧义



# 结构歧义

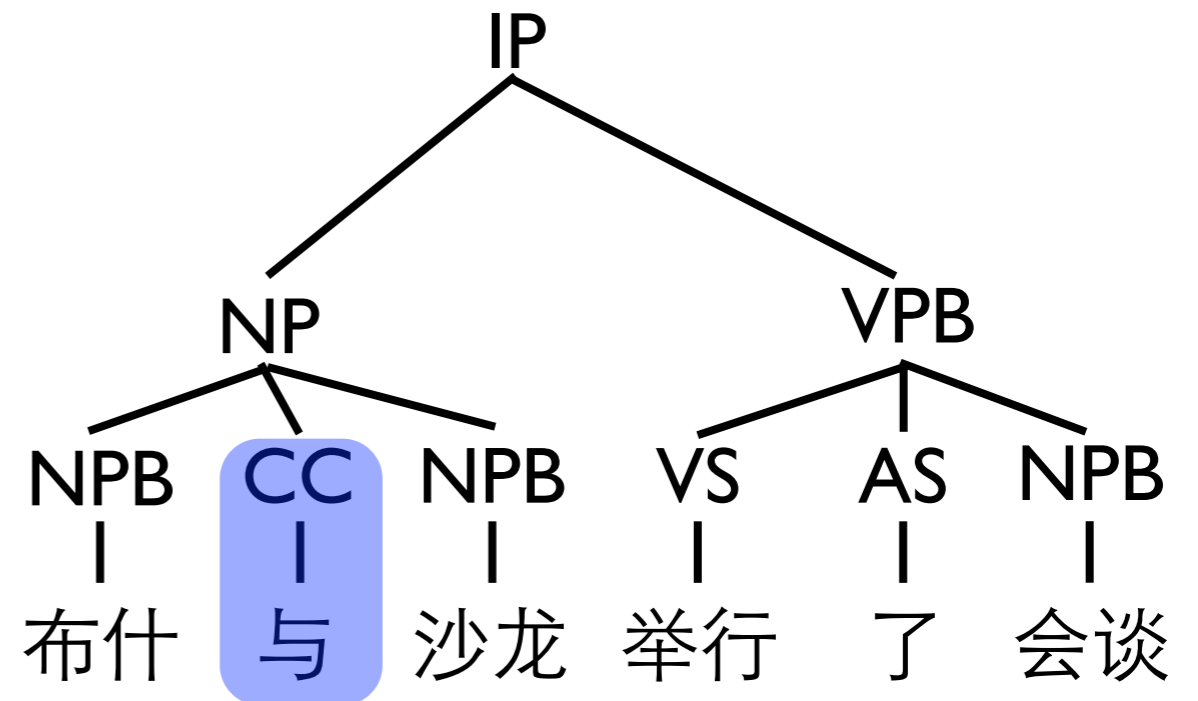
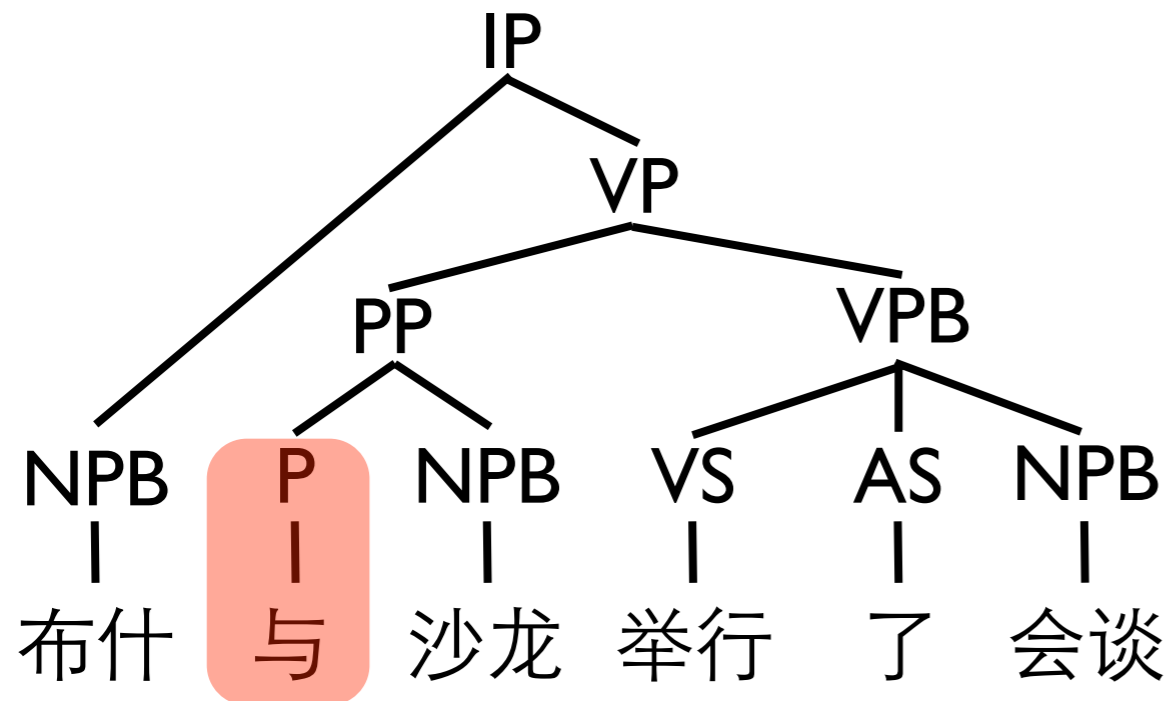


# 结构歧义



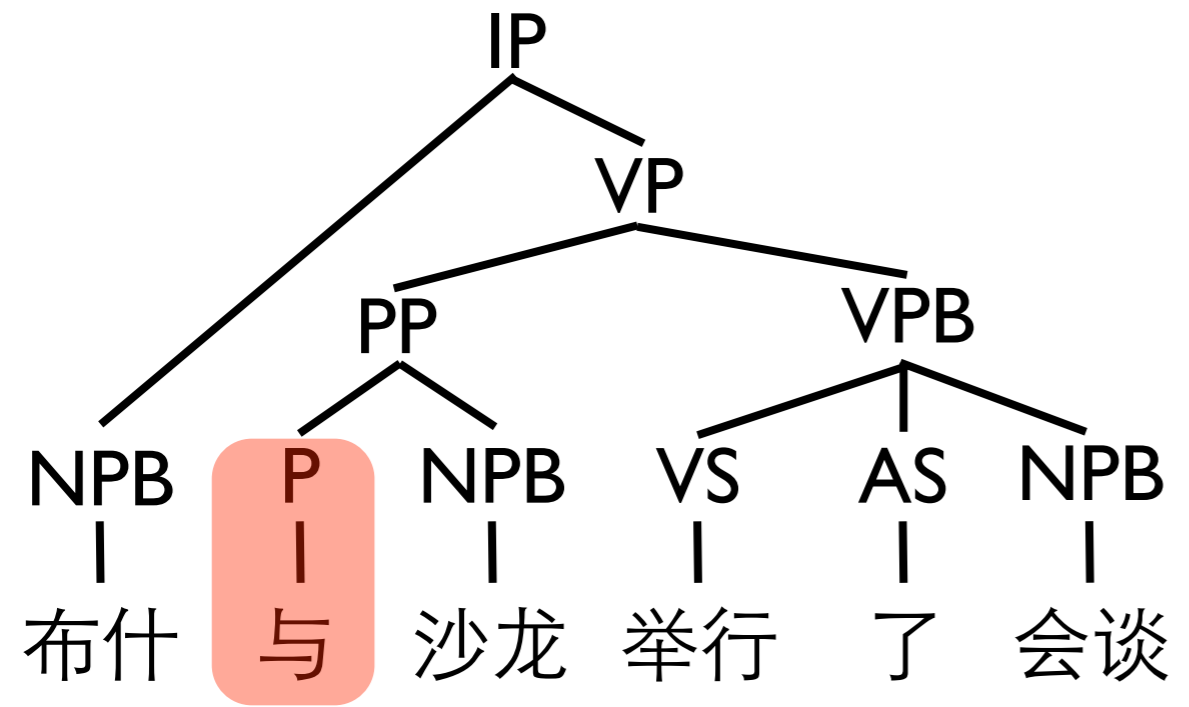


# 结构歧义

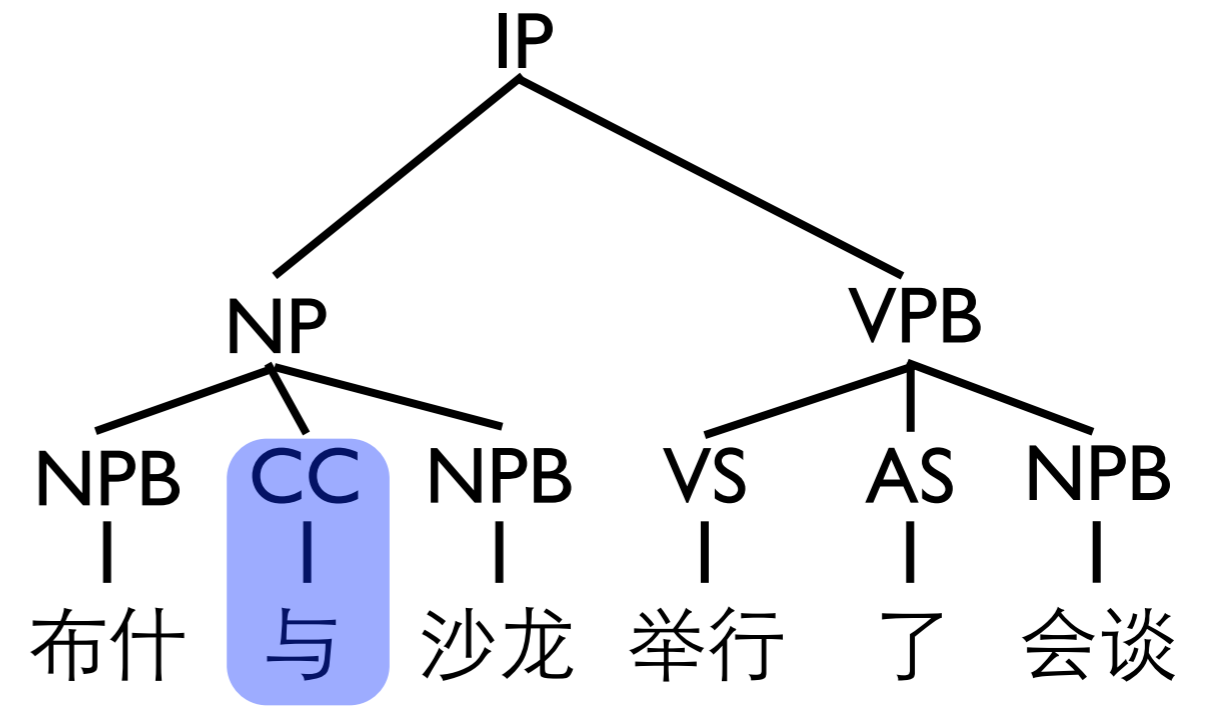


Bush held a talk **with** Sharon

# 结构歧义

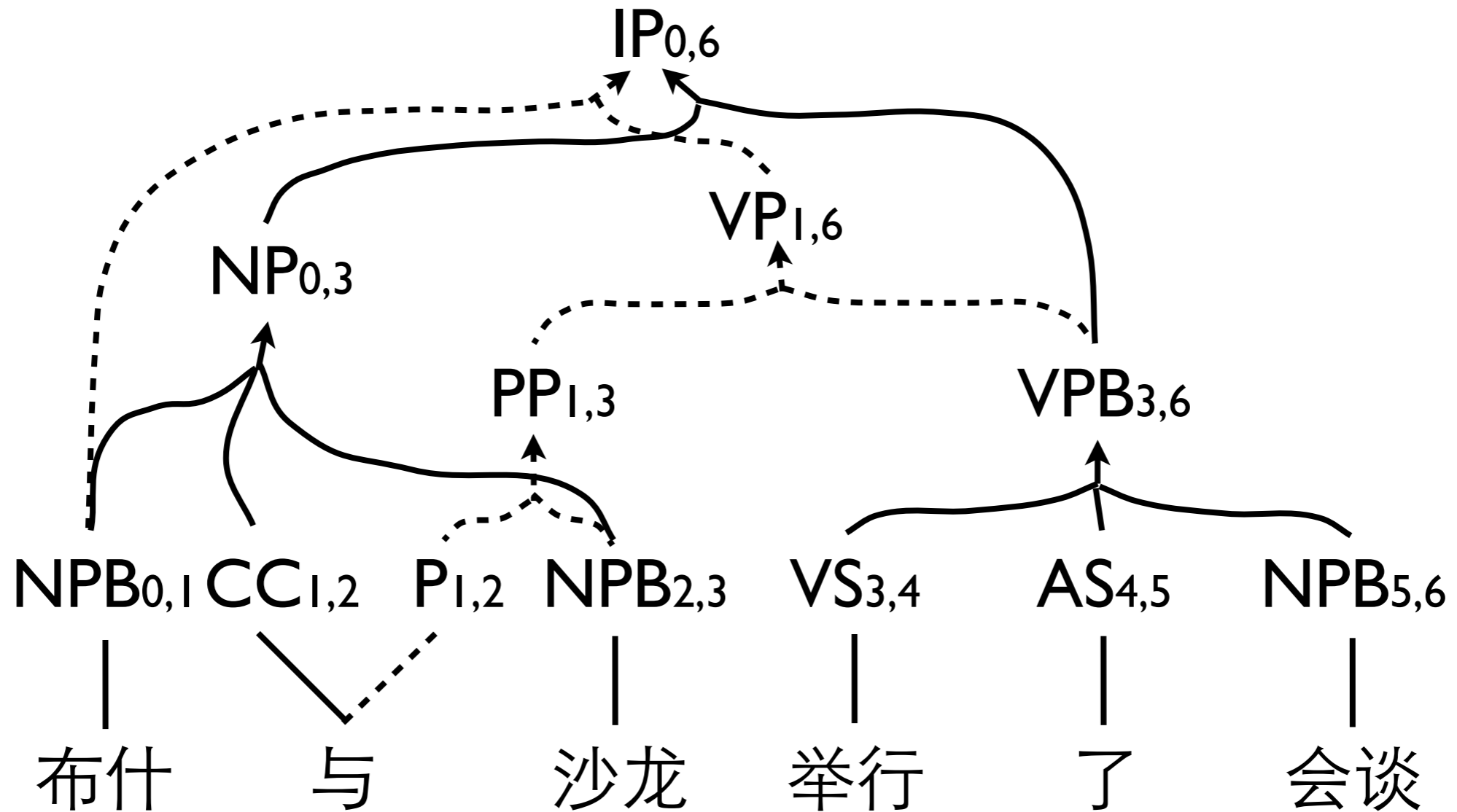


Bush held a talk **with** Sharon



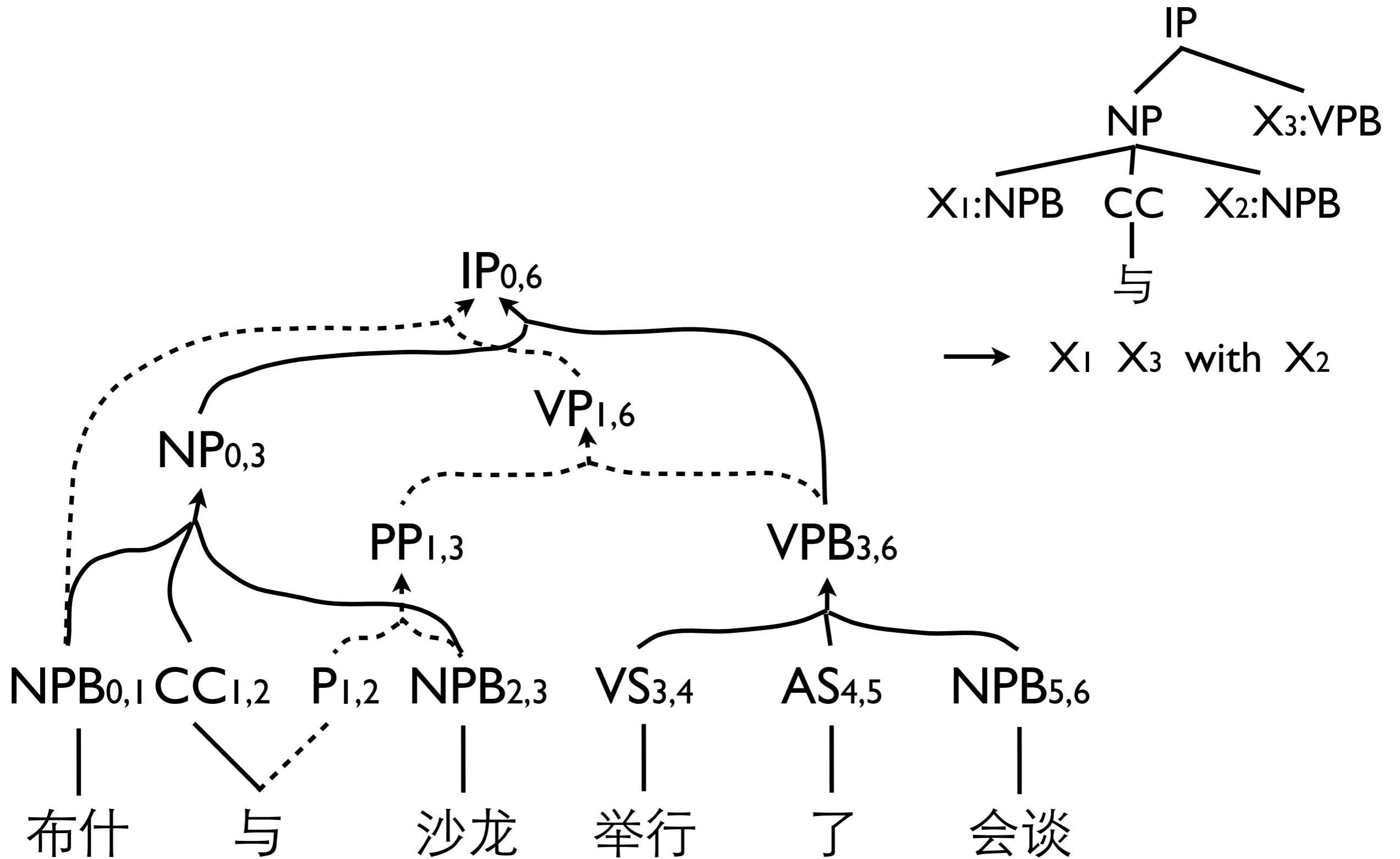
Bush **and** Sharon held a talk

# 压缩森林

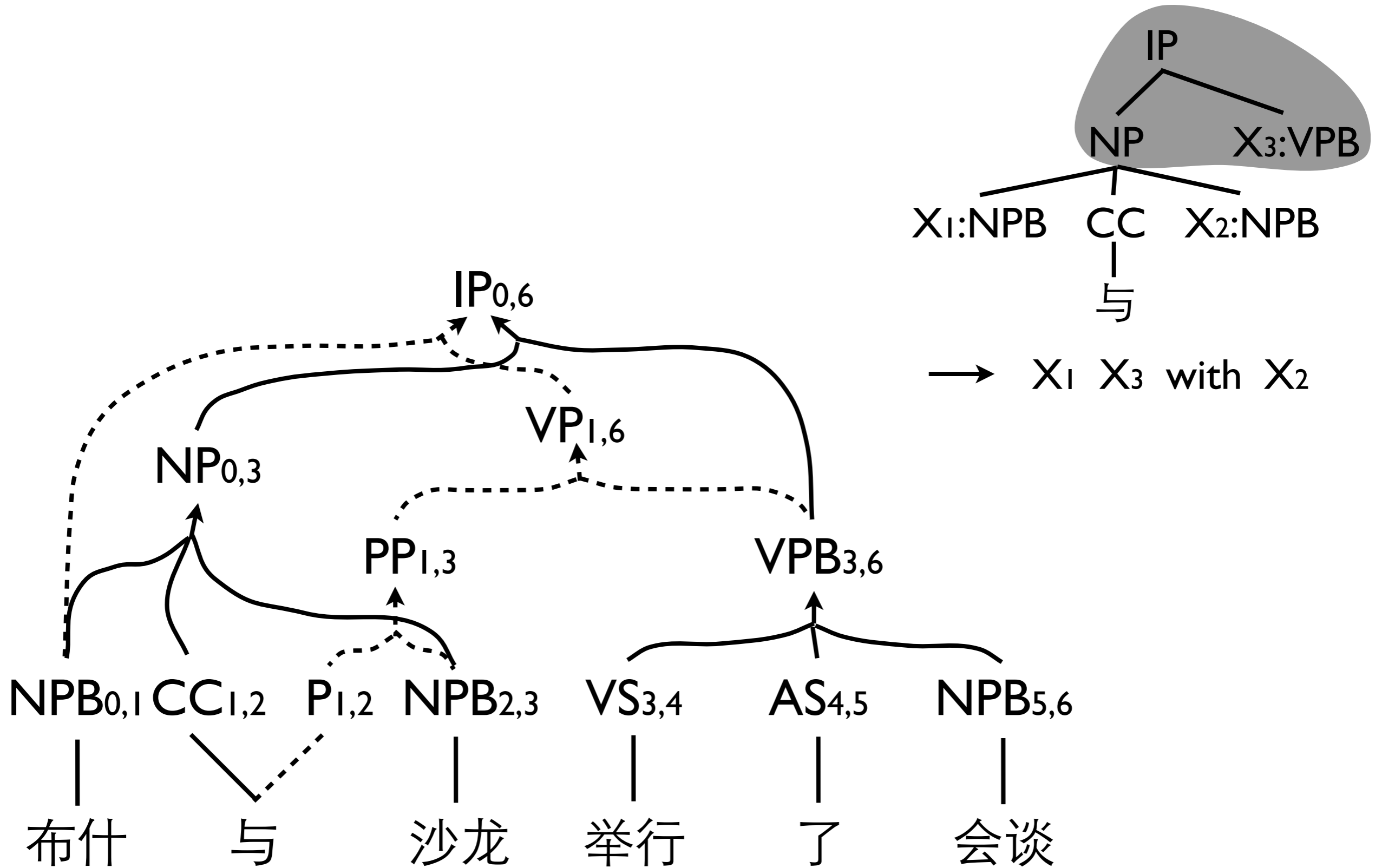


(Billot and Lang, 1989)

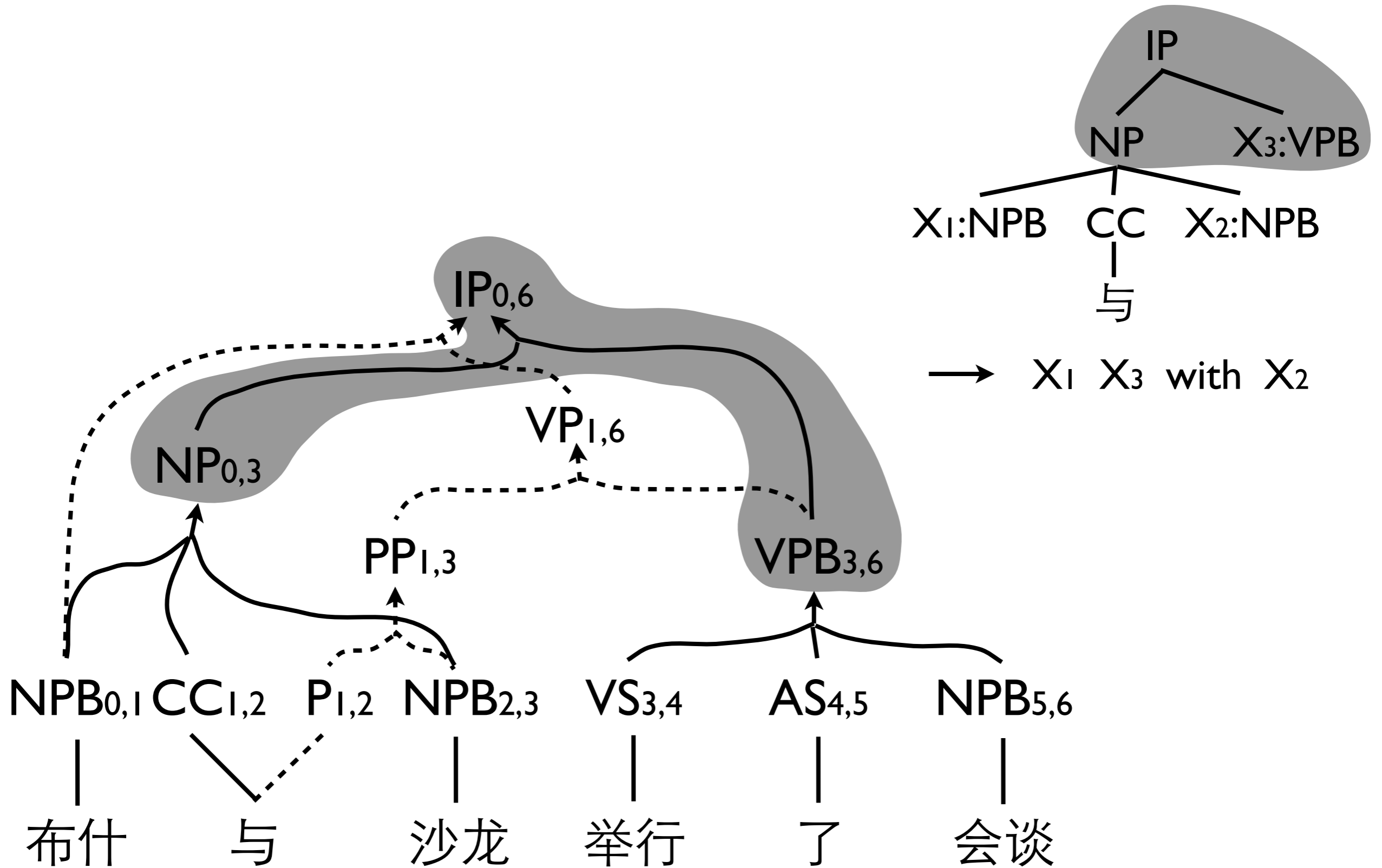
# 压缩森林上的匹配



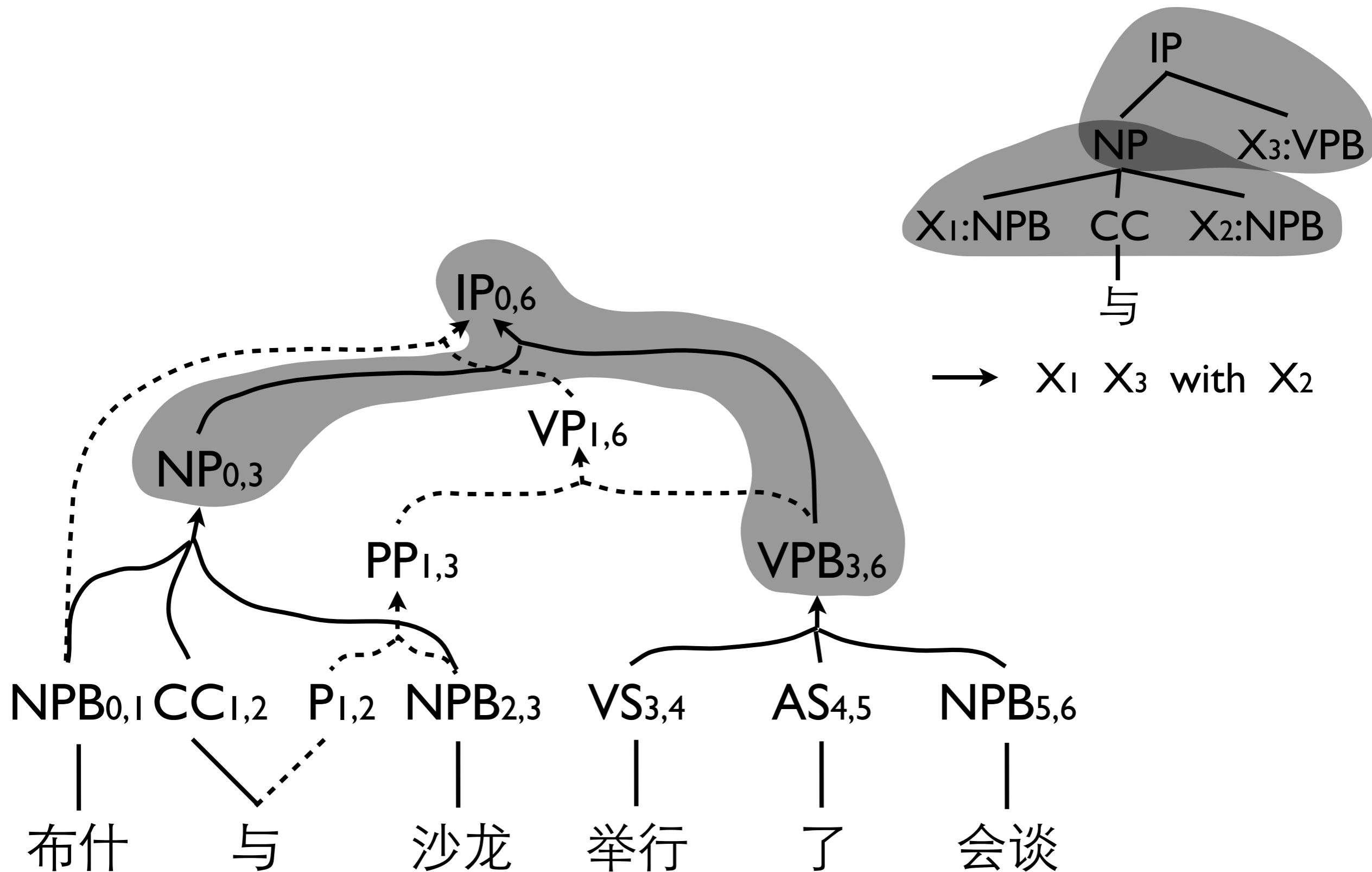
# 压缩森林上的匹配



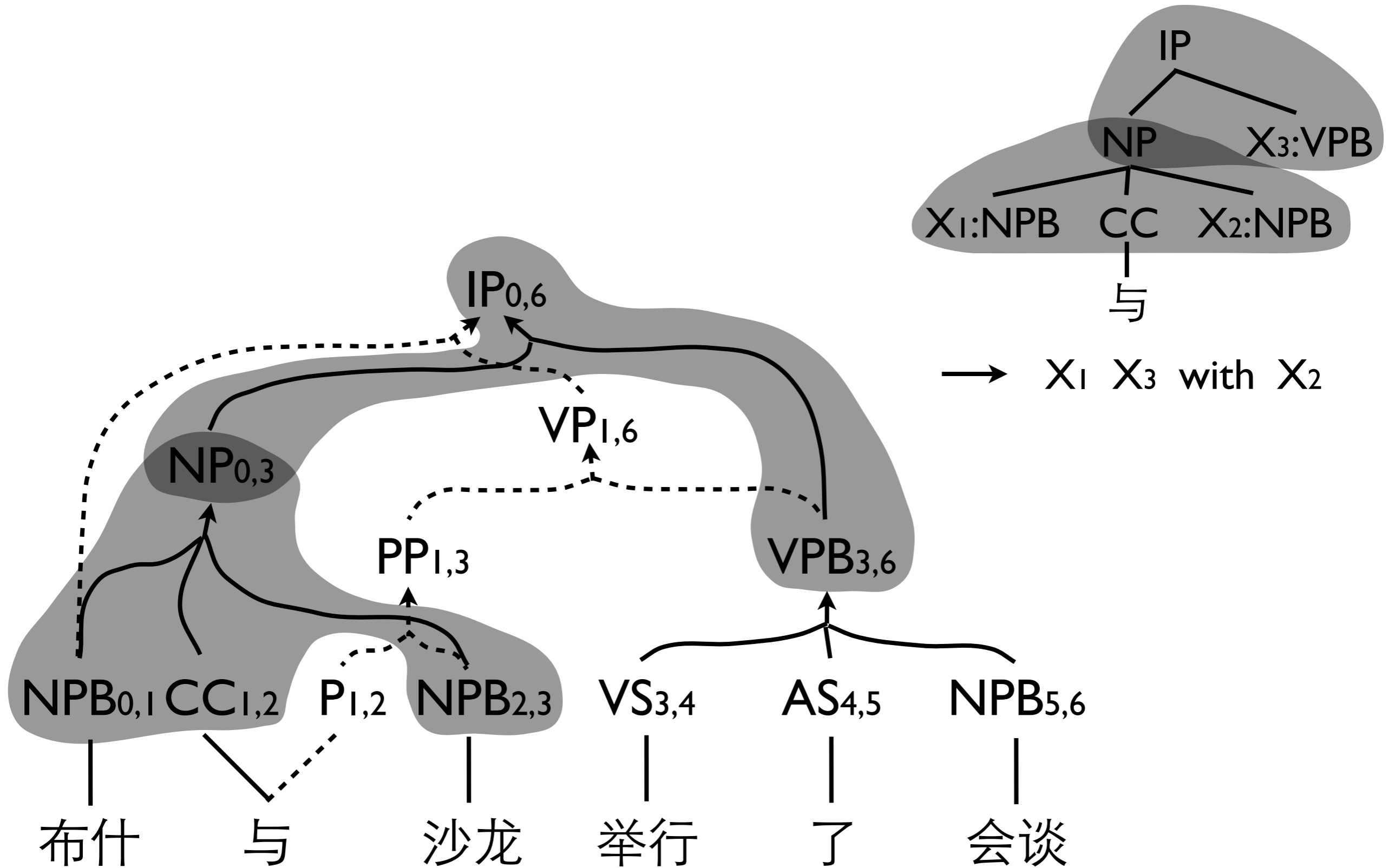
# 压缩森林上的匹配



# 压缩森林上的匹配

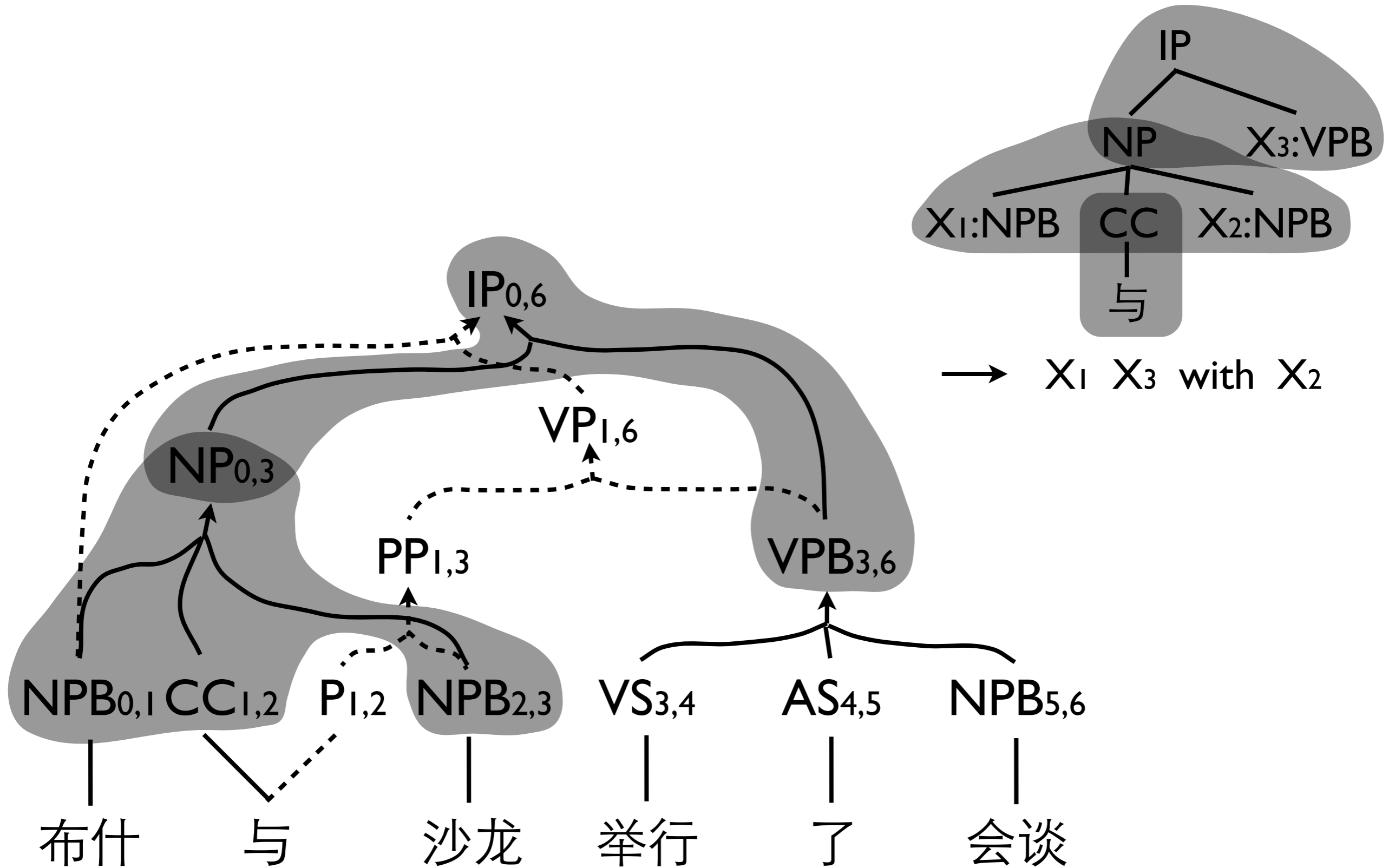


# 压缩森林上的匹配

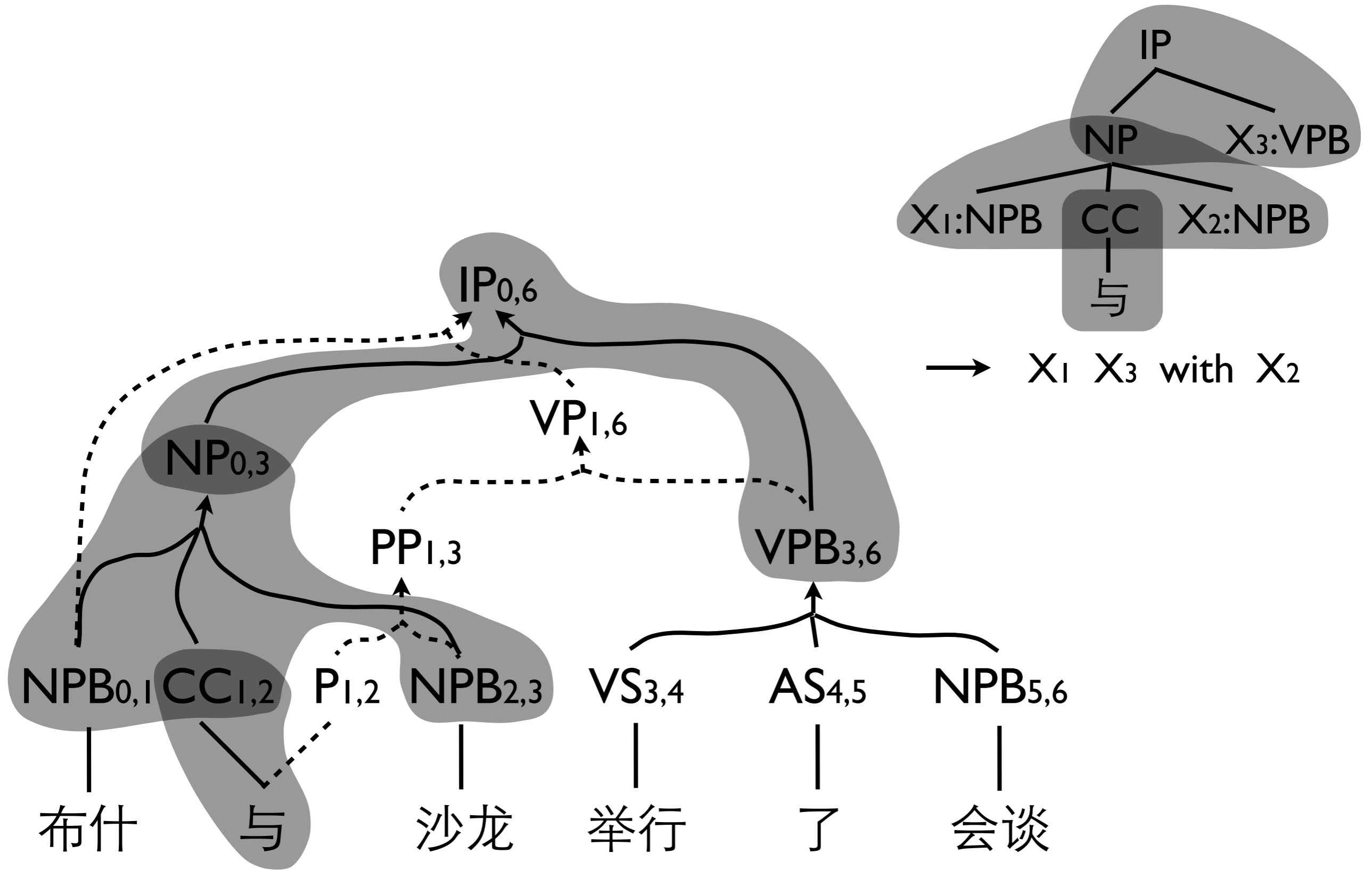




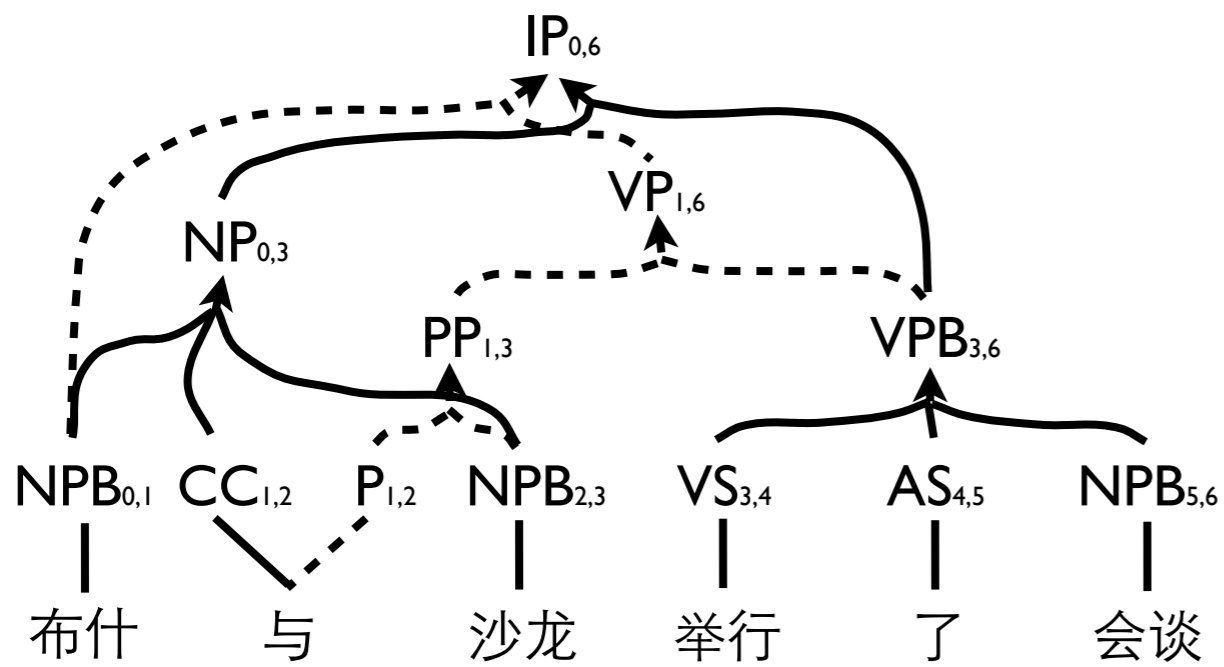
# 压缩森林上的匹配



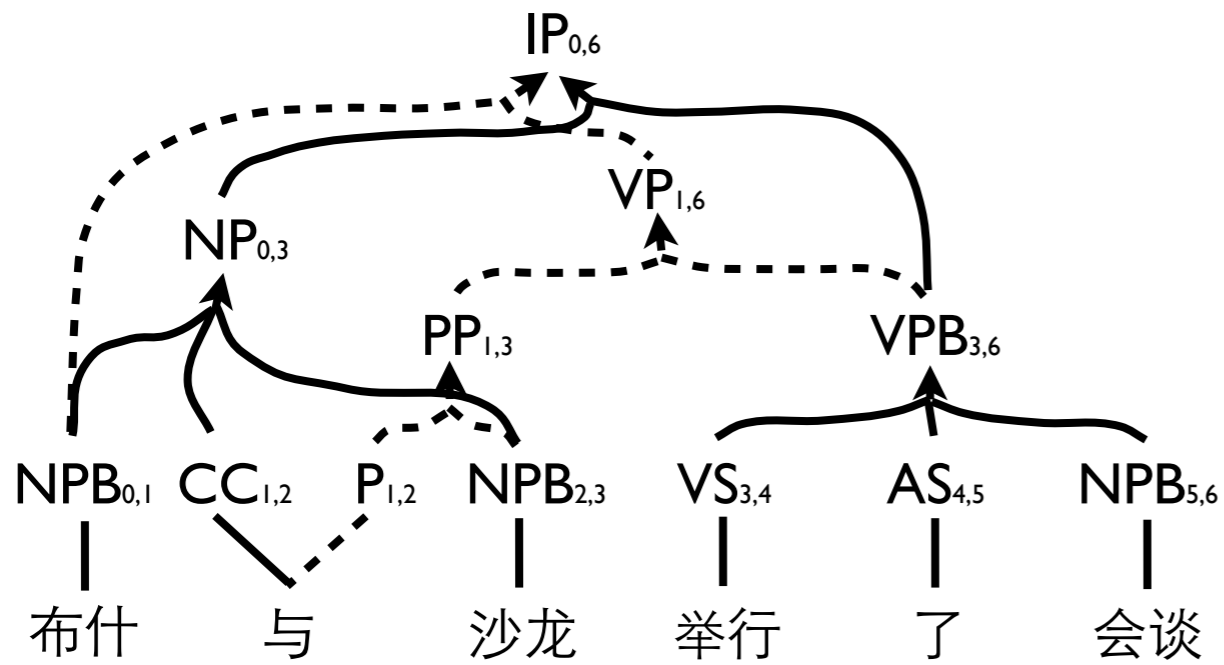
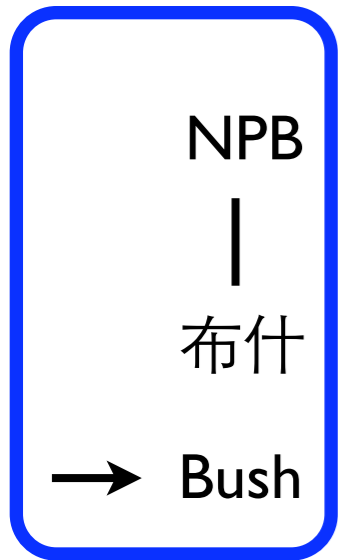
# 压缩森林上的匹配



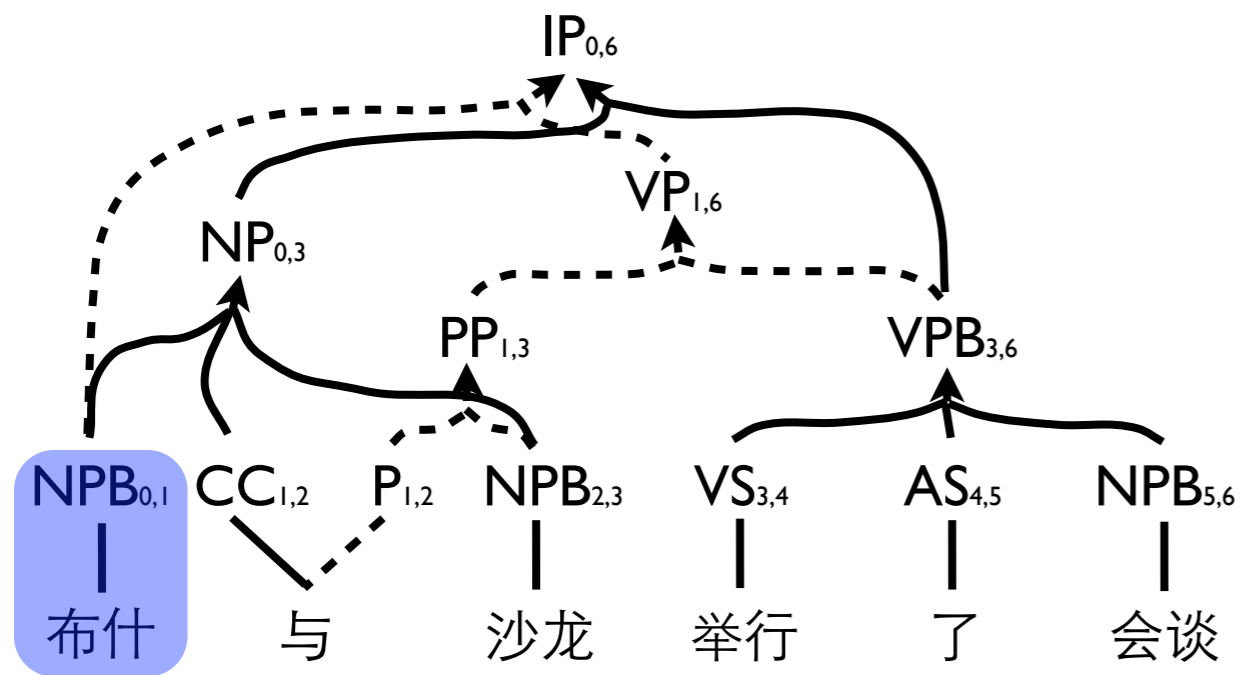
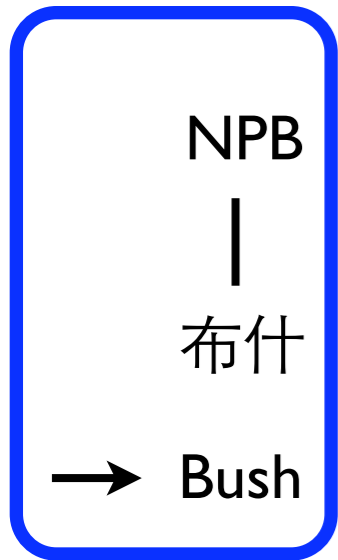
# 翻译森林



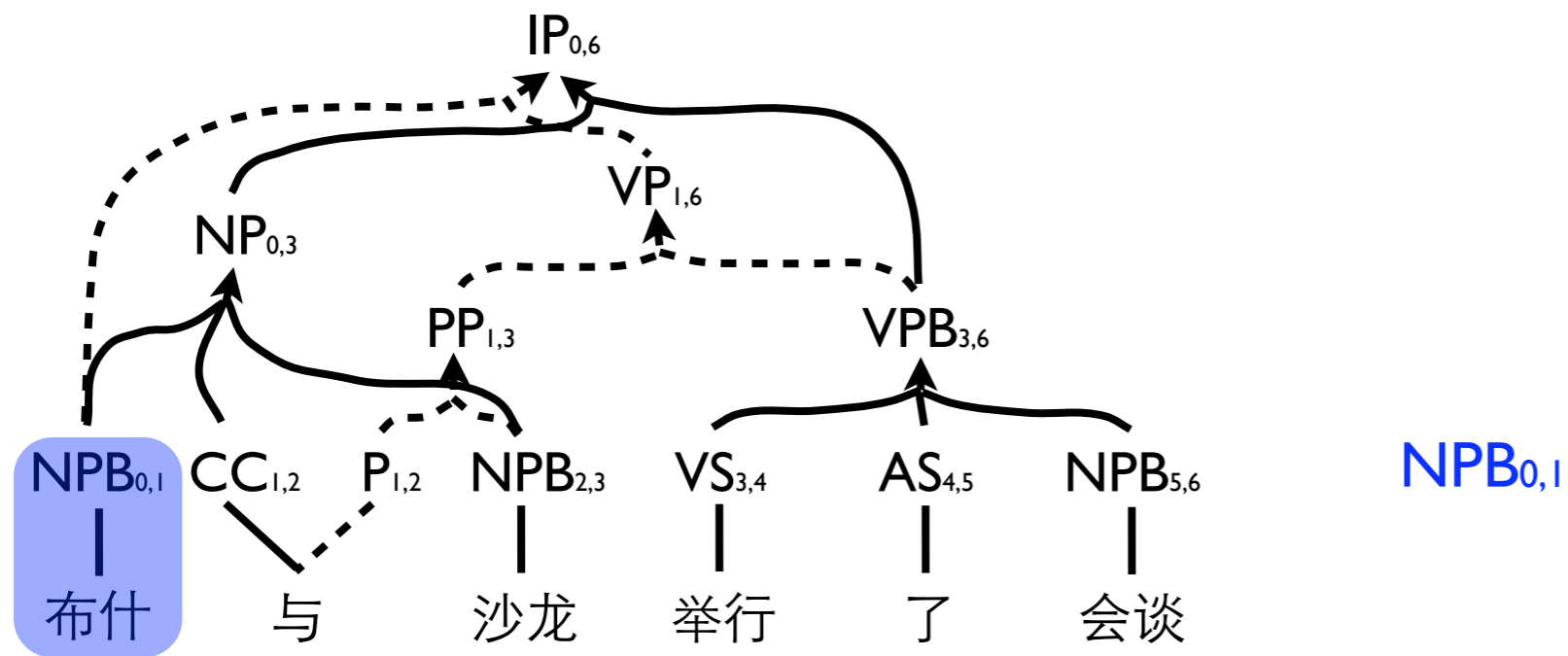
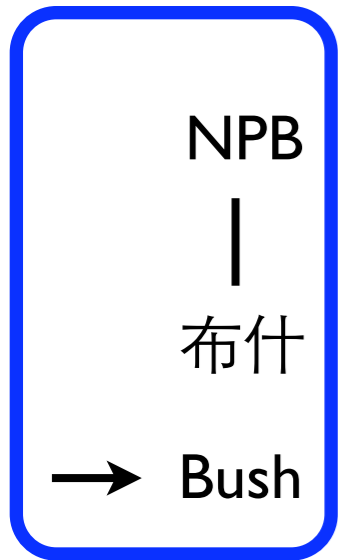
# 翻译森林



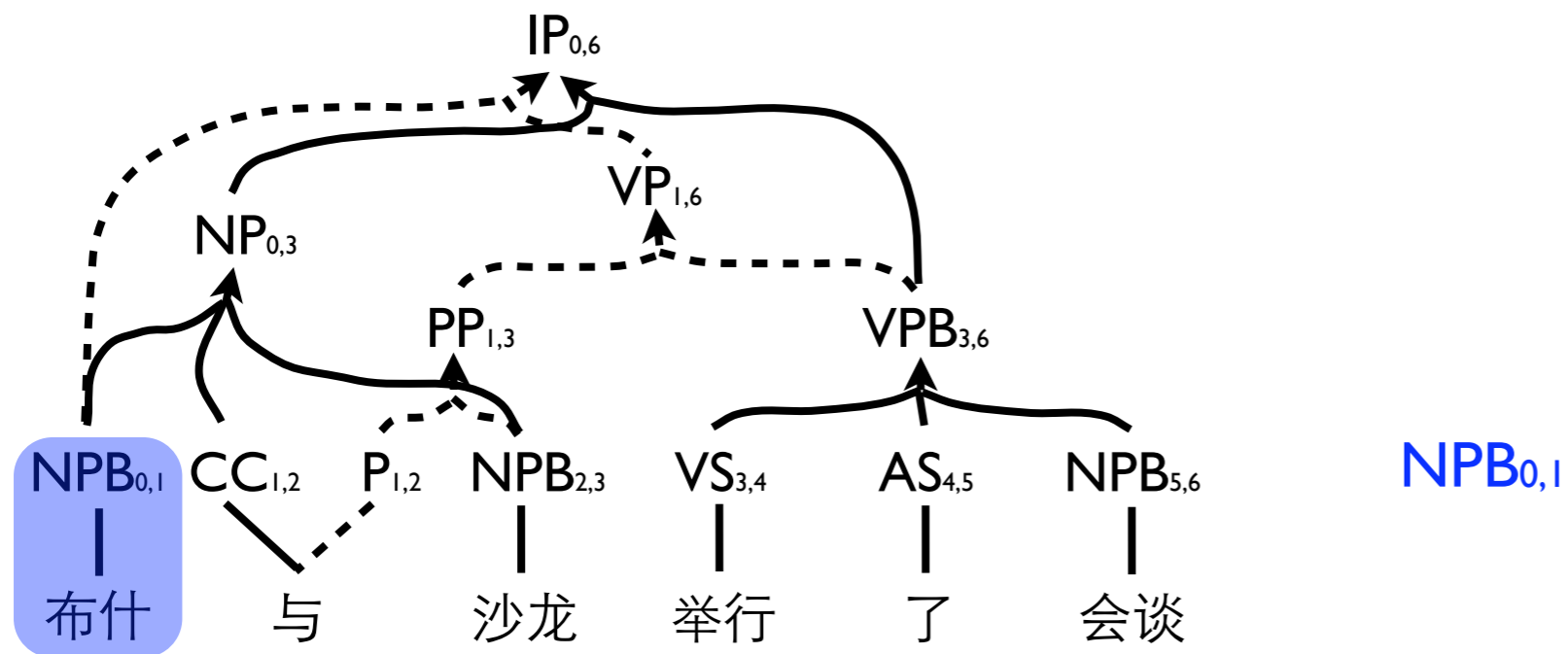
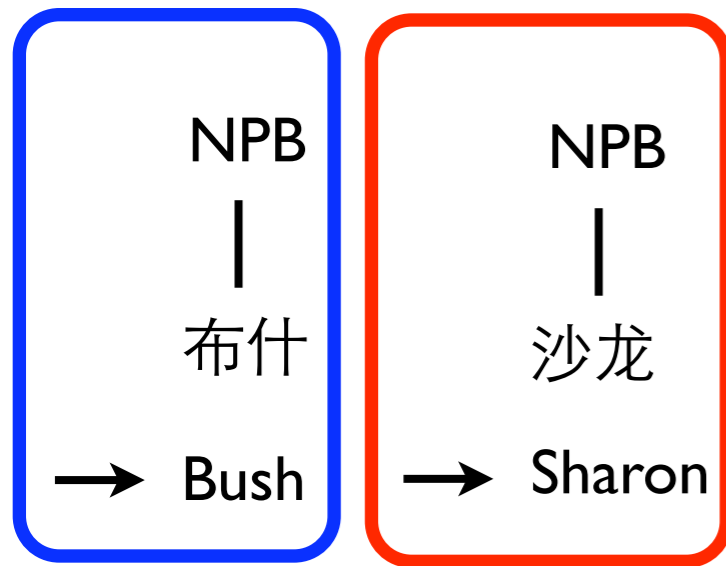
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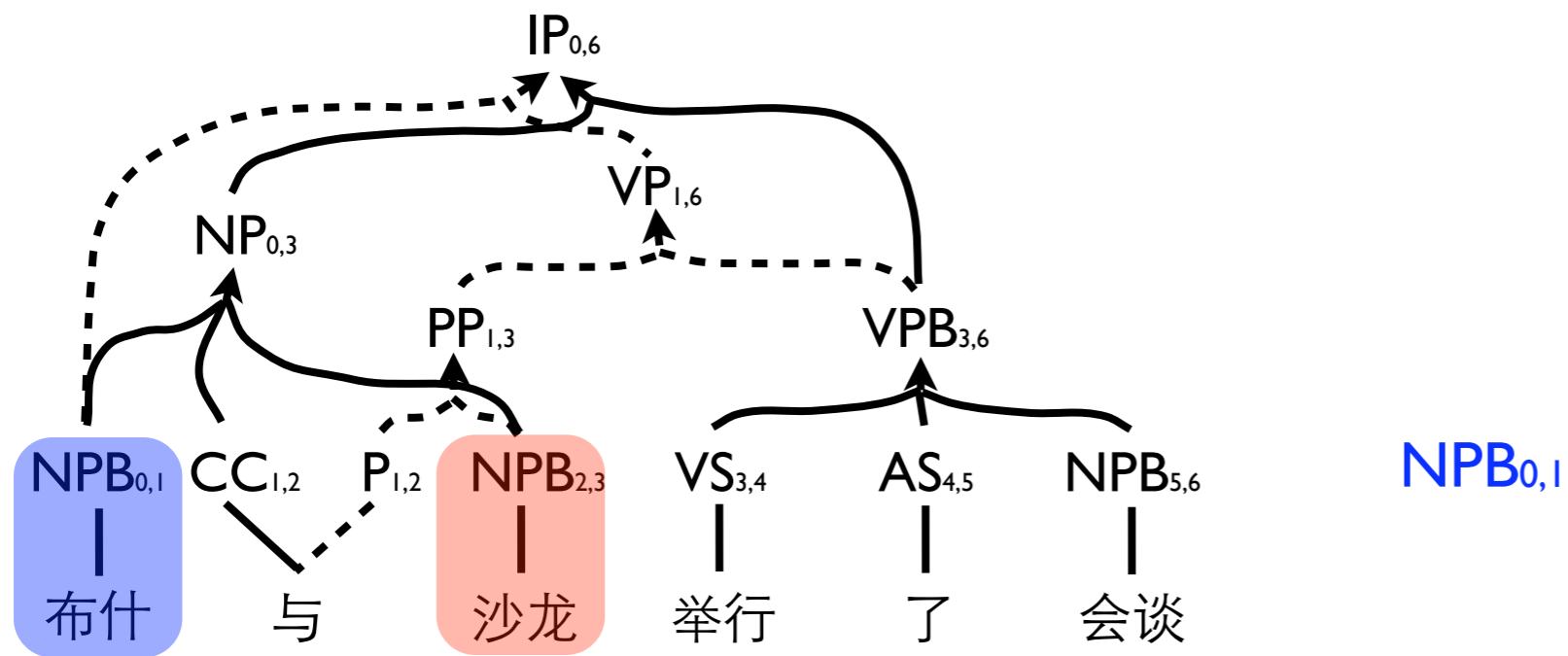
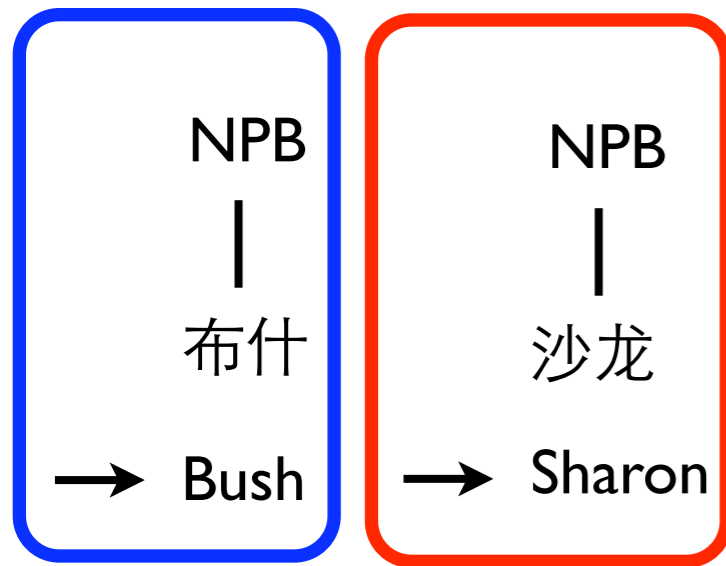
# 翻译森林



# 翻译森林

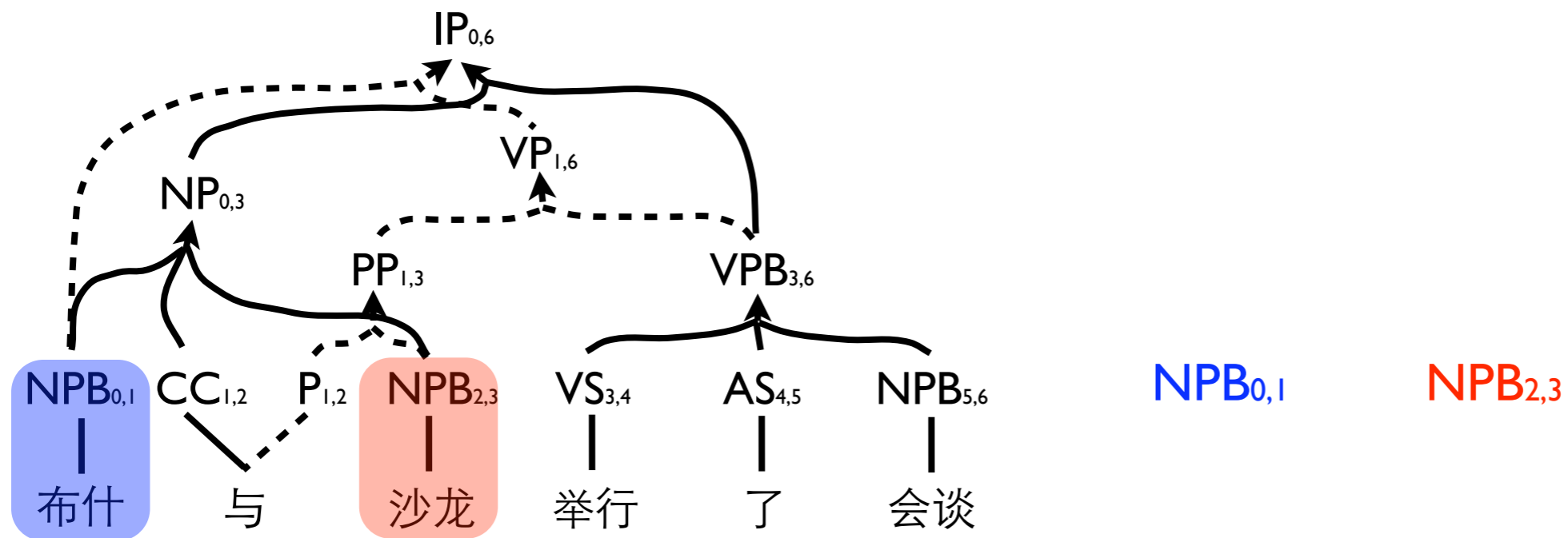
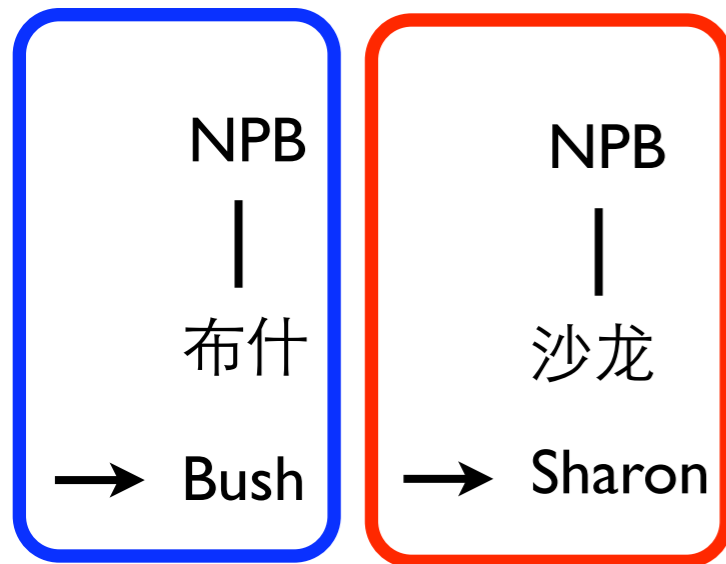


# 翻译森林

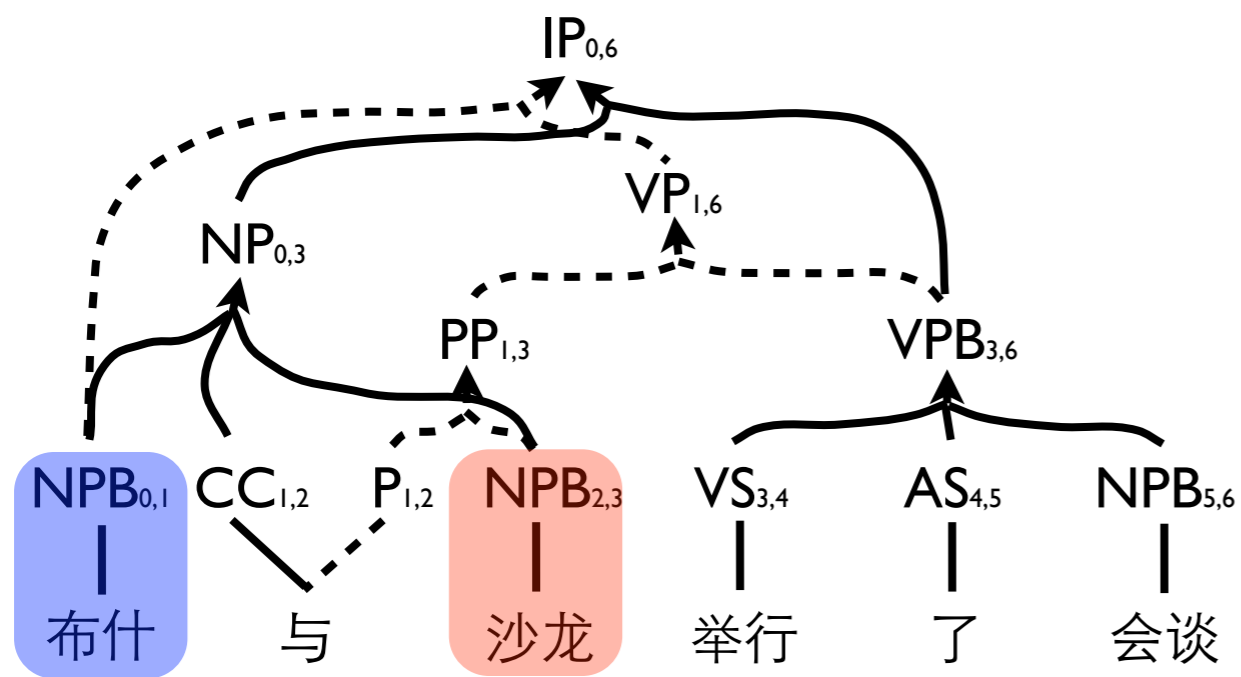
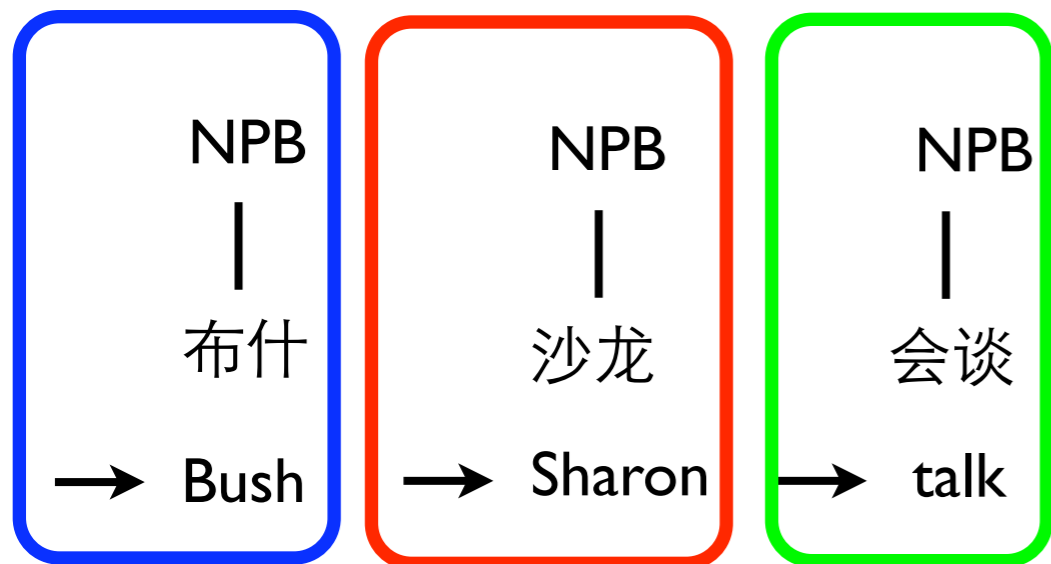




# 翻译森林



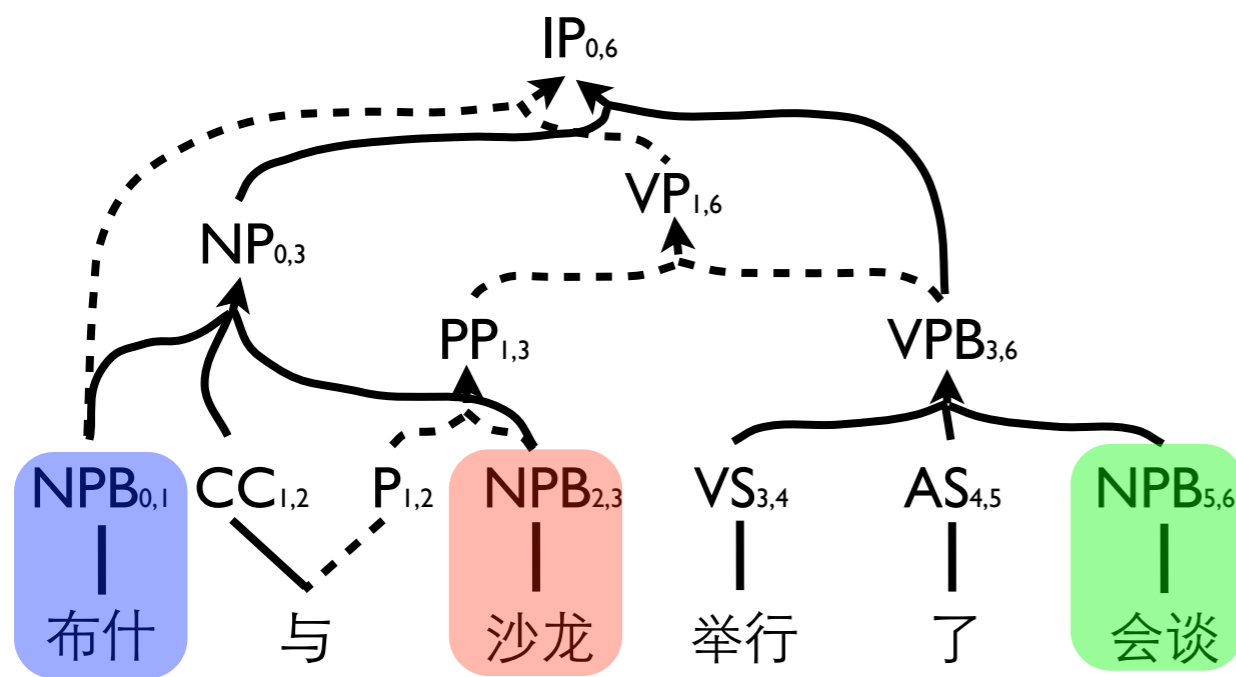
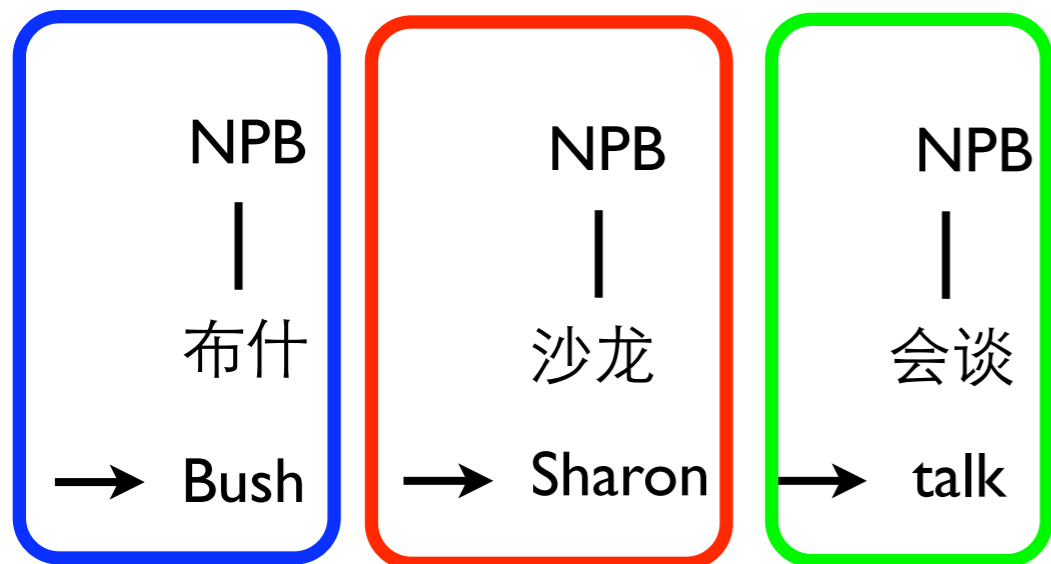
# 翻译森林



NPB<sub>0,1</sub>

NPB<sub>2,3</sub>

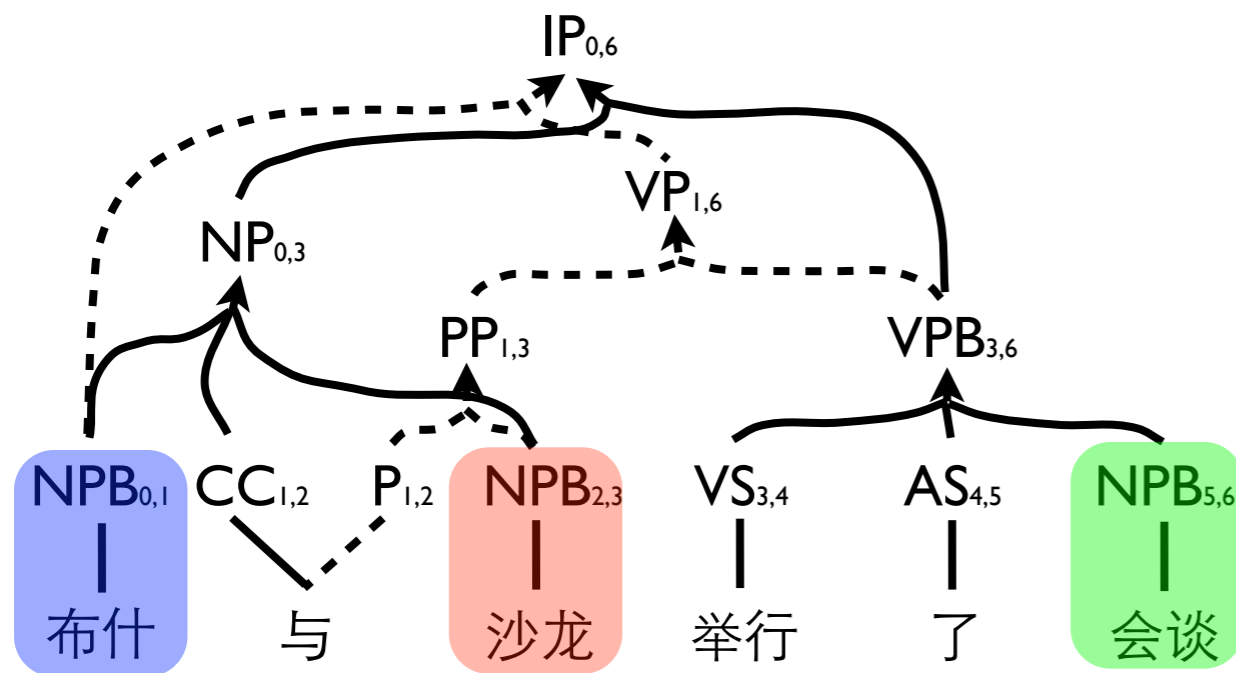
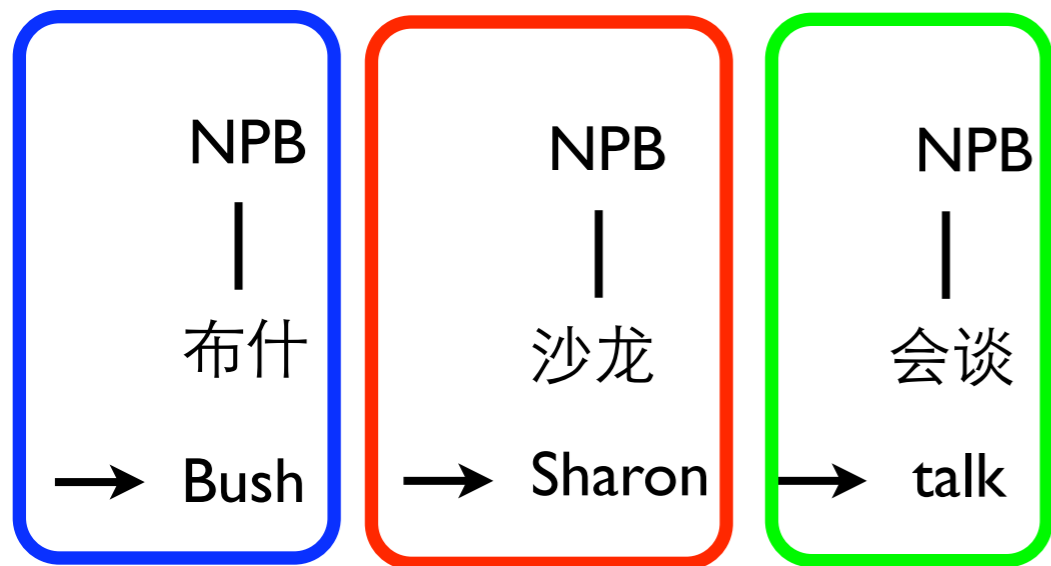
# 翻译森林



NPB<sub>0,1</sub>

NPB<sub>2,3</sub>

# 翻译森林

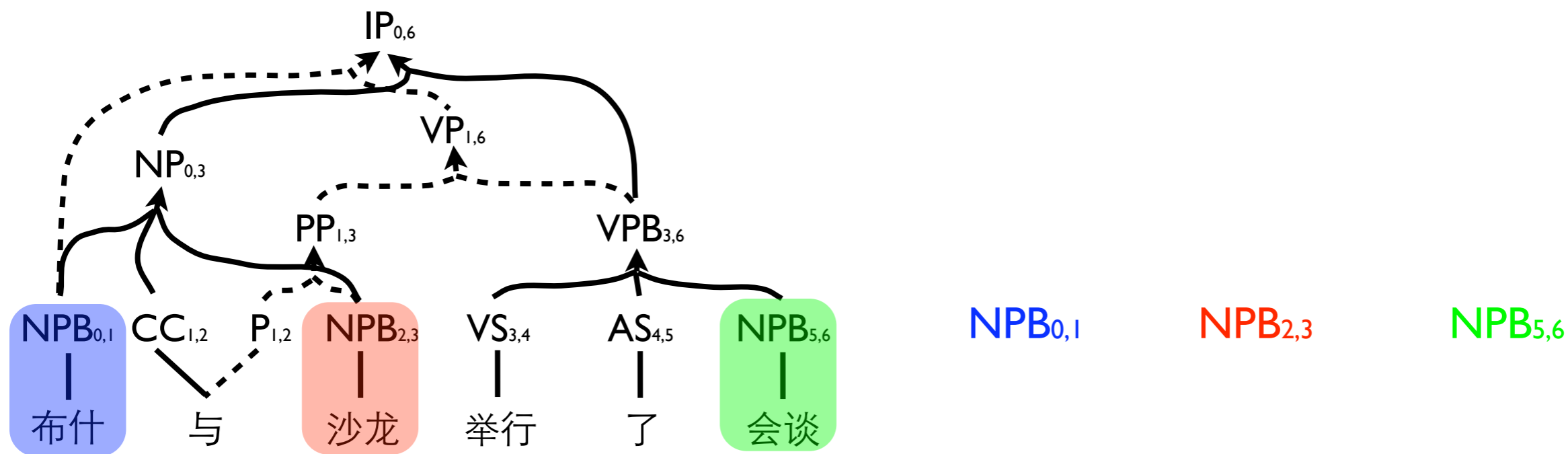
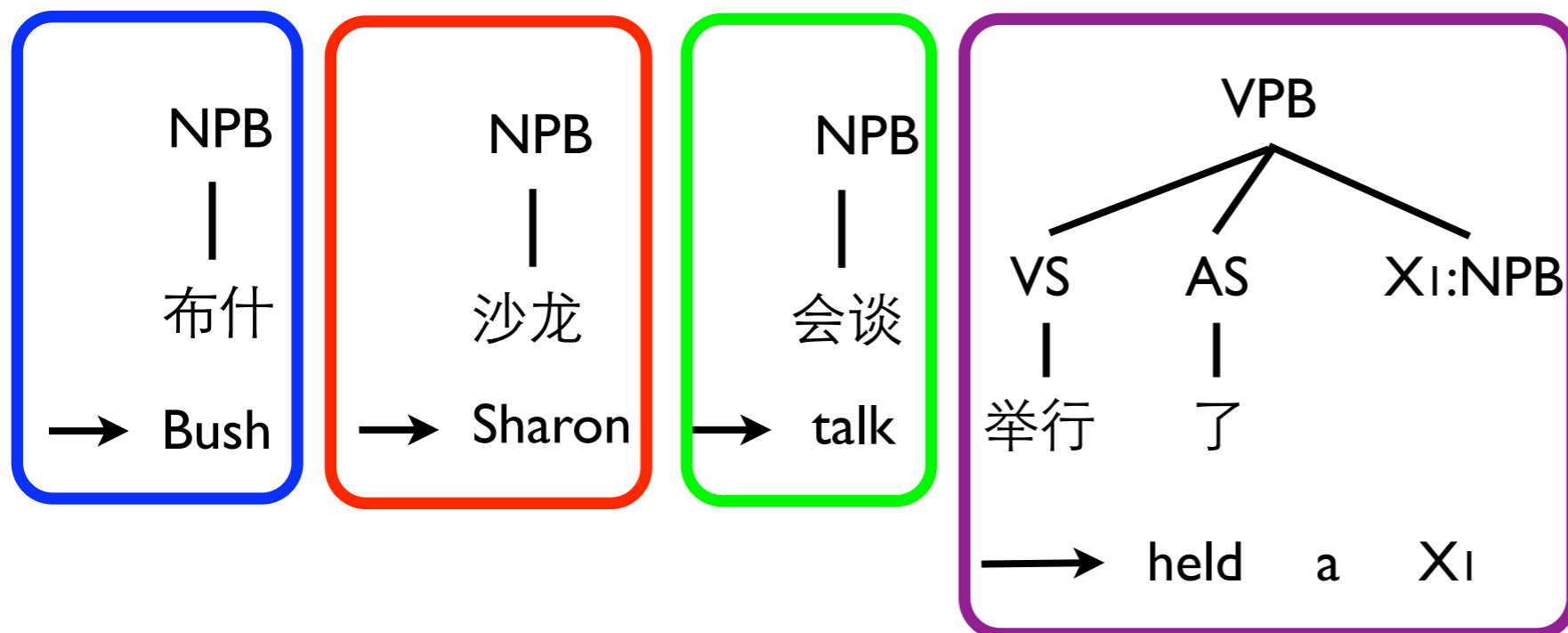


NPB<sub>0,1</sub>

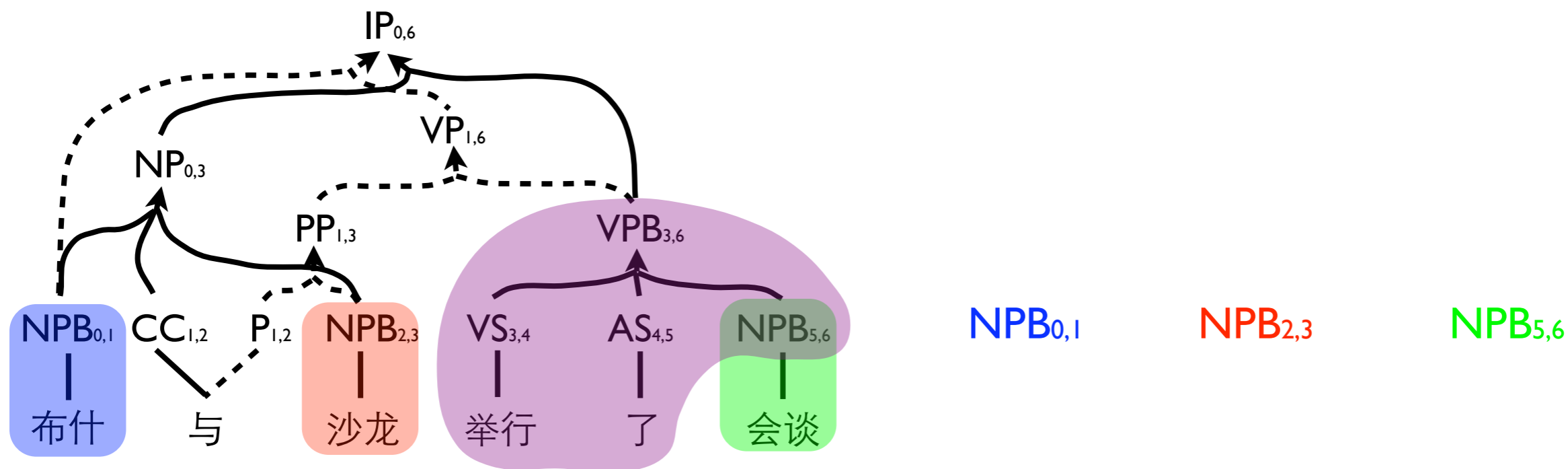
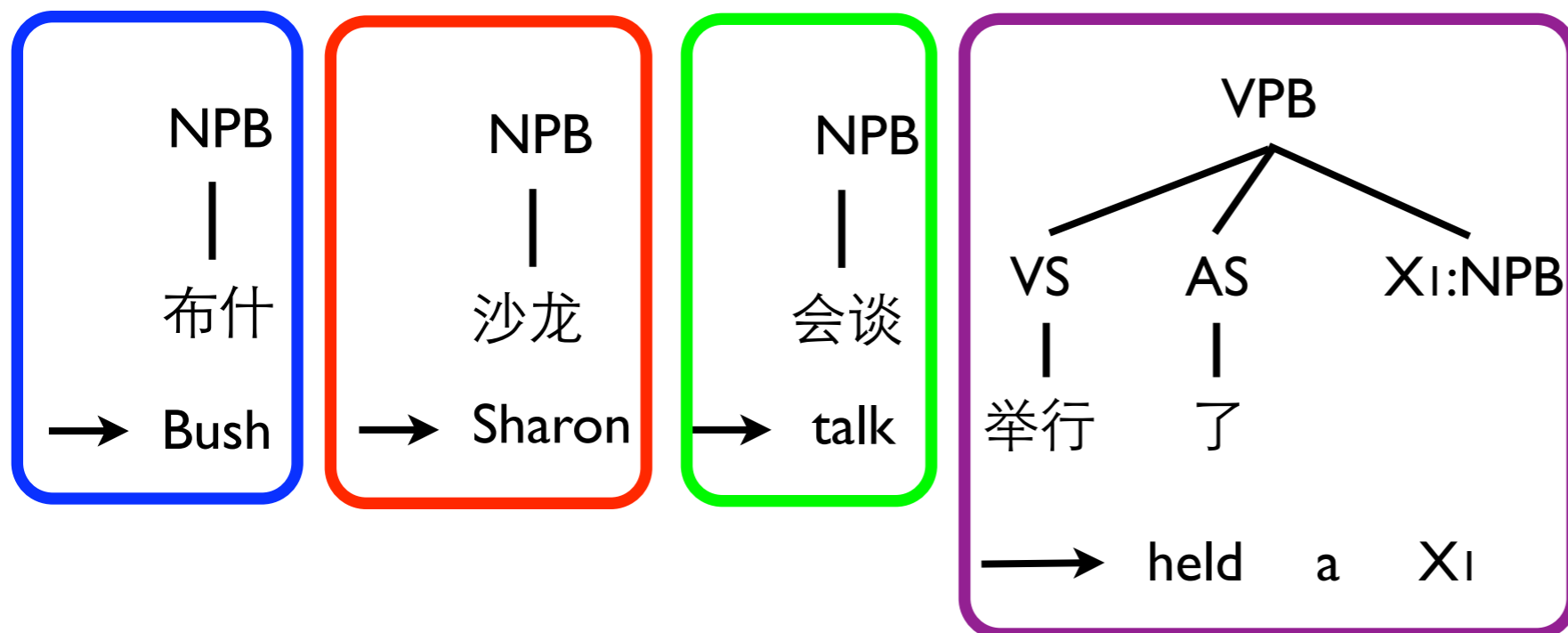
NPB<sub>2,3</sub>

NPB<sub>5,6</sub>

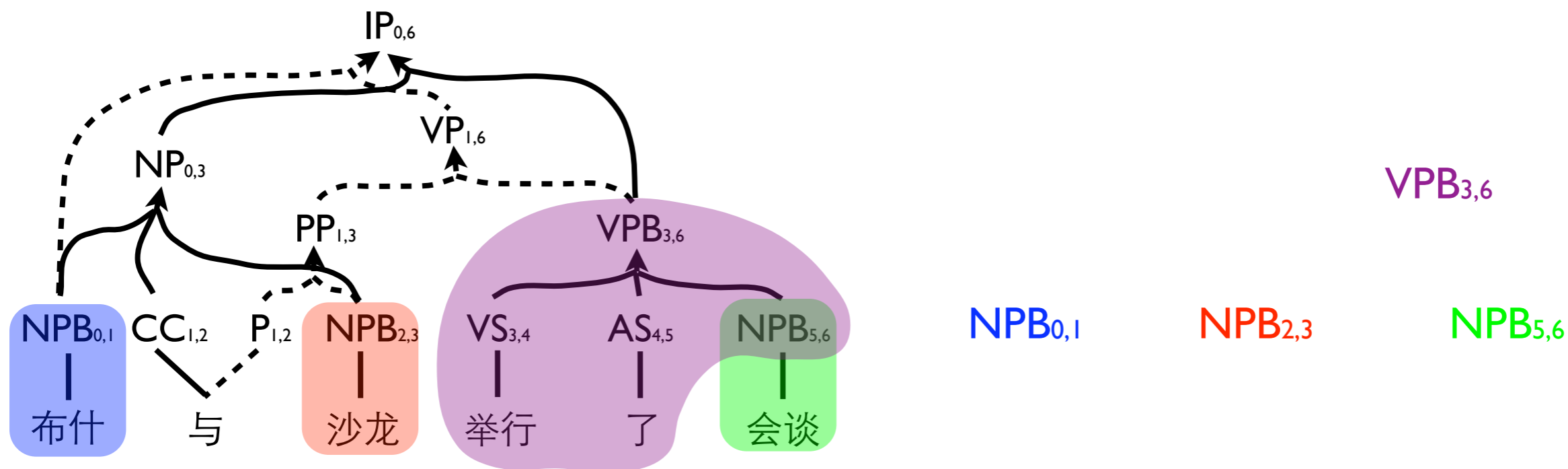
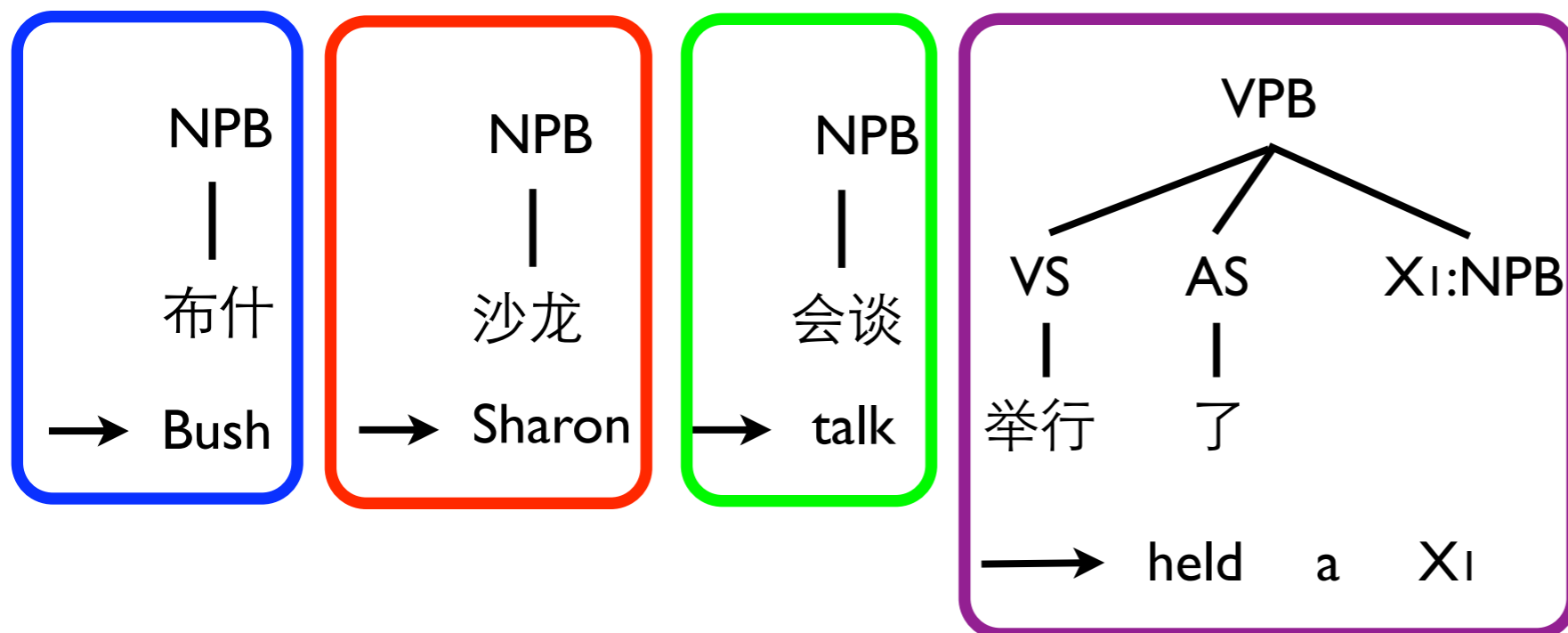
# 翻译森林



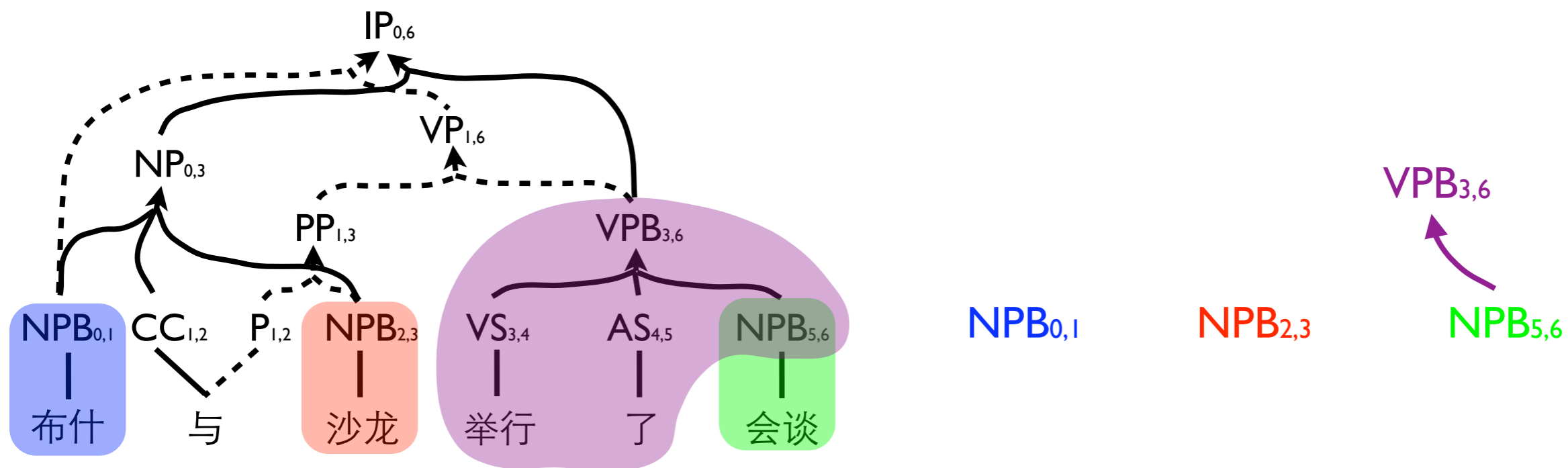
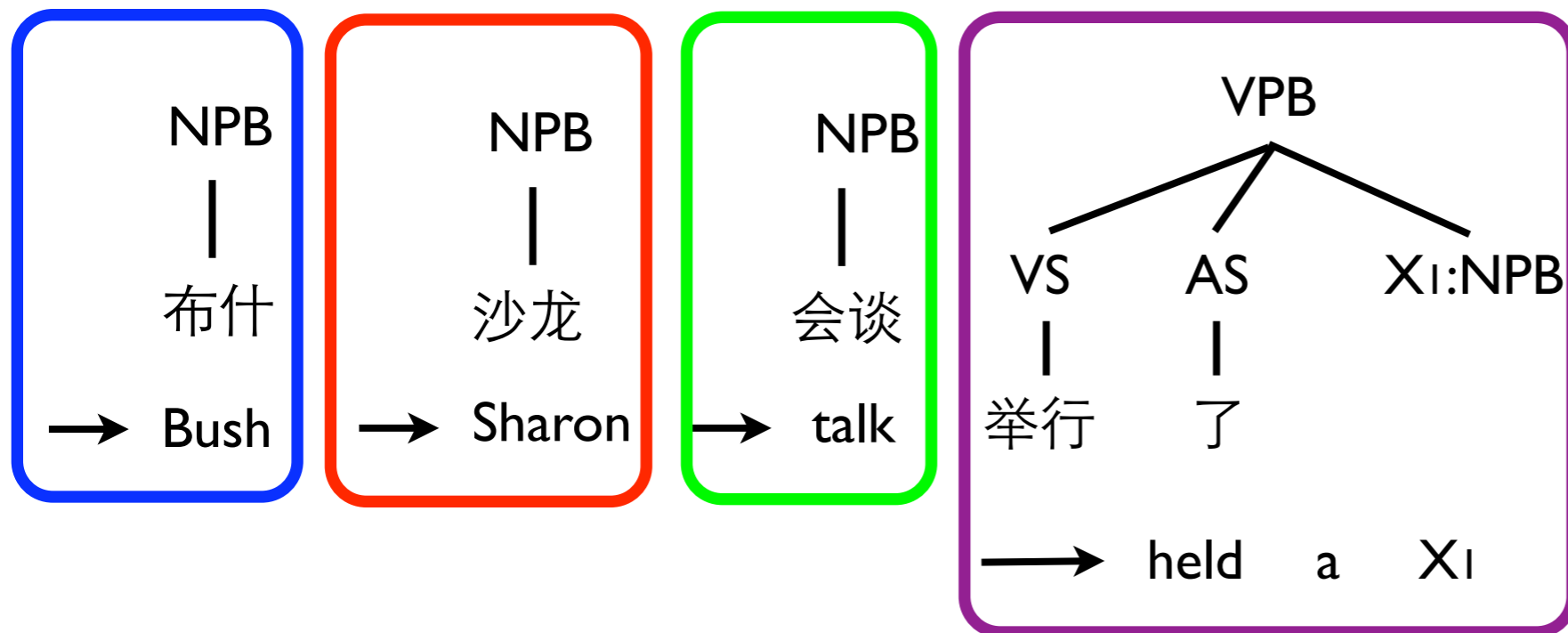
# 翻译森林



# 翻译森林

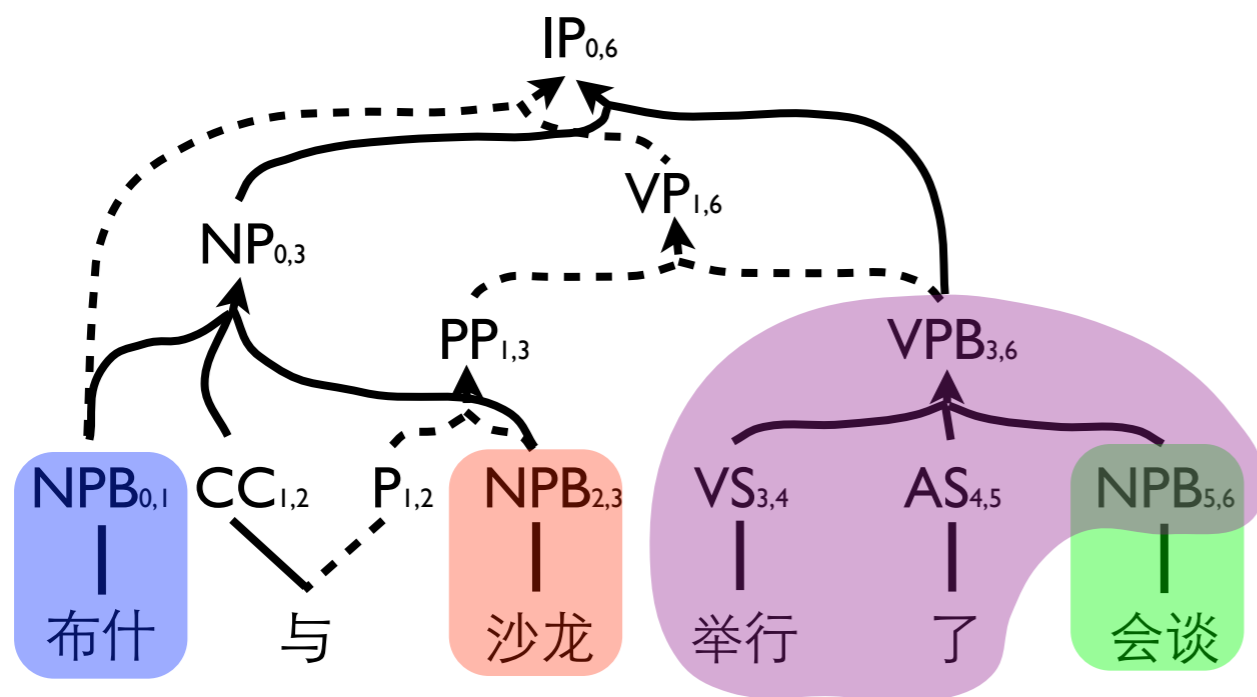
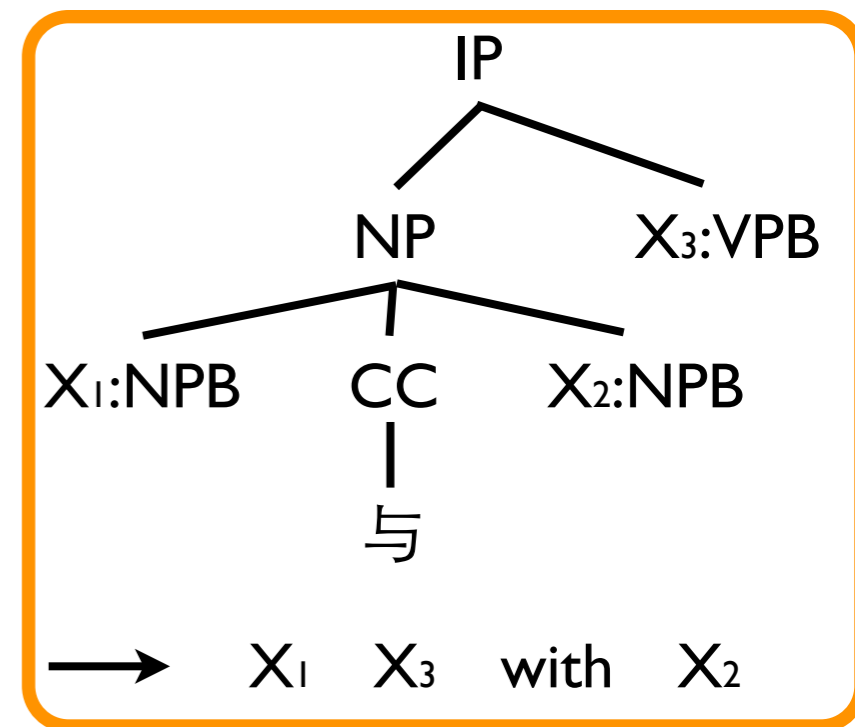
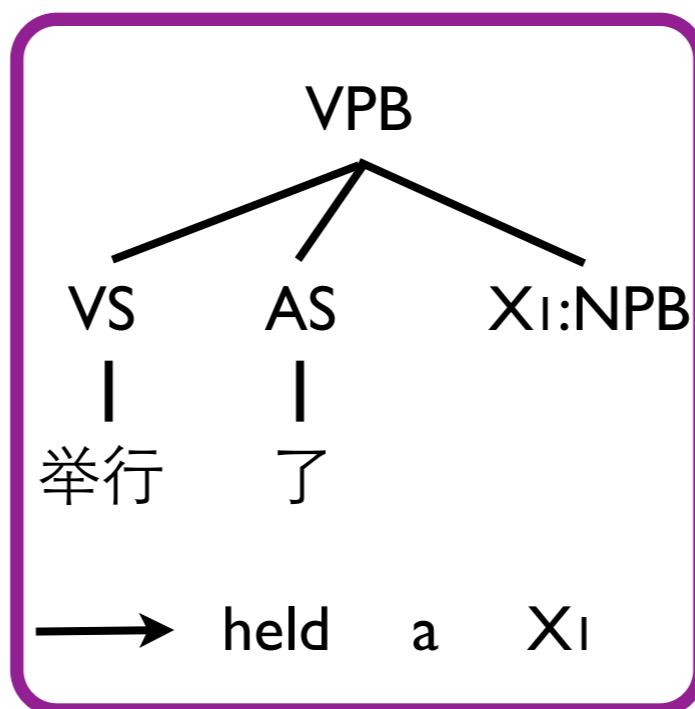
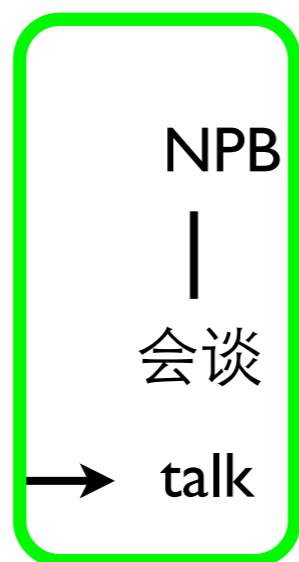
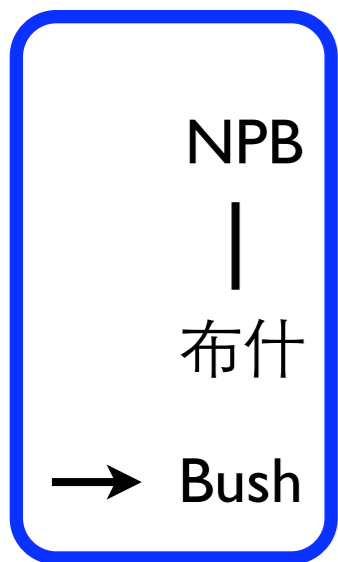


# 翻译森林





# 翻译森林



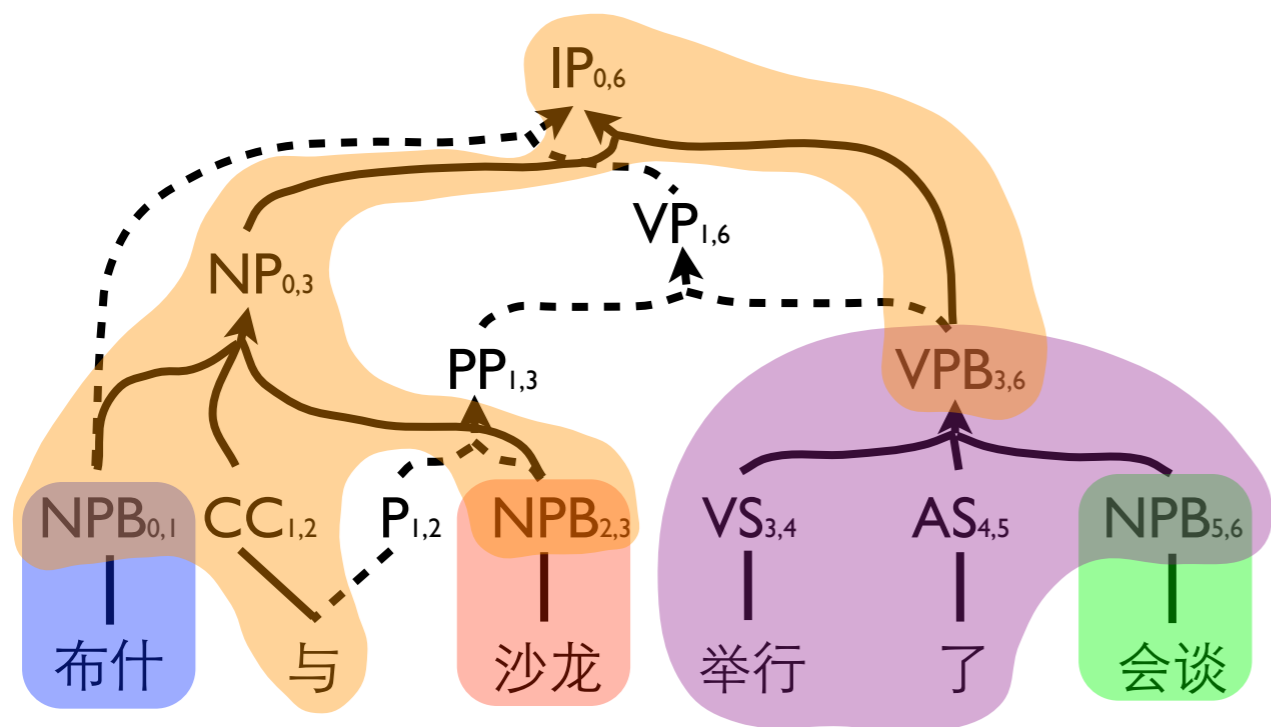
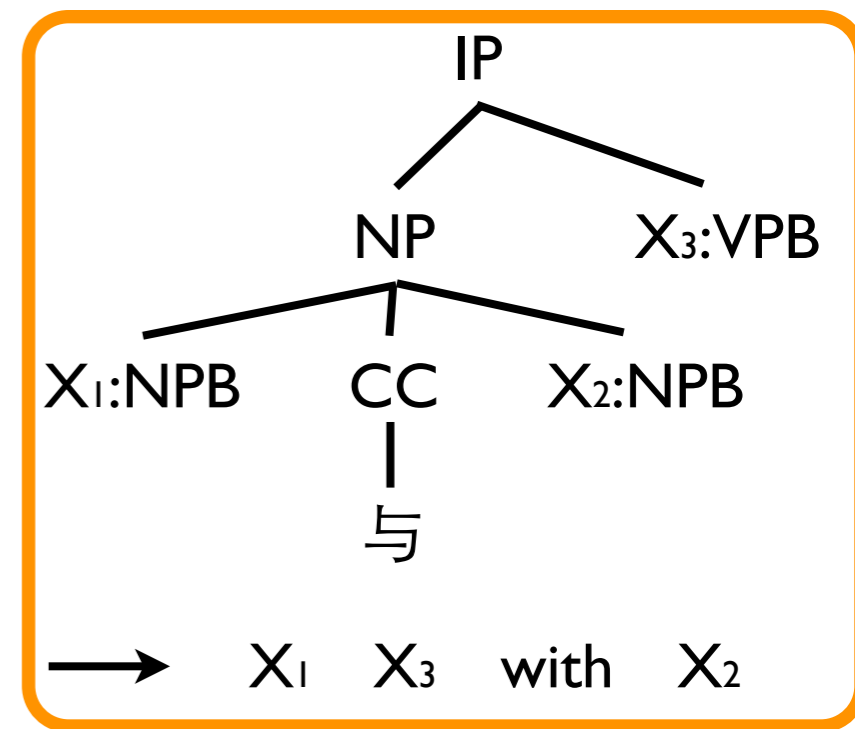
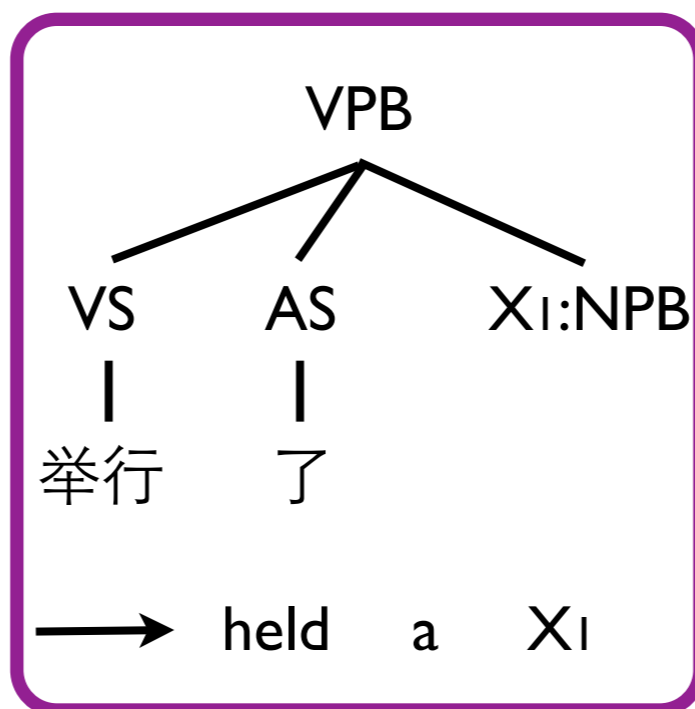
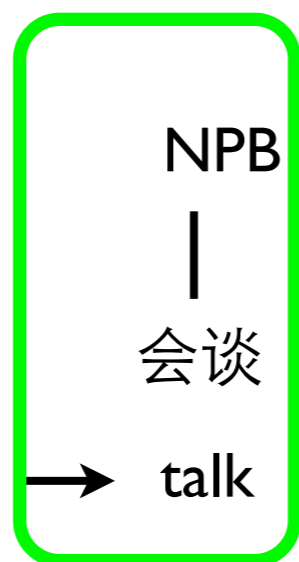
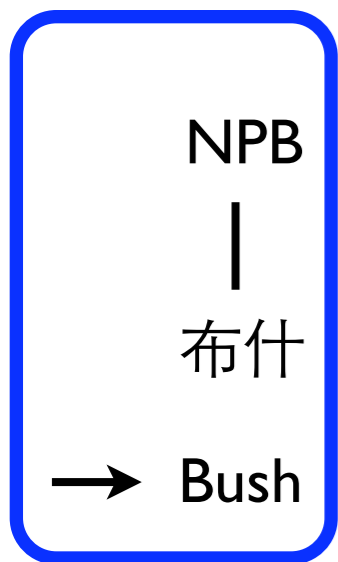
NPB<sub>0,1</sub>

NPB<sub>2,3</sub>

NPB<sub>5,6</sub>

VPB<sub>3,6</sub>

# 翻译森林



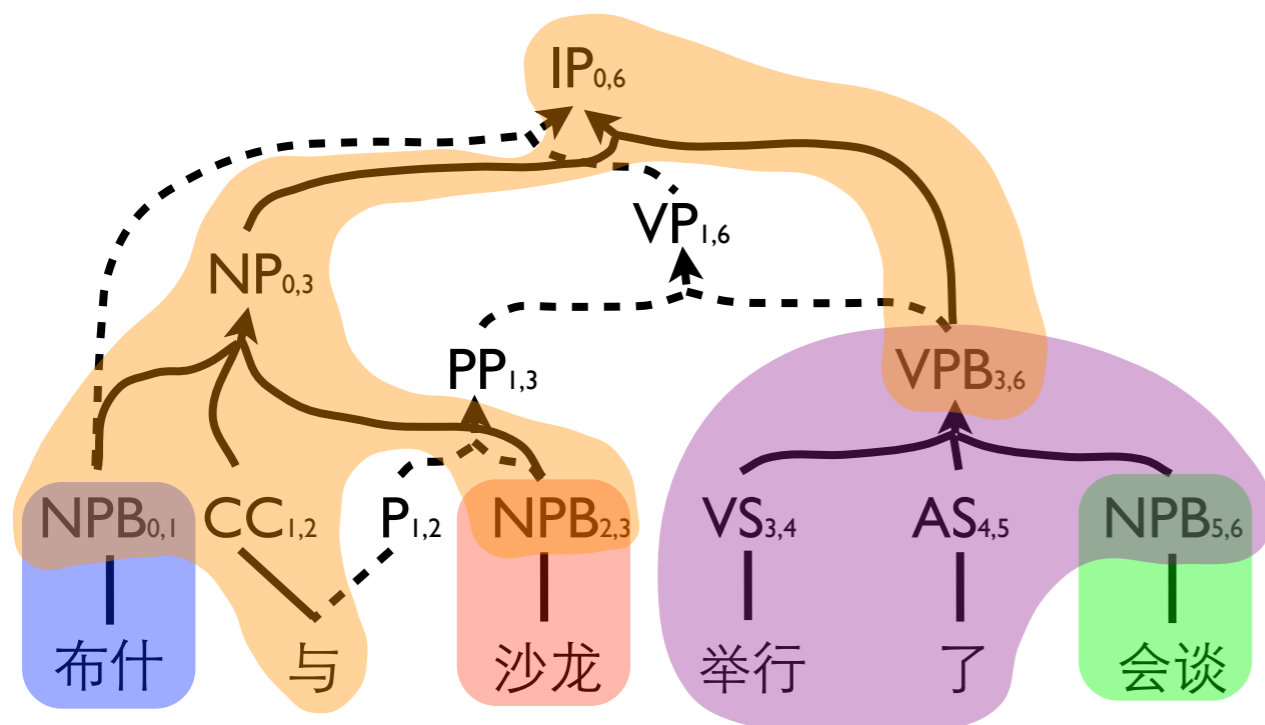
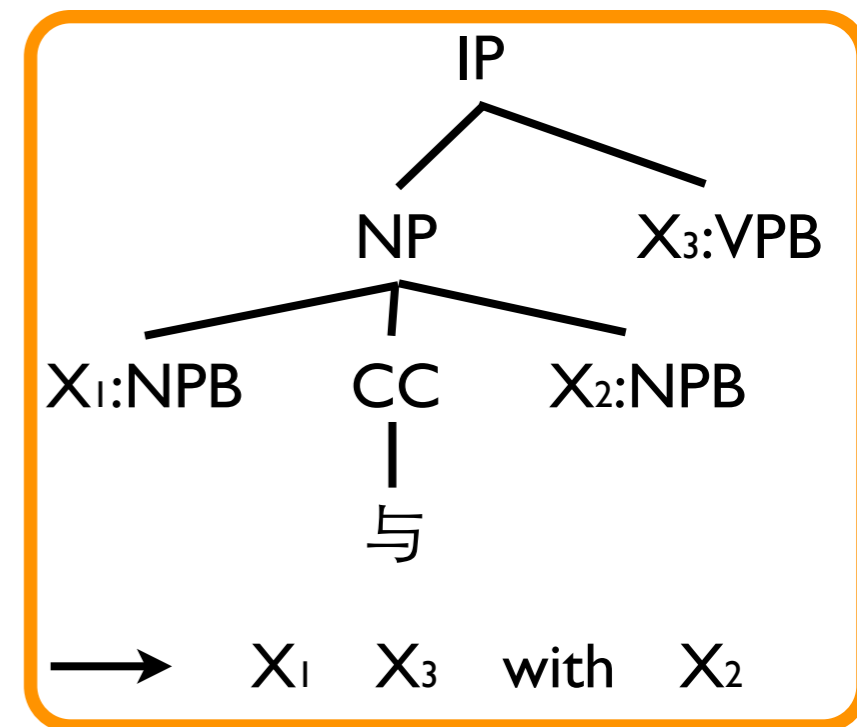
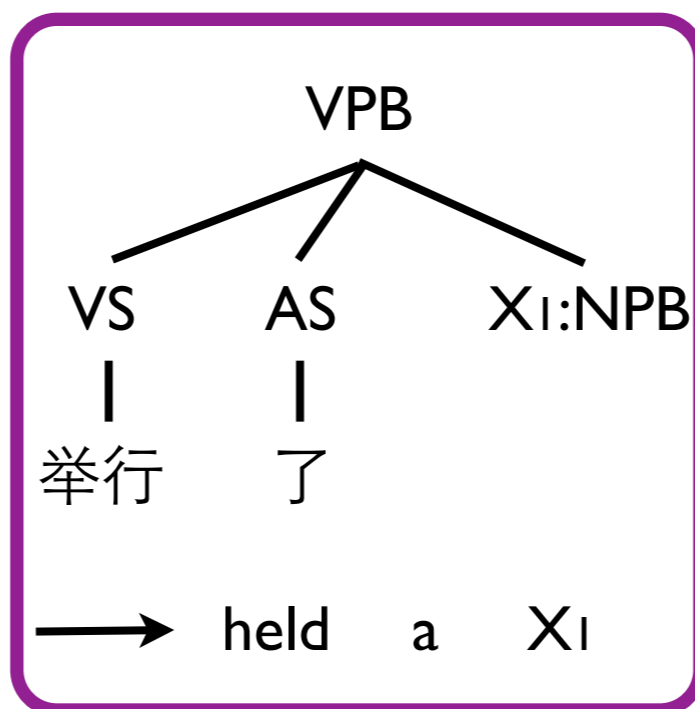
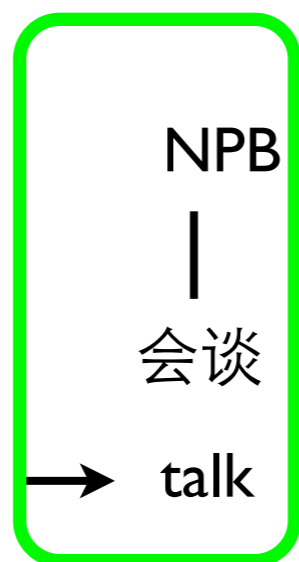
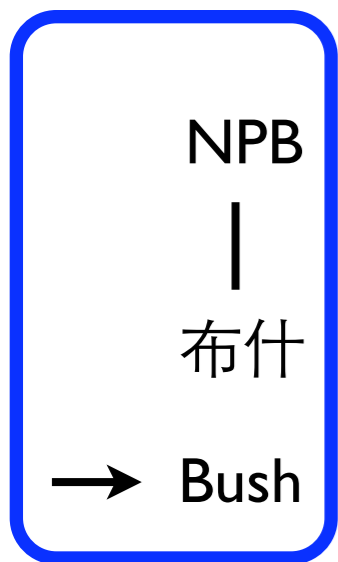
NPB<sub>0,1</sub>

NPB<sub>2,3</sub>

NPB<sub>5,6</sub>

VPB<sub>3,6</sub>

# 翻译森林



NPB<sub>0,1</sub>

NPB<sub>2,3</sub>

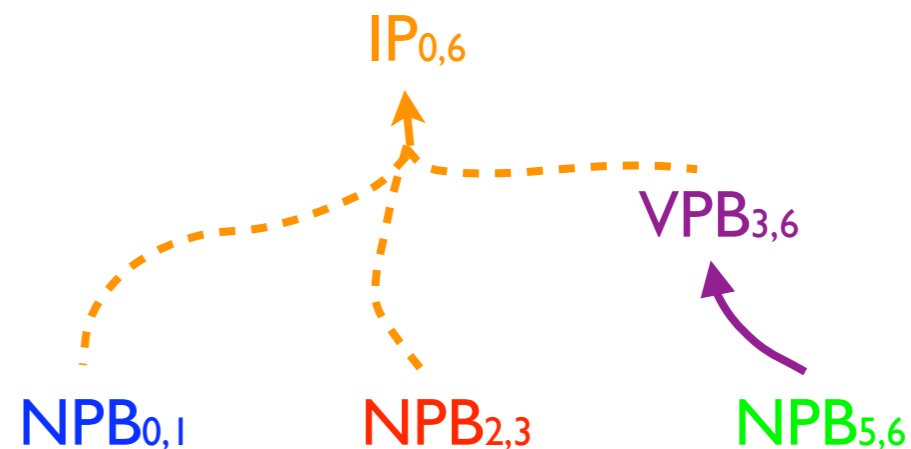
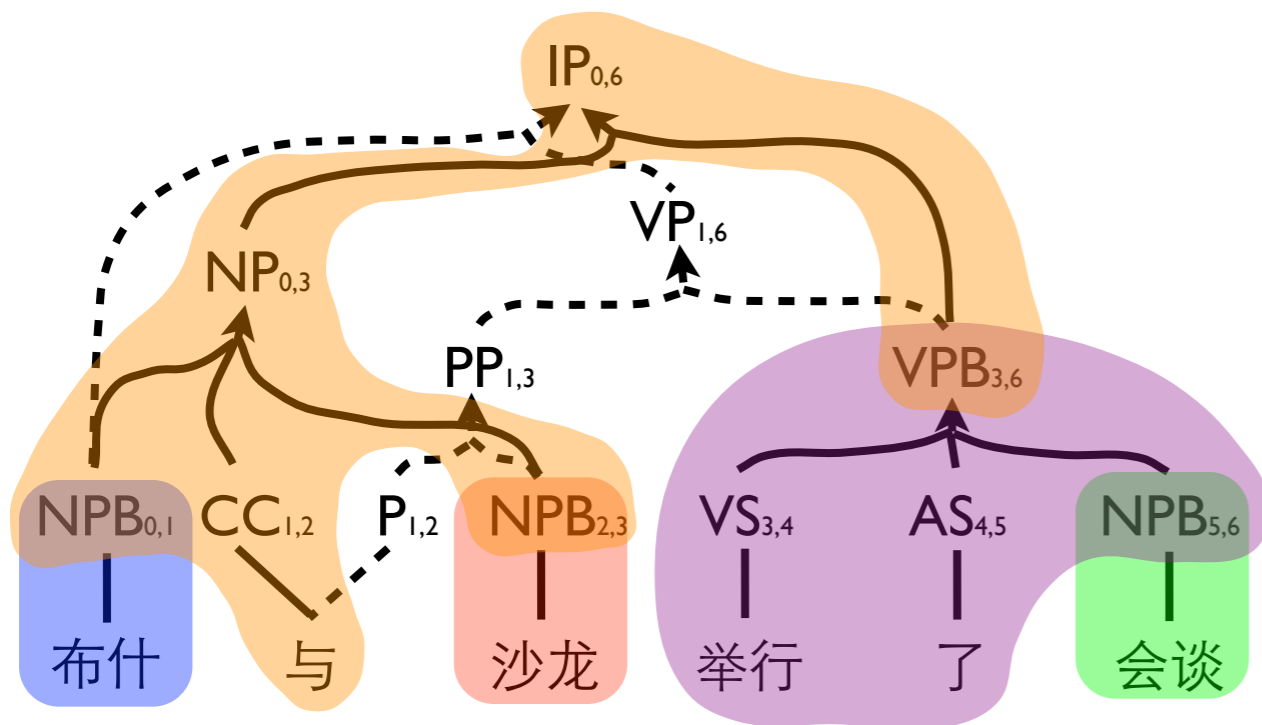
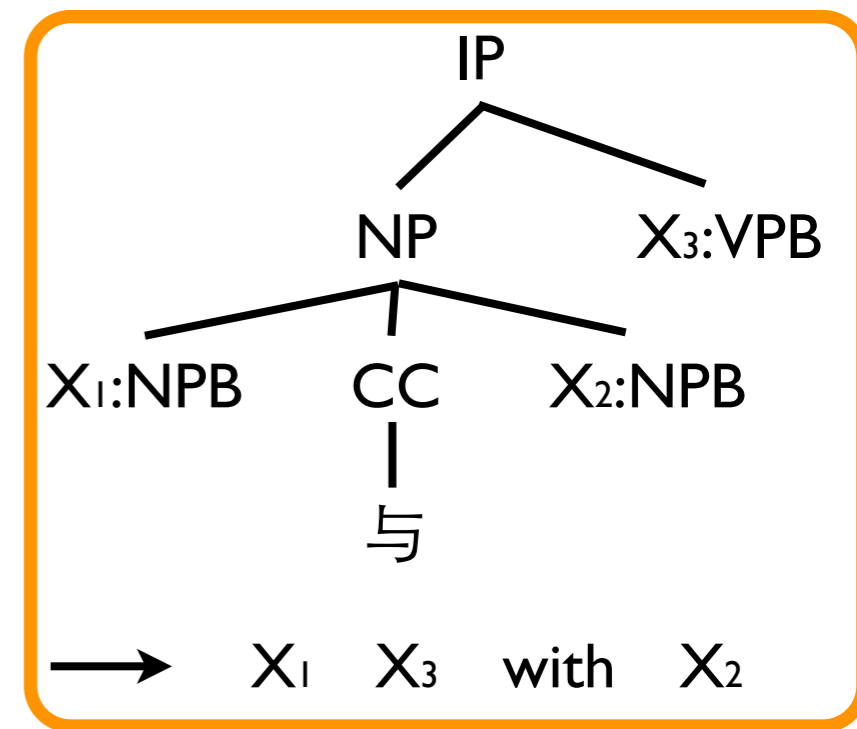
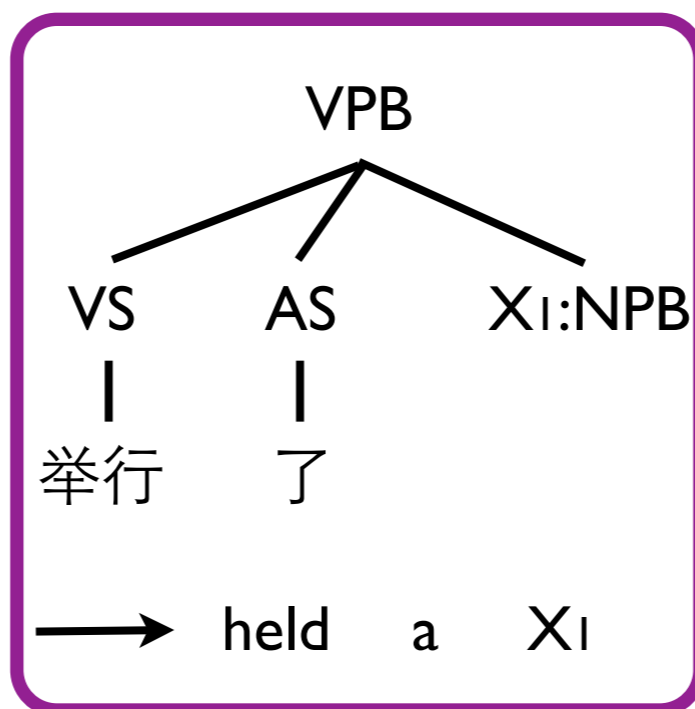
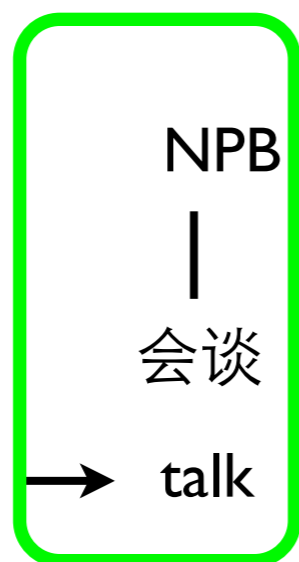
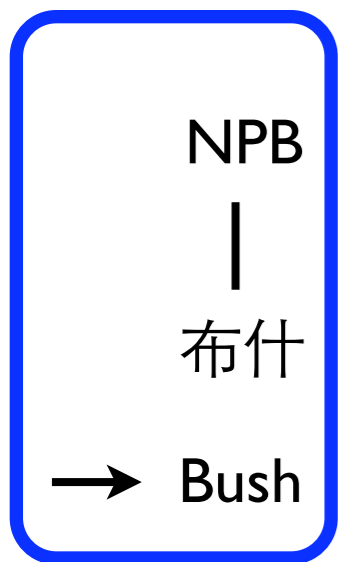
NPB<sub>5,6</sub>

IP<sub>0,6</sub>

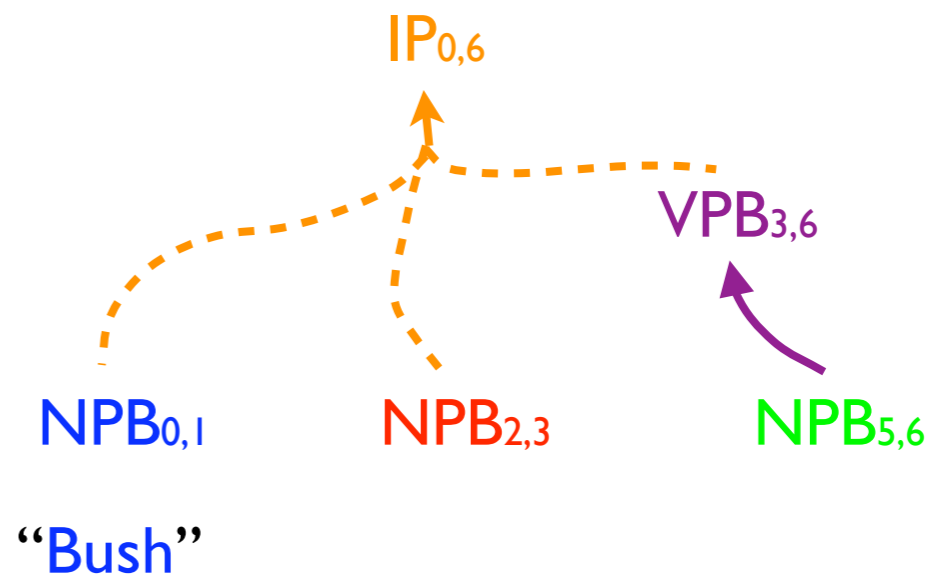
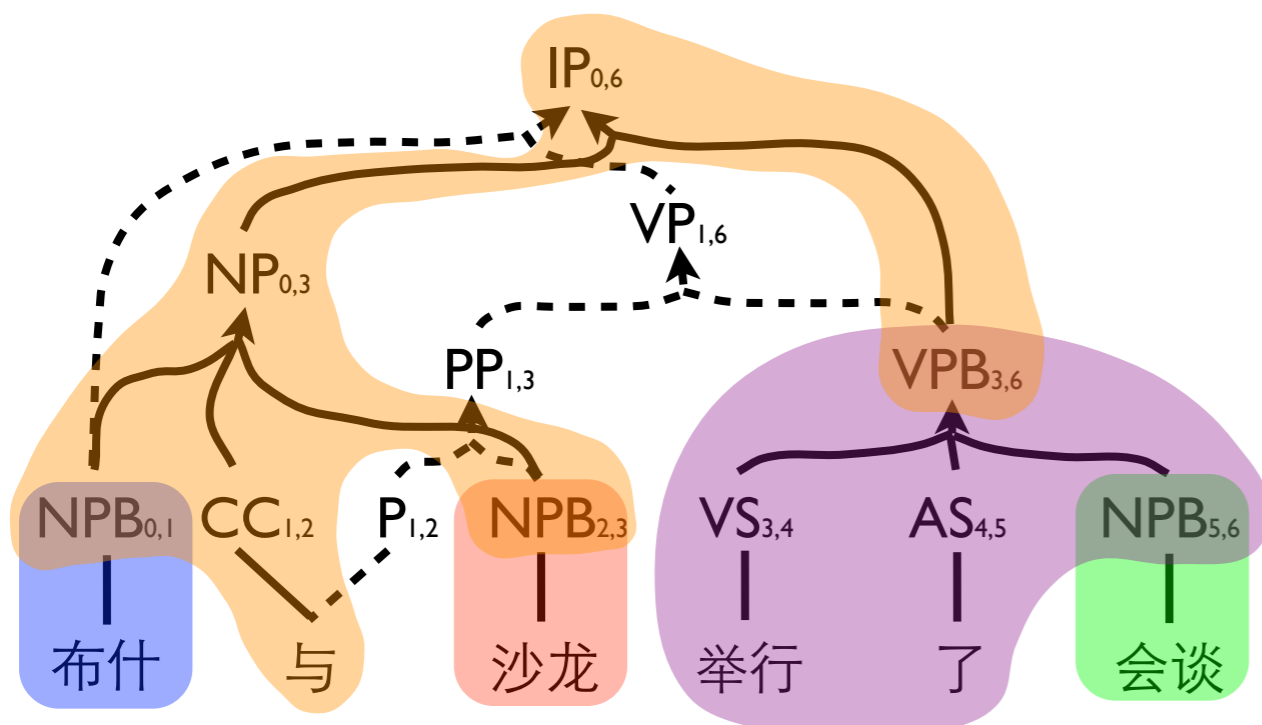
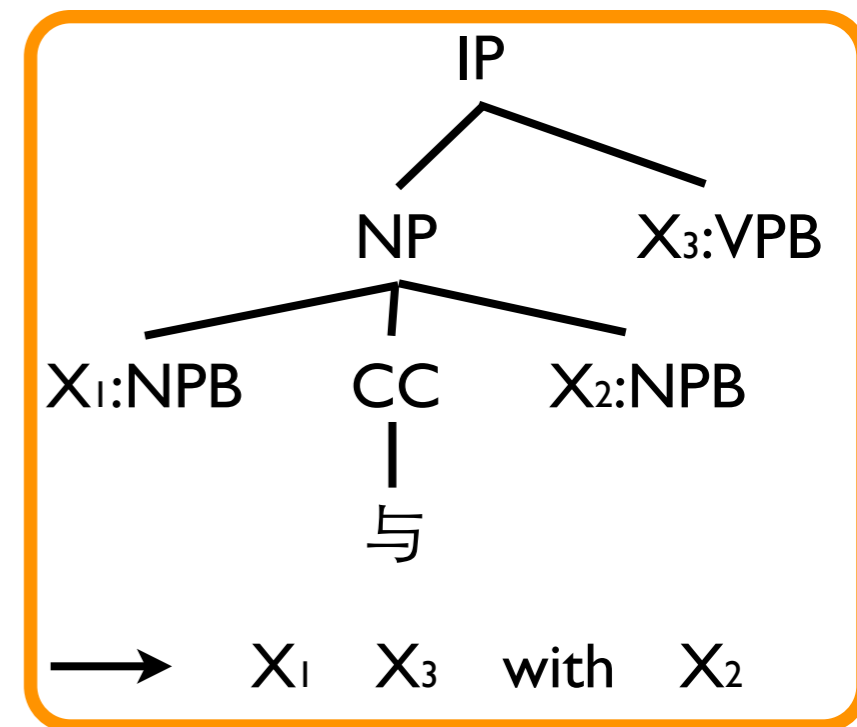
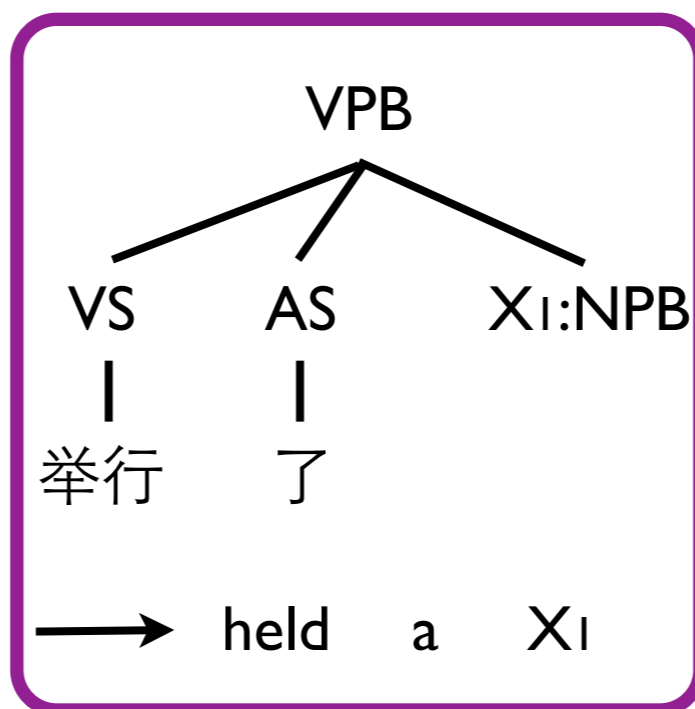
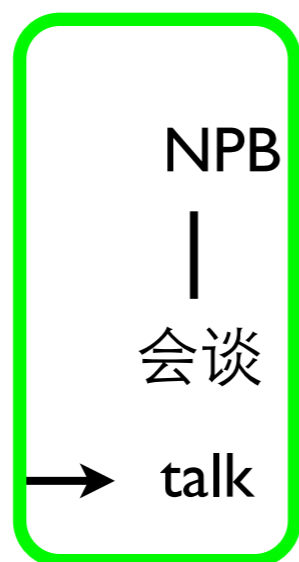
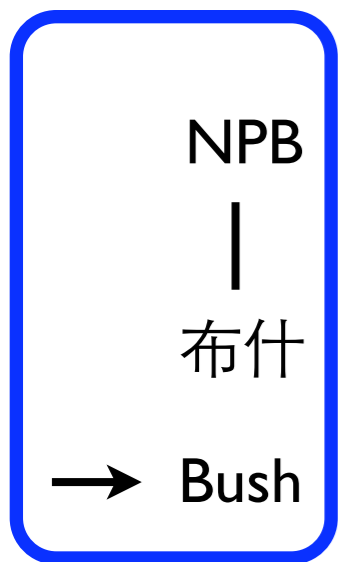
VPB<sub>3,6</sub>

(Mi et al., 2008)

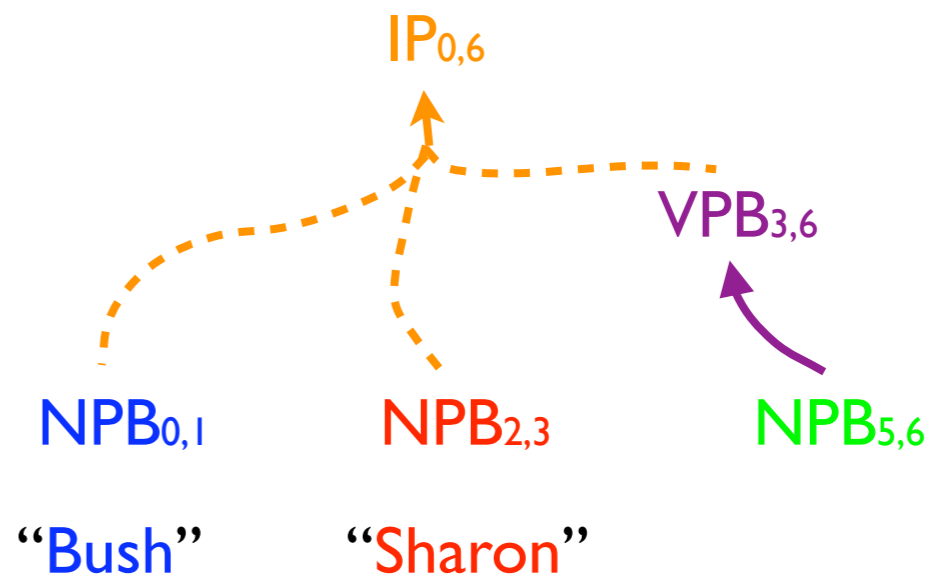
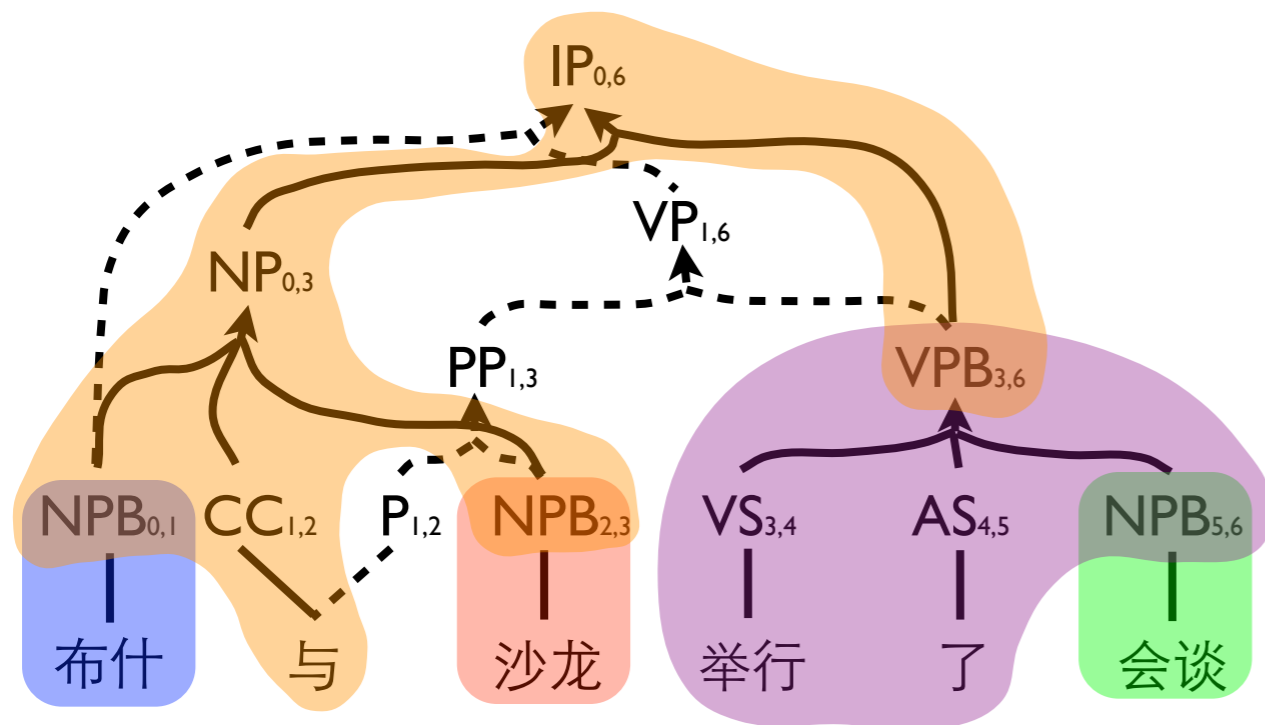
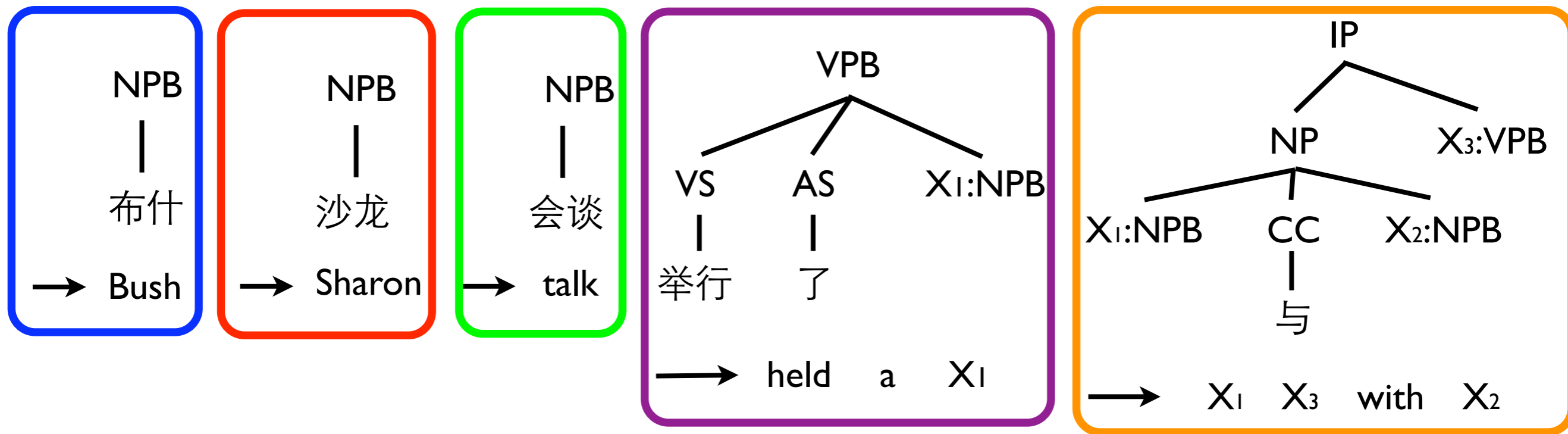
# 翻译森林



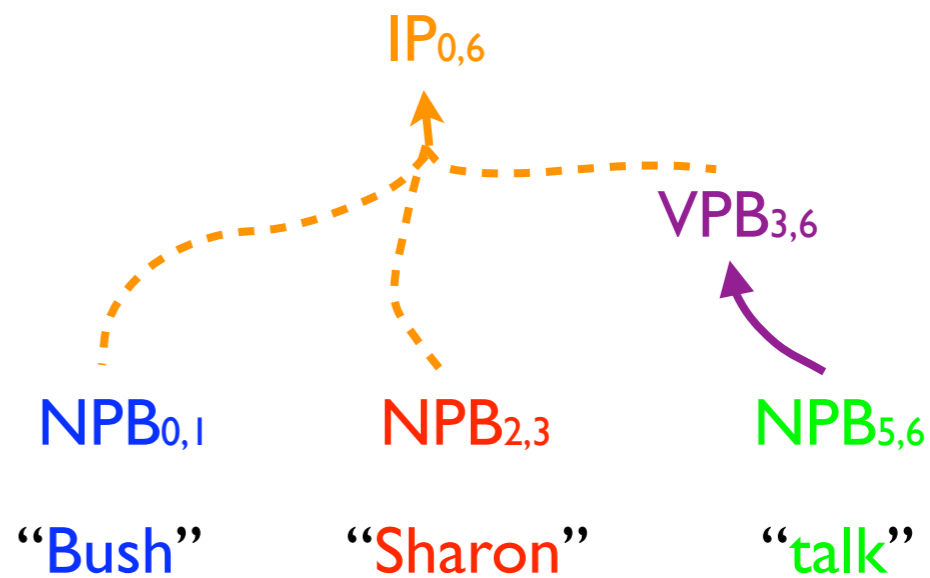
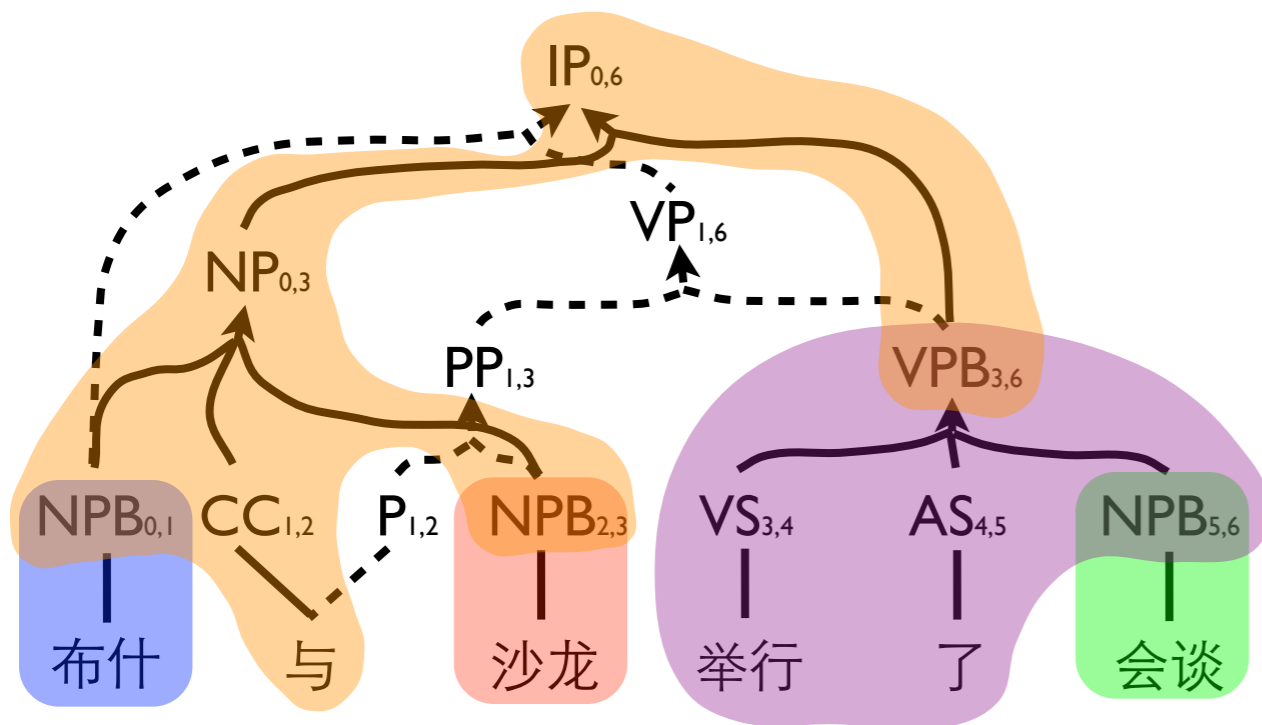
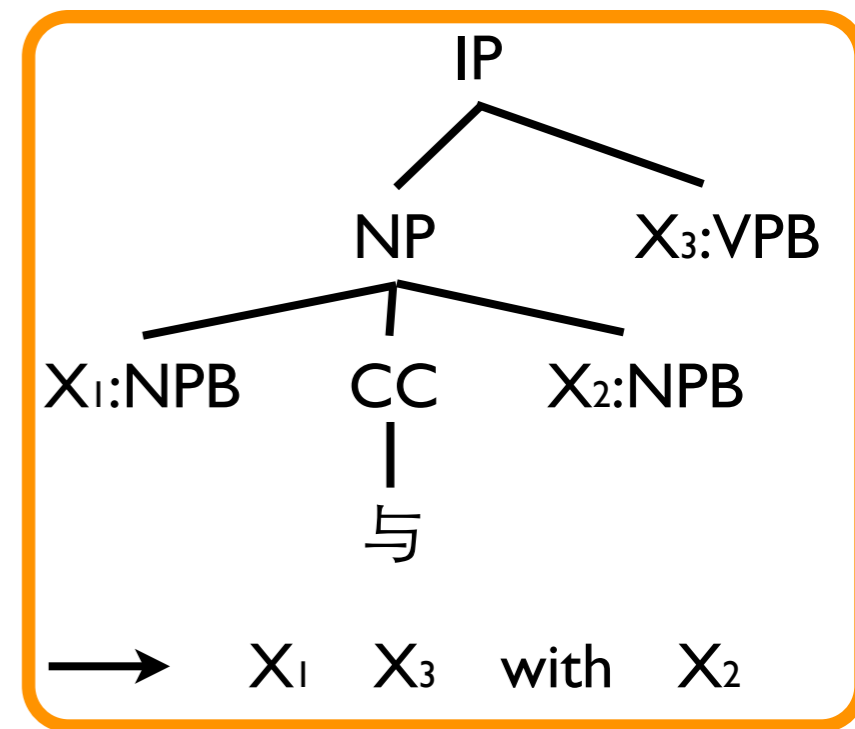
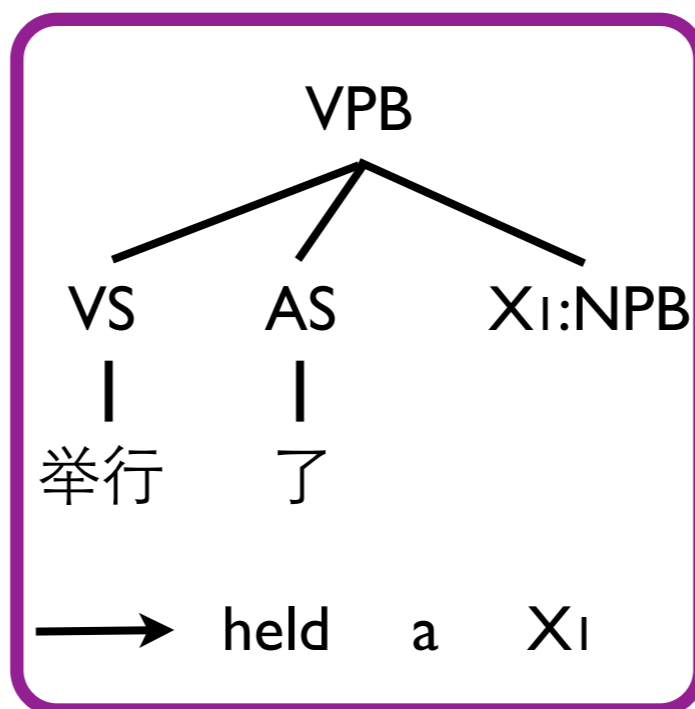
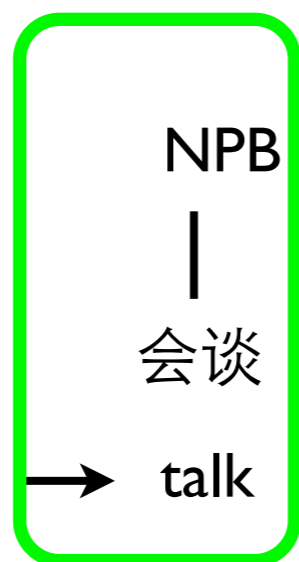
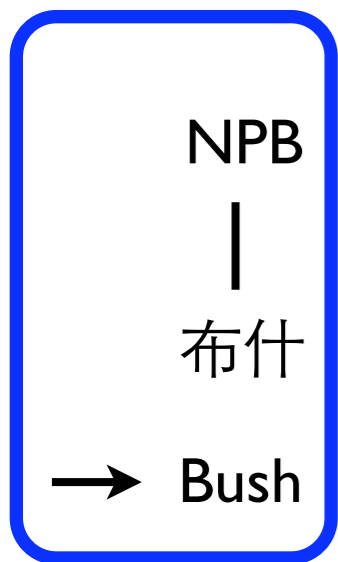
# 翻译森林



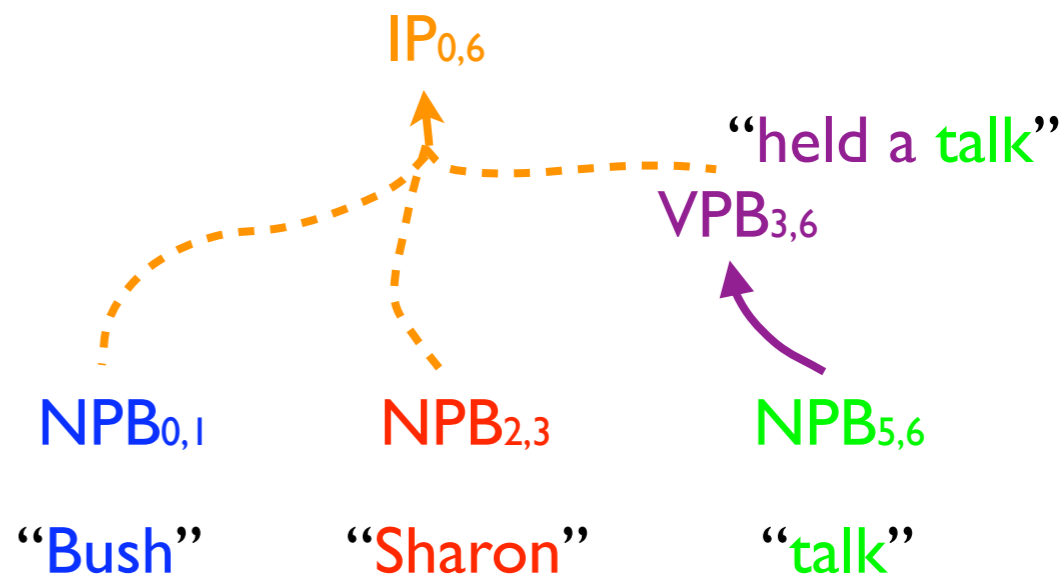
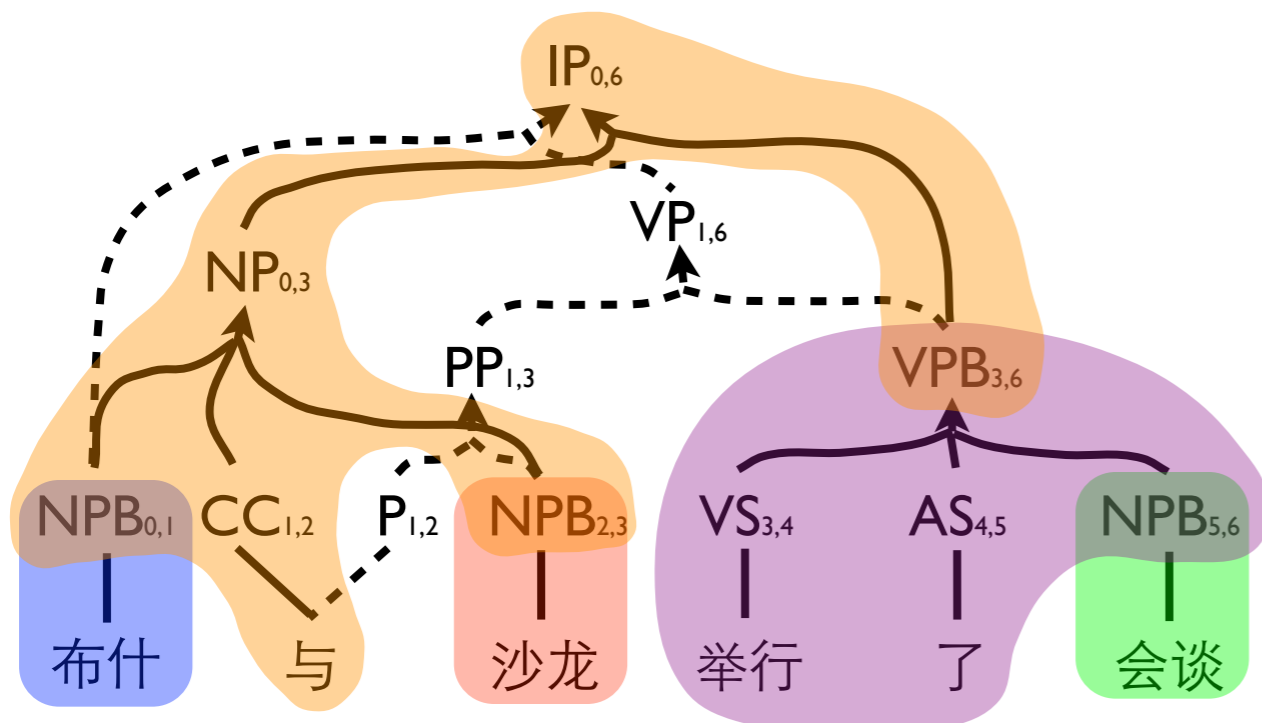
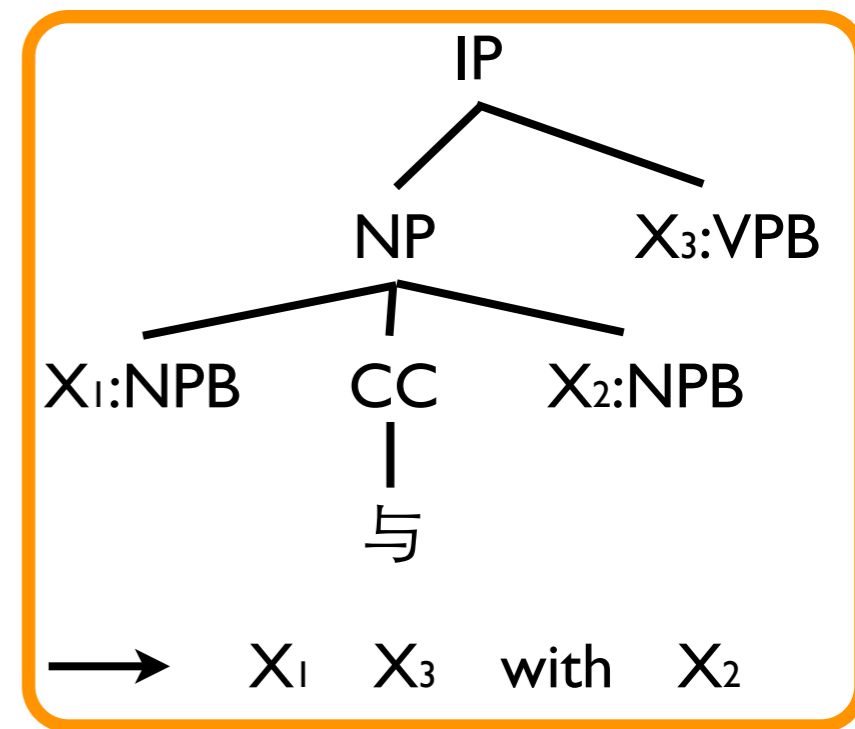
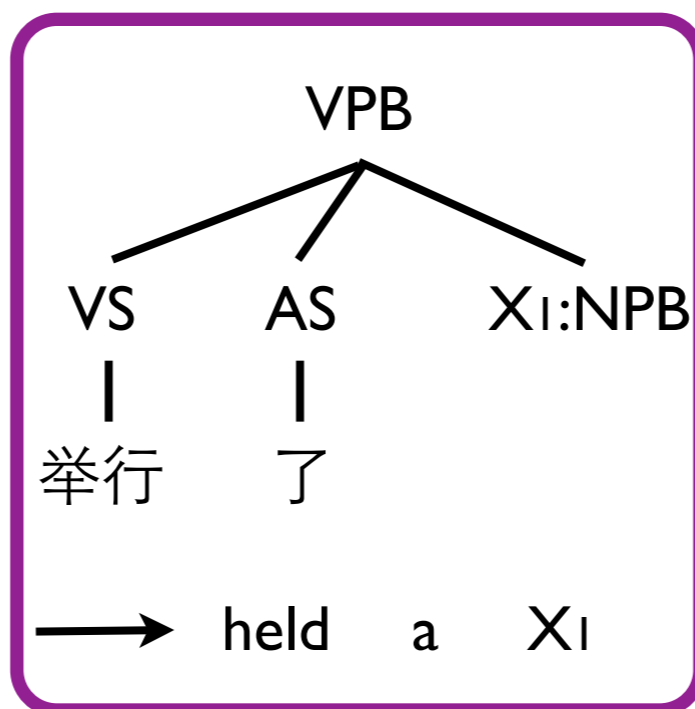
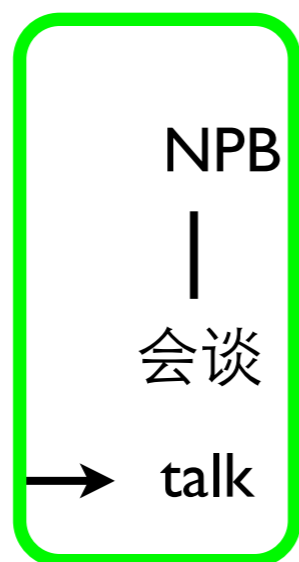
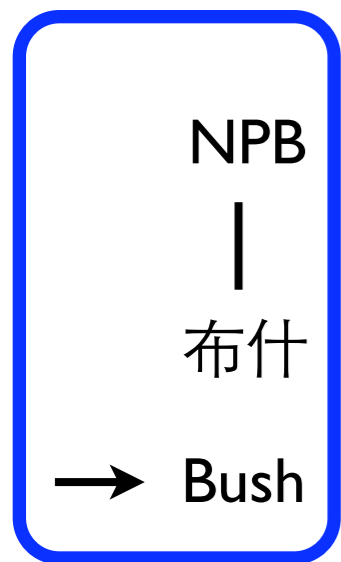
# 翻译森林



# 翻译森林

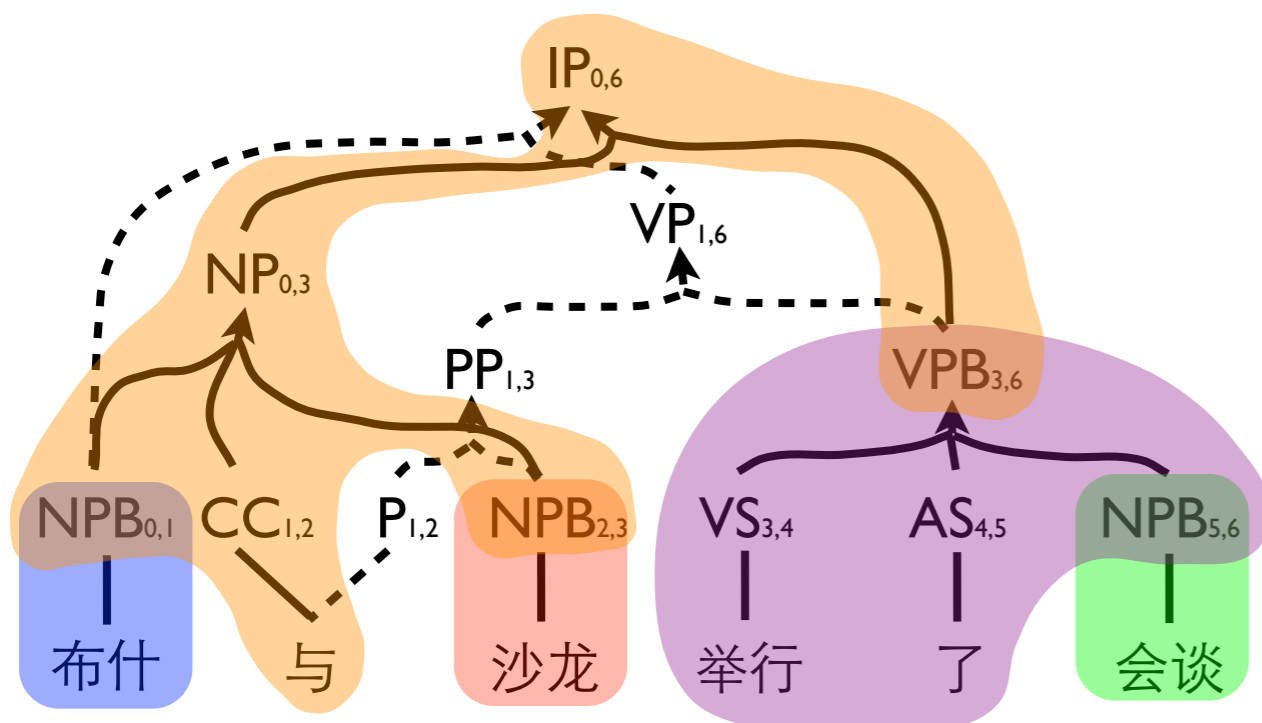
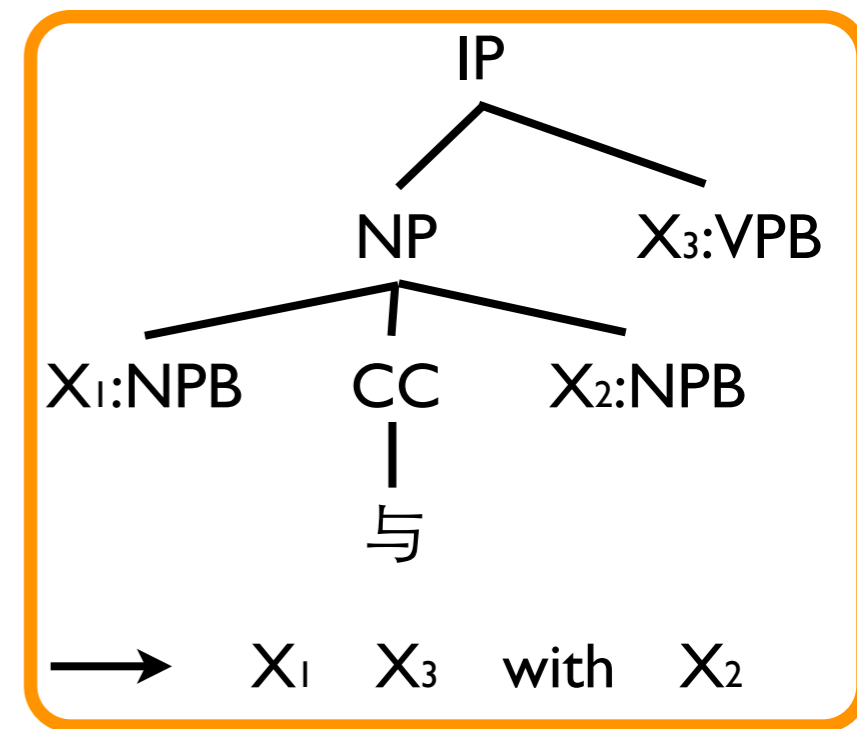
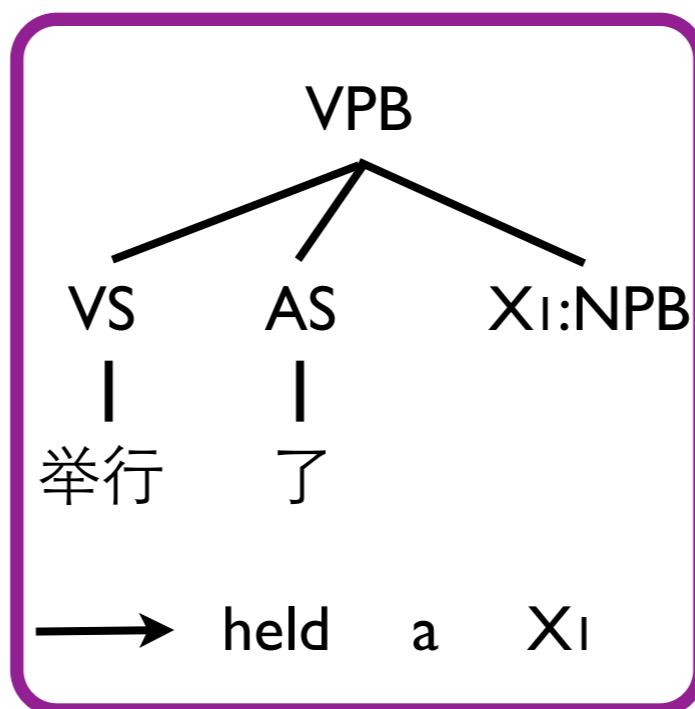
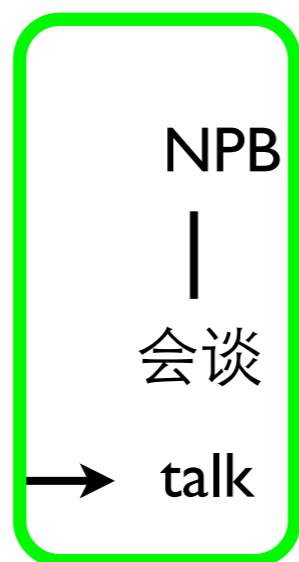
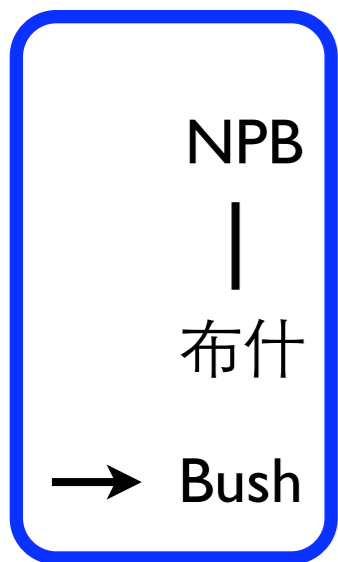


# 翻译森林

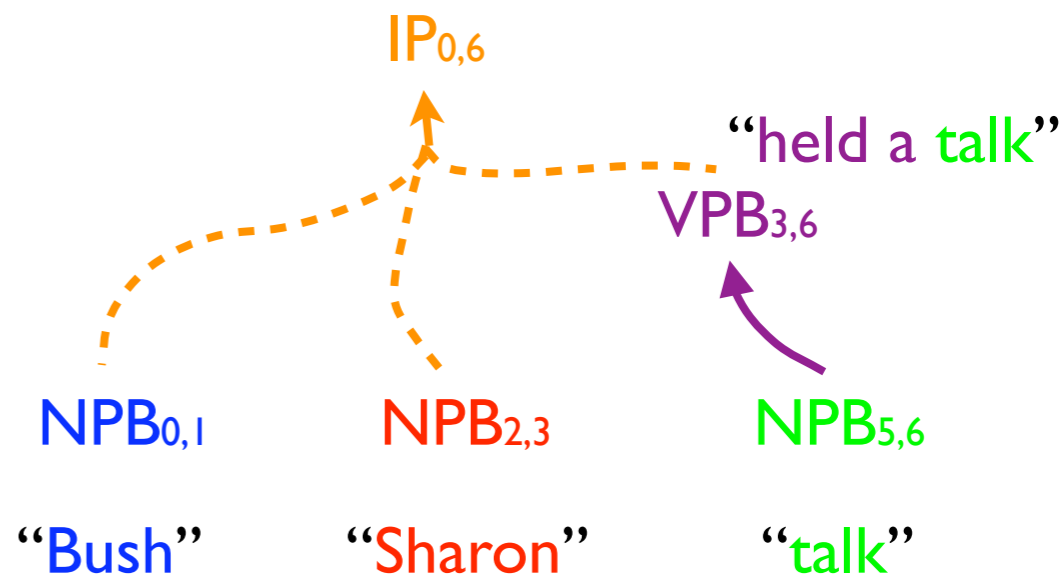




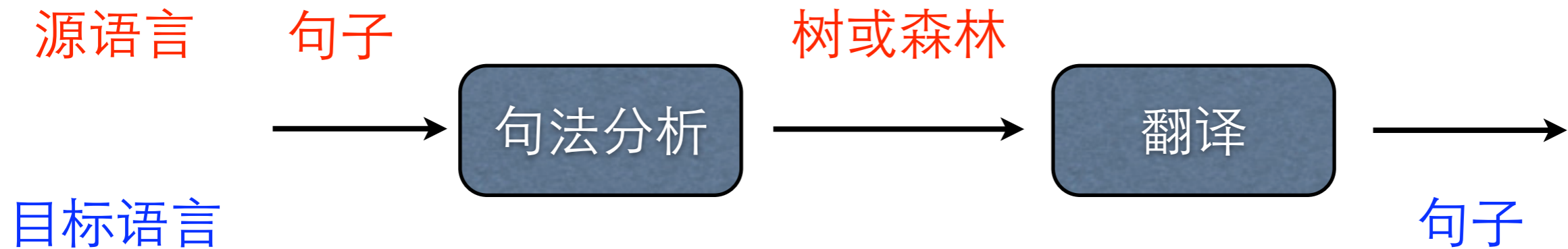
# 翻译森林



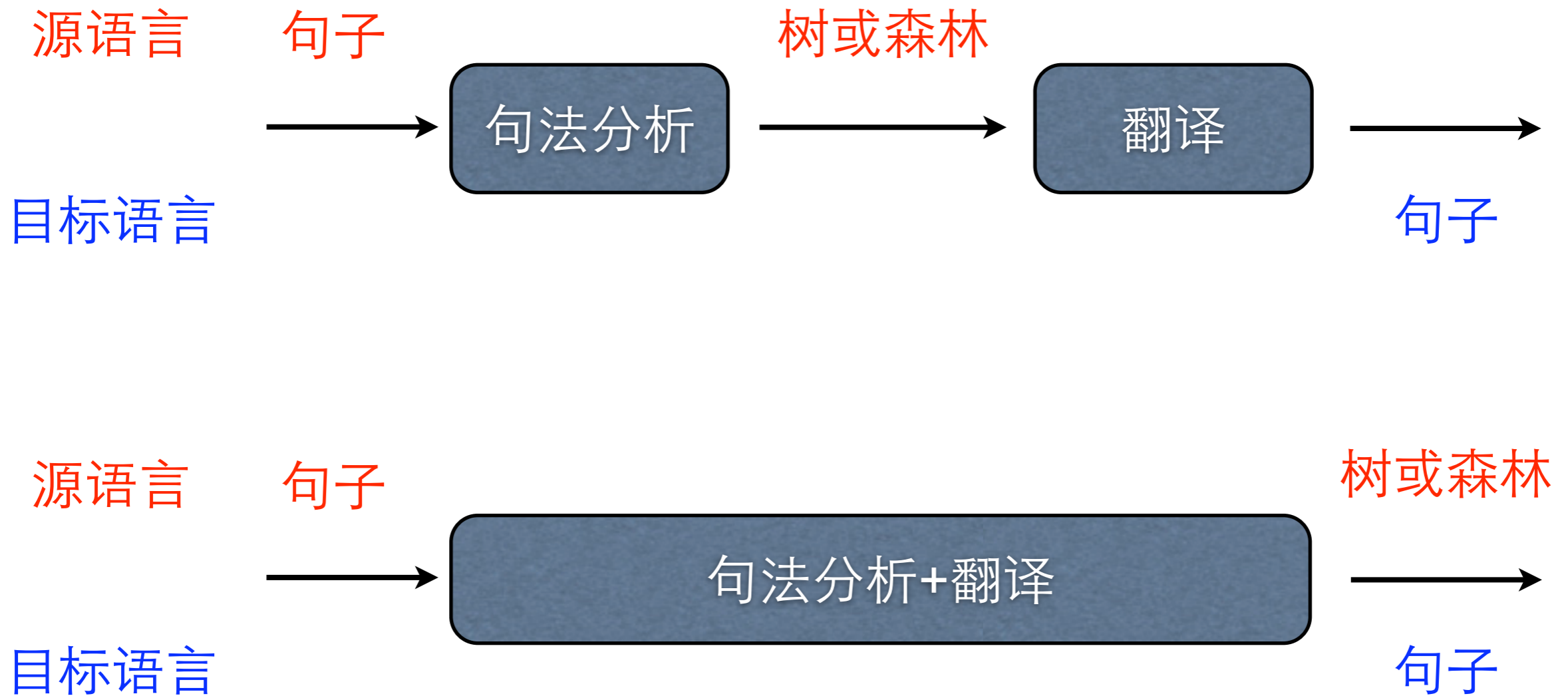
“Bush held a talk with Sharon”



# 句法分析和翻译



# 句法分析和翻译



# 联合句法分析和翻译

布什 与 沙龙 举行 了 会谈

# 联合句法分析和翻译

NPB

|

布什

→

Bush

布什 与 沙龙 举行 了 会谈

# 联合句法分析和翻译

NPB

|

布什

→

Bush

NPB

|

布什

与 沙龙 举行 了 会谈

# 联合句法分析和翻译

NPB  
|  
布什  
→ Bush

NPB  
|  
布什

与 沙龙 举行 了 会谈

Bush

# 联合句法分析和翻译

NPB

|

布什

与 沙龙 举行 了 会谈

Bush



# 联合句法分析和翻译

NPB  
|  
沙龙  
→ Sharon

NPB  
|  
布什

与 沙龙 举行 了 会谈

Bush

# 联合句法分析和翻译

NPB  
|  
沙龙  
→ Sharon

NPB                      NPB  
|                            |  
布什                      沙龙                      举行                      了                      会谈

Bush

# 联合句法分析和翻译

NPB  
|  
沙龙  
→ Sharon

NPB  
|  
布什

与

NPB  
|  
沙龙

举行

了

会谈

Bush

Sharon

# 联合句法分析和翻译

NPB  
|  
布什

与

NPB  
|  
沙龙

举行

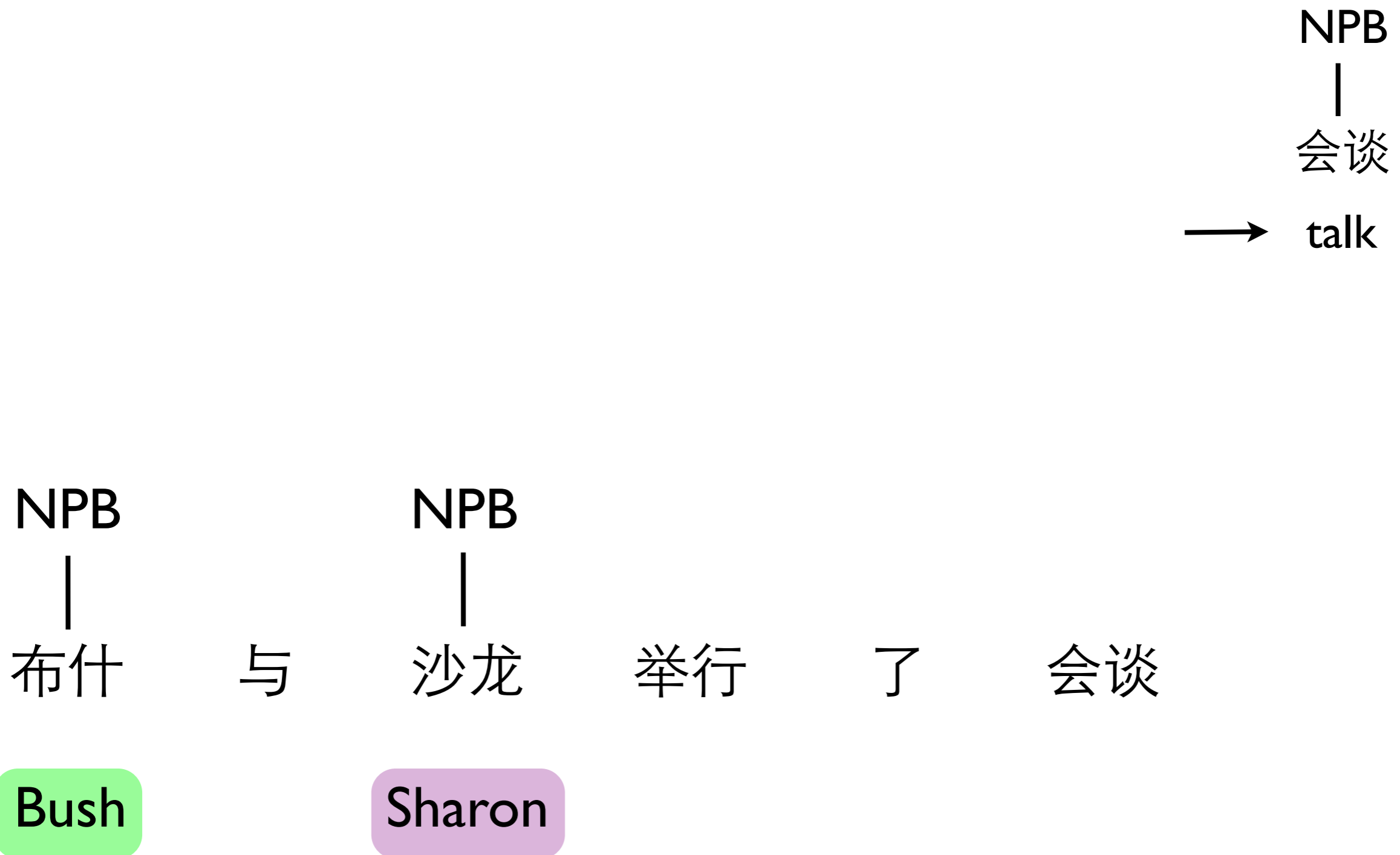
了

会谈

Bush

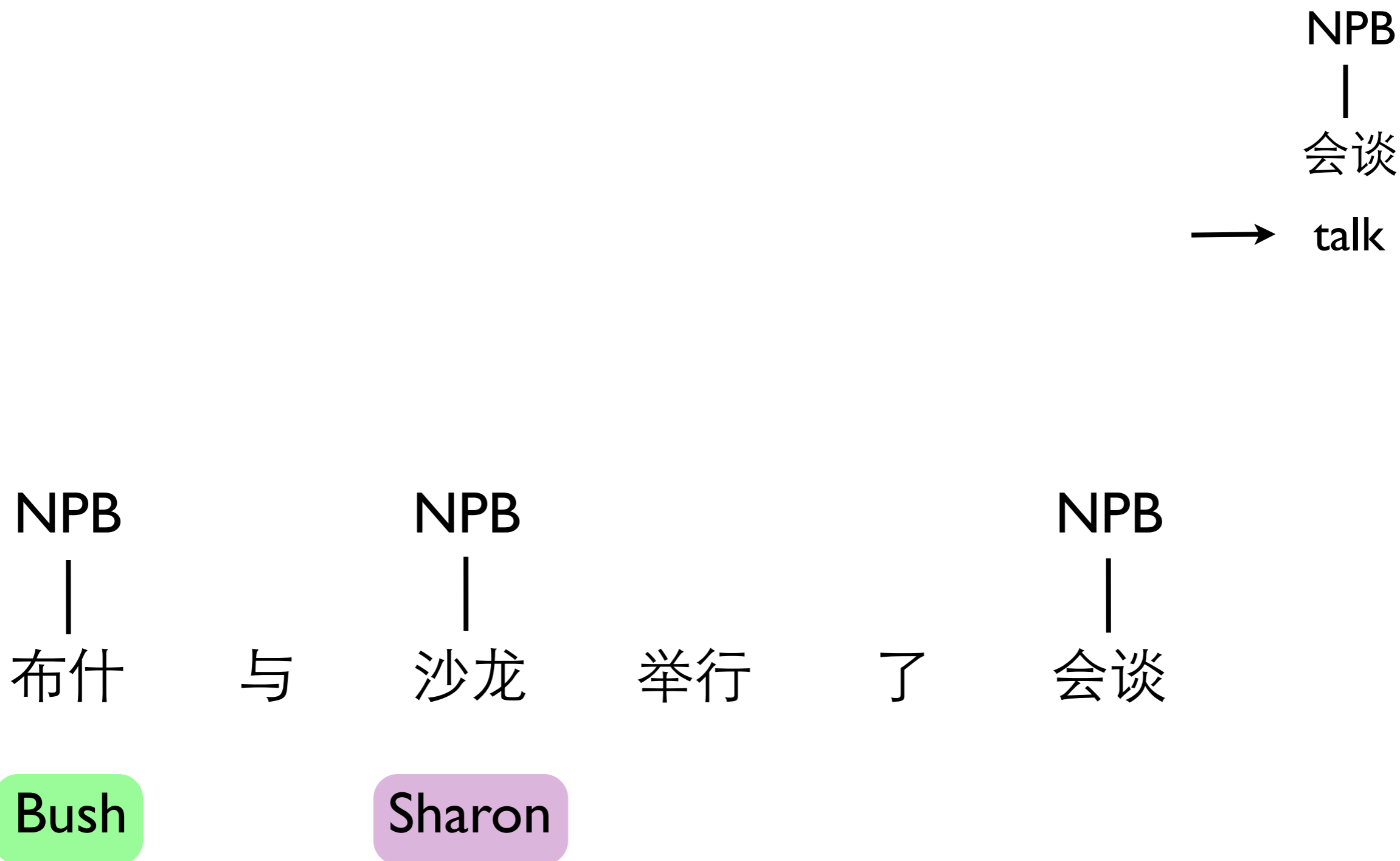
Sharon

# 联合句法分析和翻译



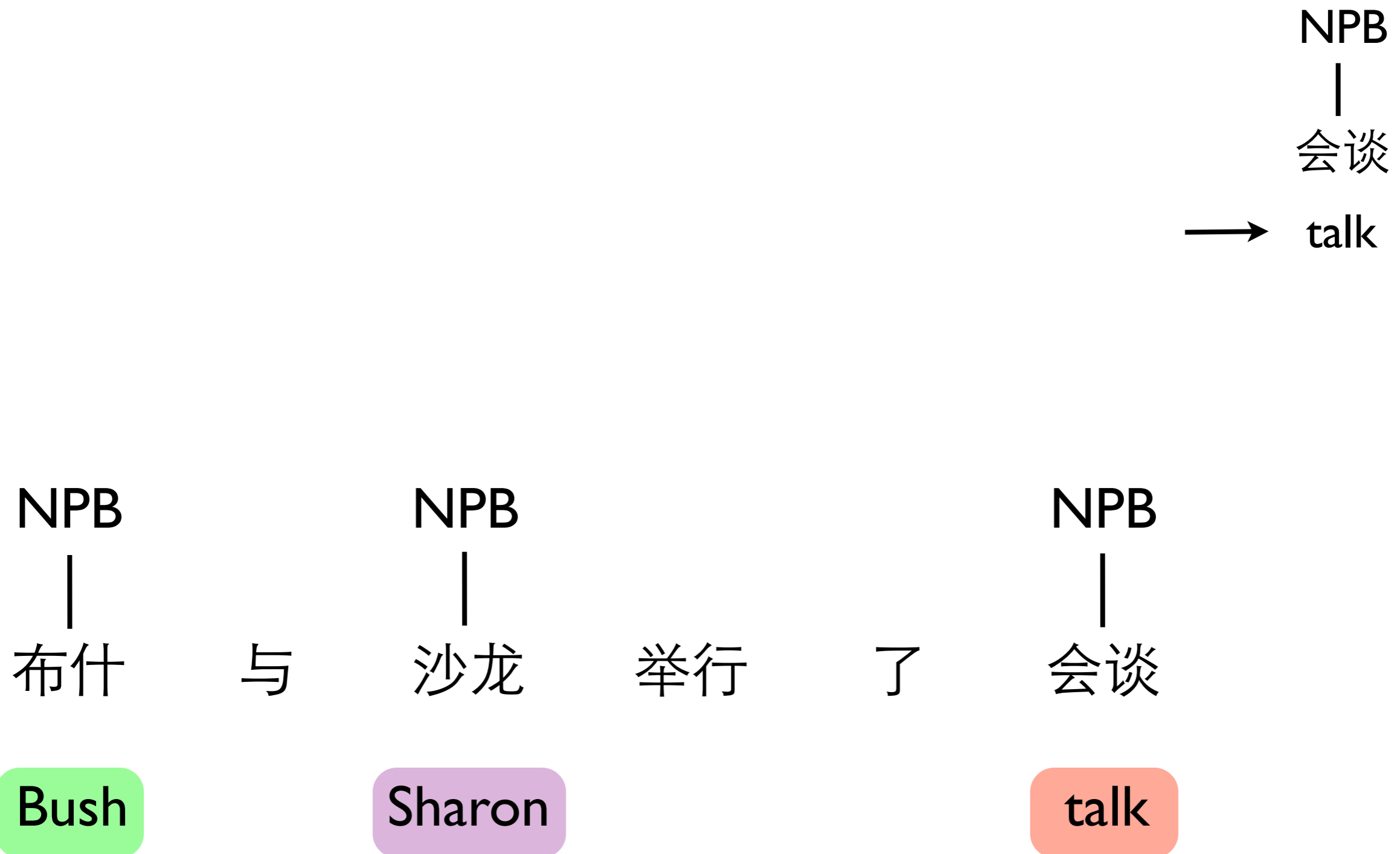
(Liu and Liu, 2010)

# 联合句法分析和翻译



(Liu and Liu, 2010)

# 联合句法分析和翻译



(Liu and Liu, 2010)

# 联合句法分析和翻译

NPB  
|  
布什

Bush

与

NPB  
|  
沙龙

Sharon

举行

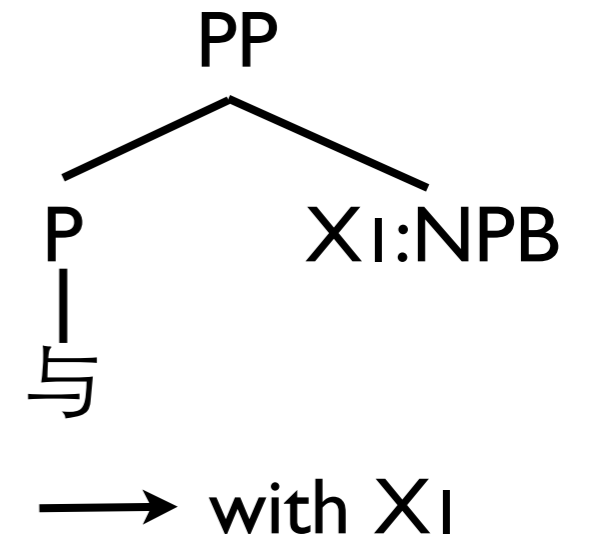
了

NPB  
|  
会谈

talk



# 联合句法分析和翻译



NPB  
|  
布什

Bush

与

NPB  
|  
沙龙

Sharon

举行

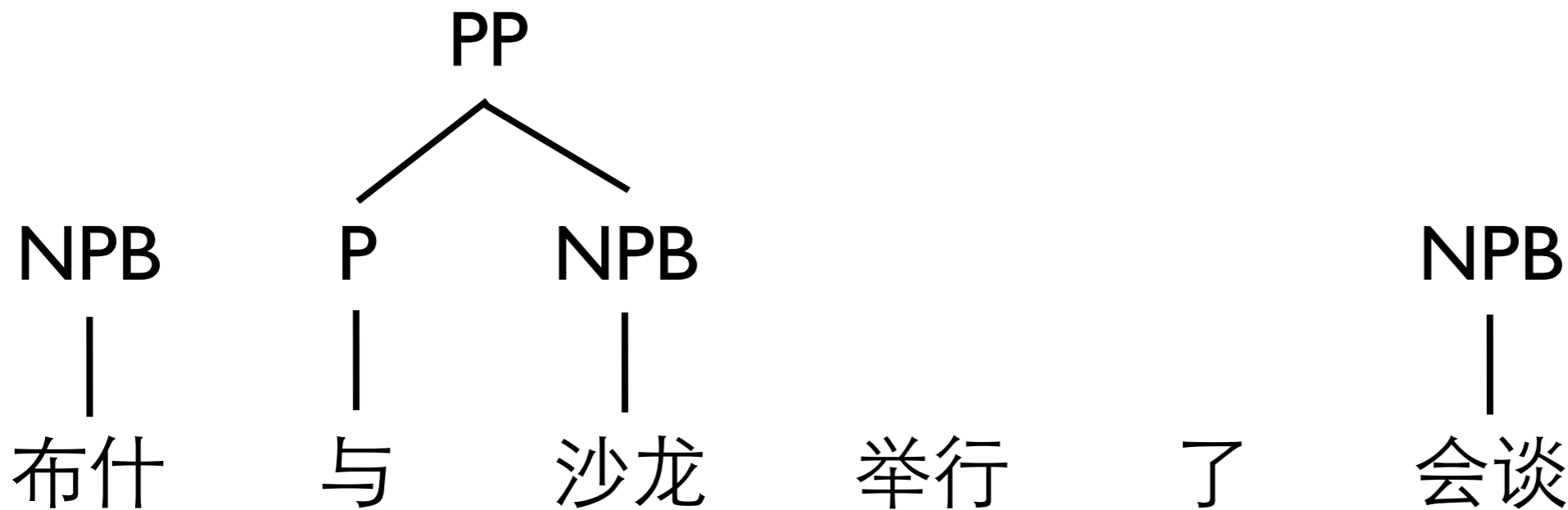
了

NPB  
|  
会谈

talk

(Liu and Liu, 2010)

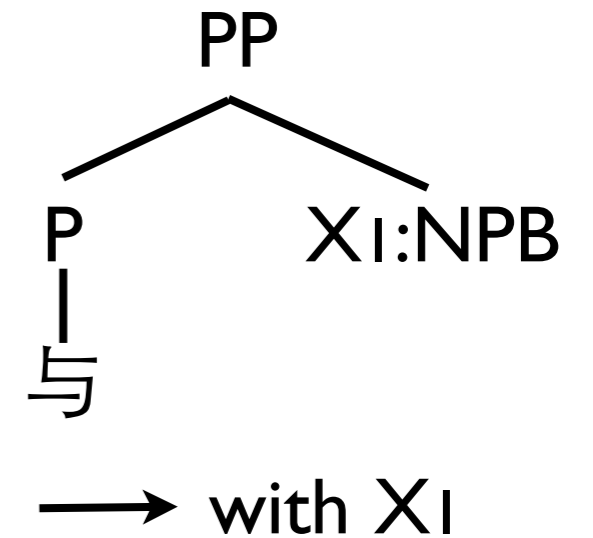
# 联合句法分析和翻译



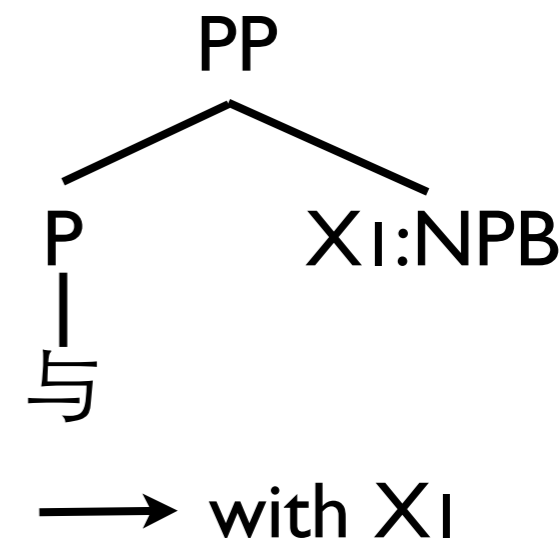
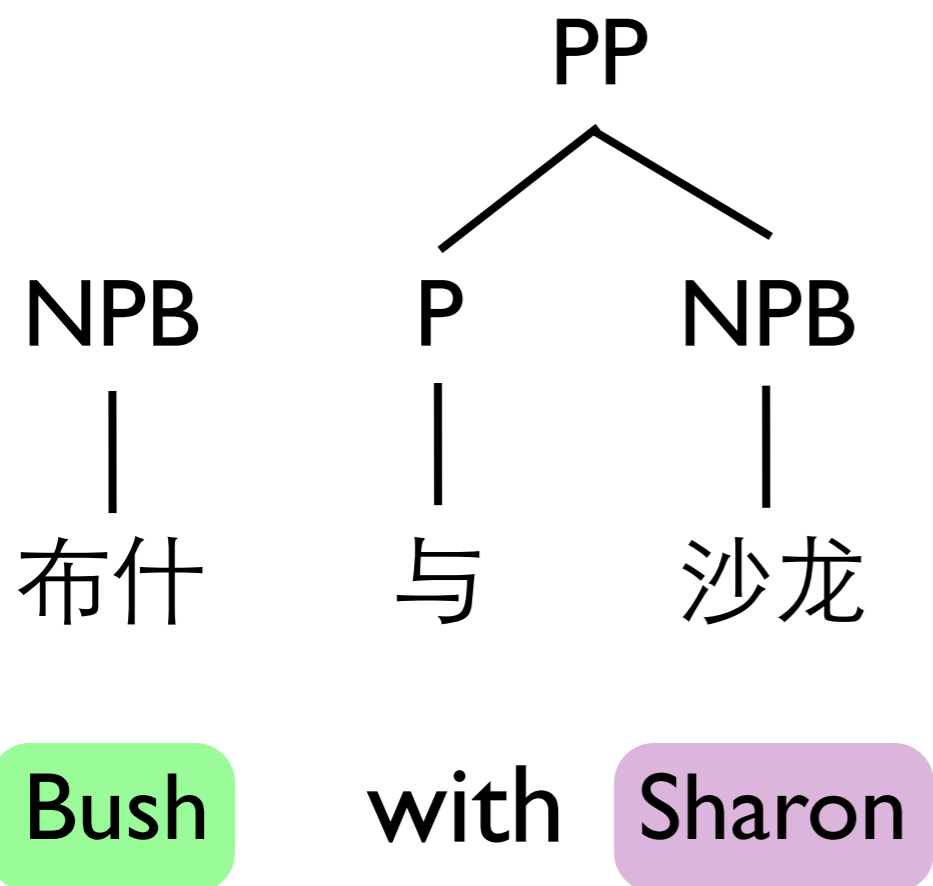
Bush

Sharon

talk



# 联合句法分析和翻译

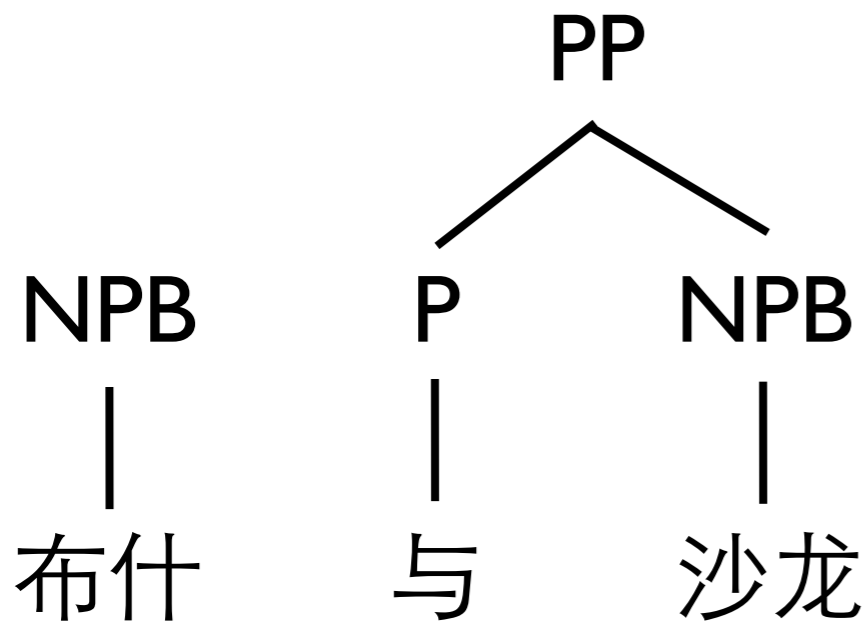


举行了会谈

talk

(Liu and Liu, 2010)

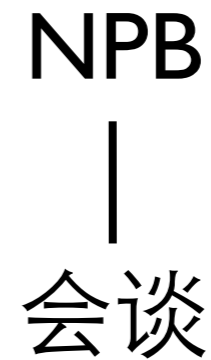
# 联合句法分析和翻译



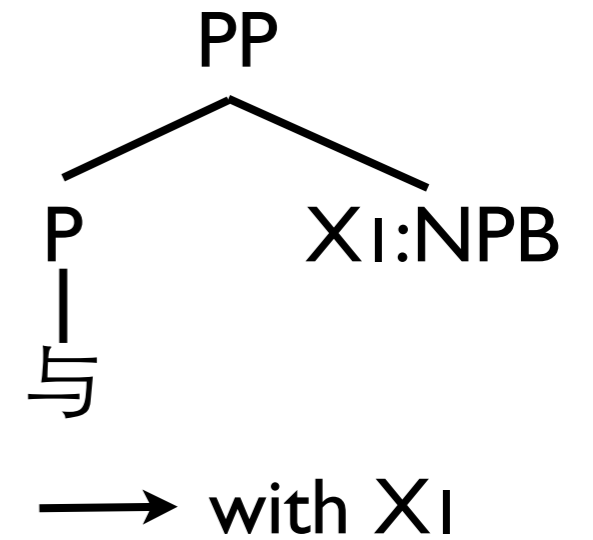
Bush

with Sharon

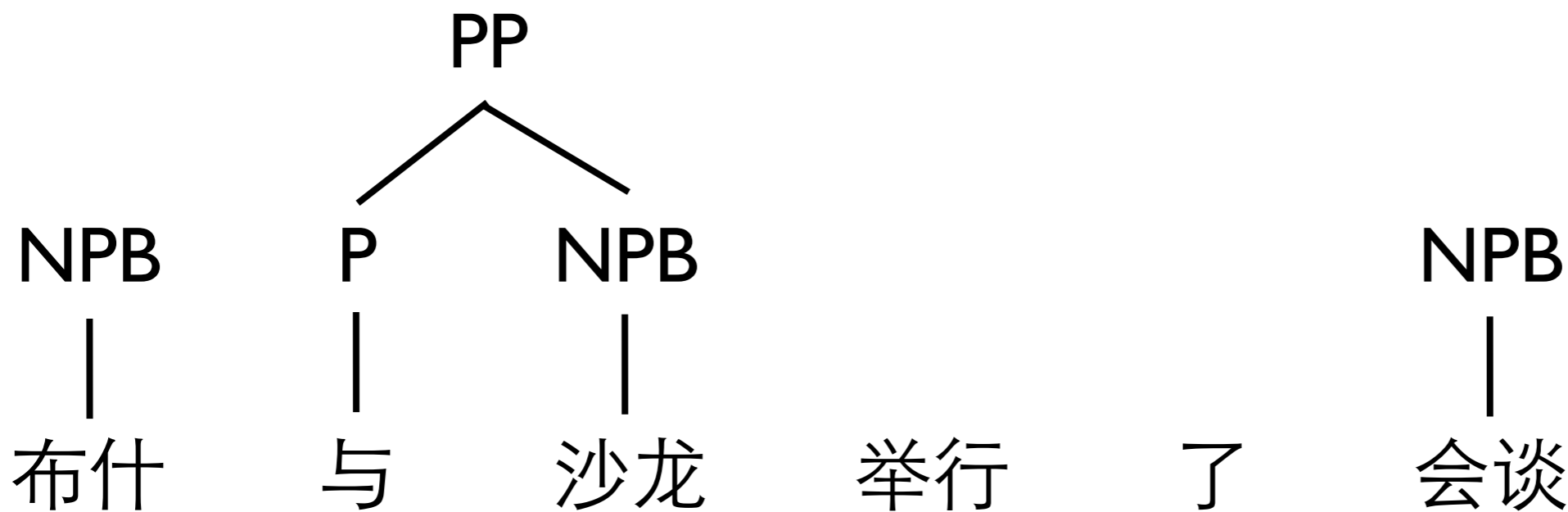
举行 了



talk



# 联合句法分析和翻译

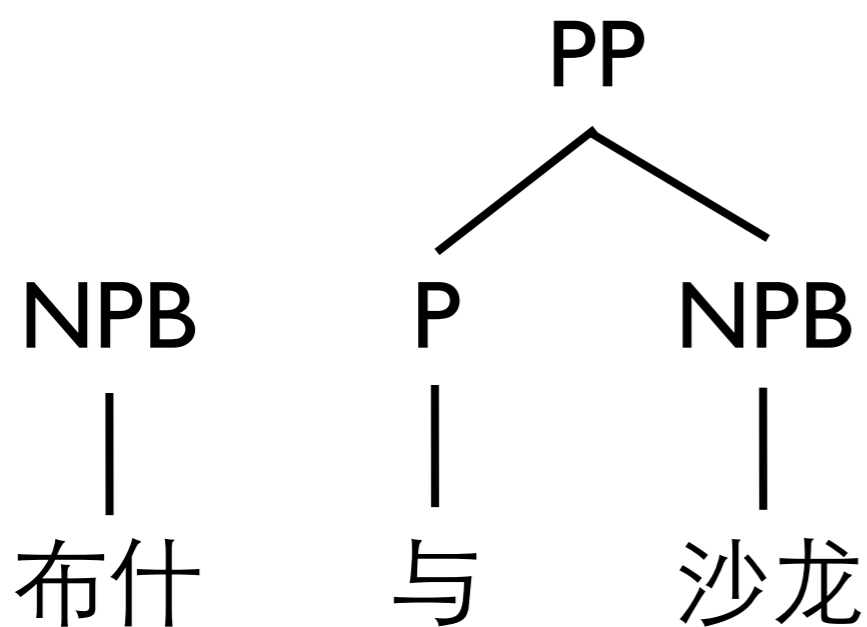


Bush

with Sharon

talk

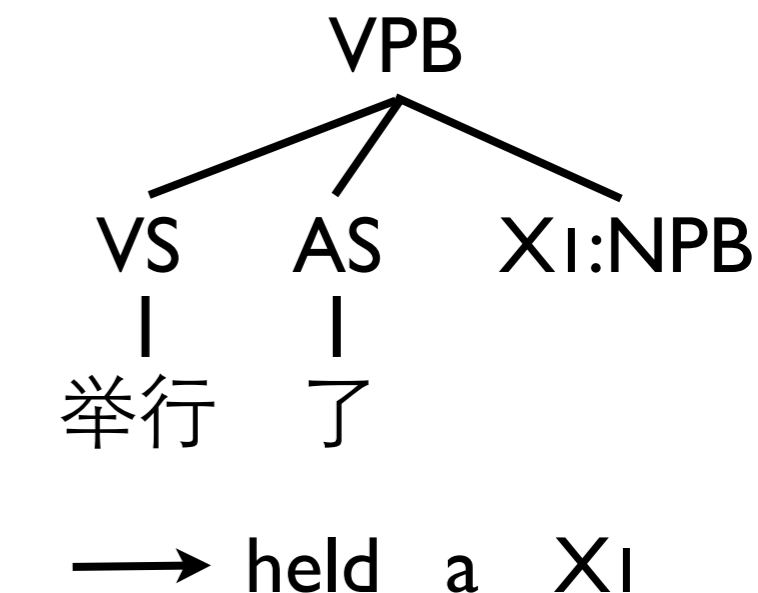
# 联合句法分析和翻译



Bush

with Sharon

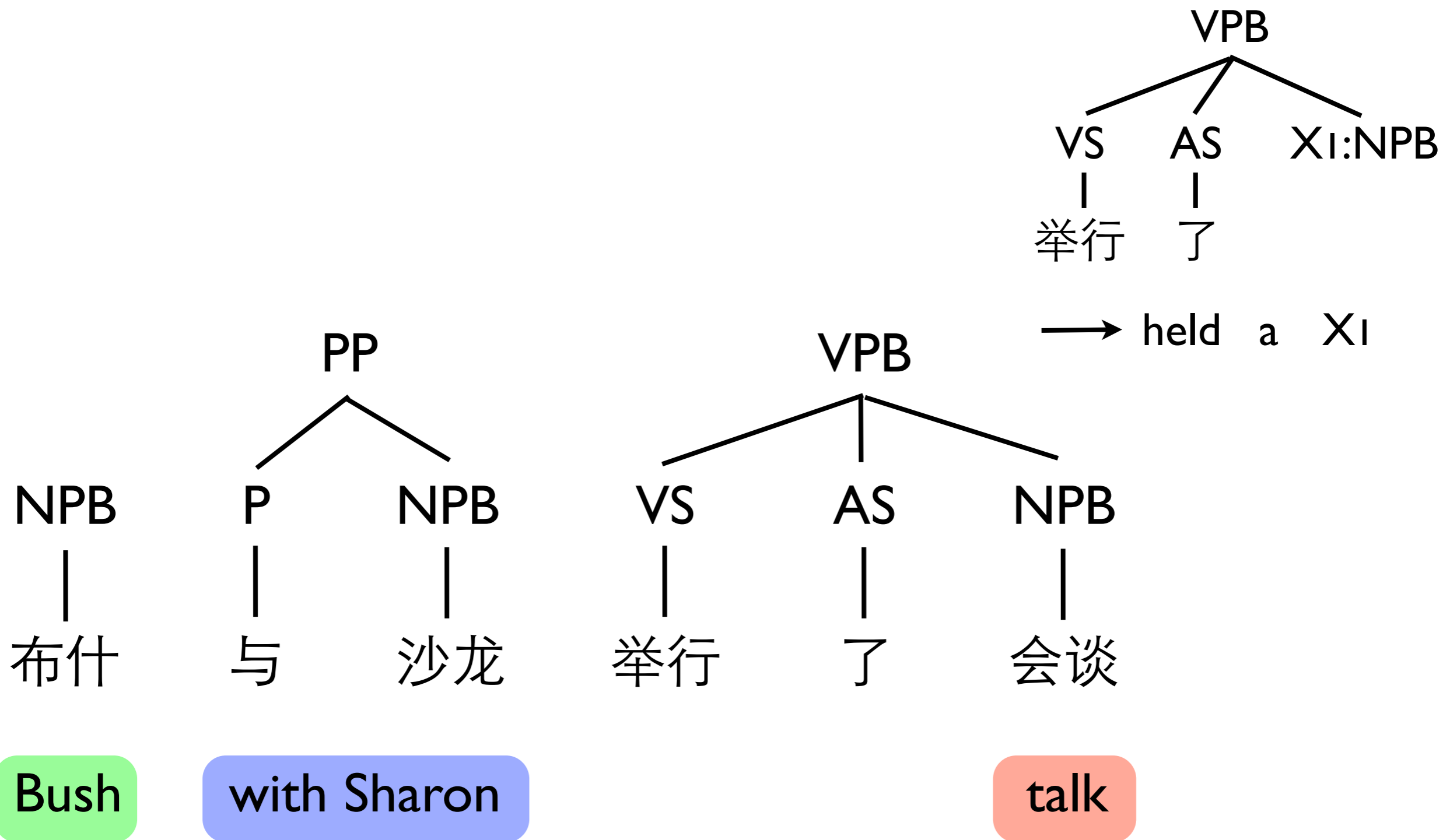
举行 了



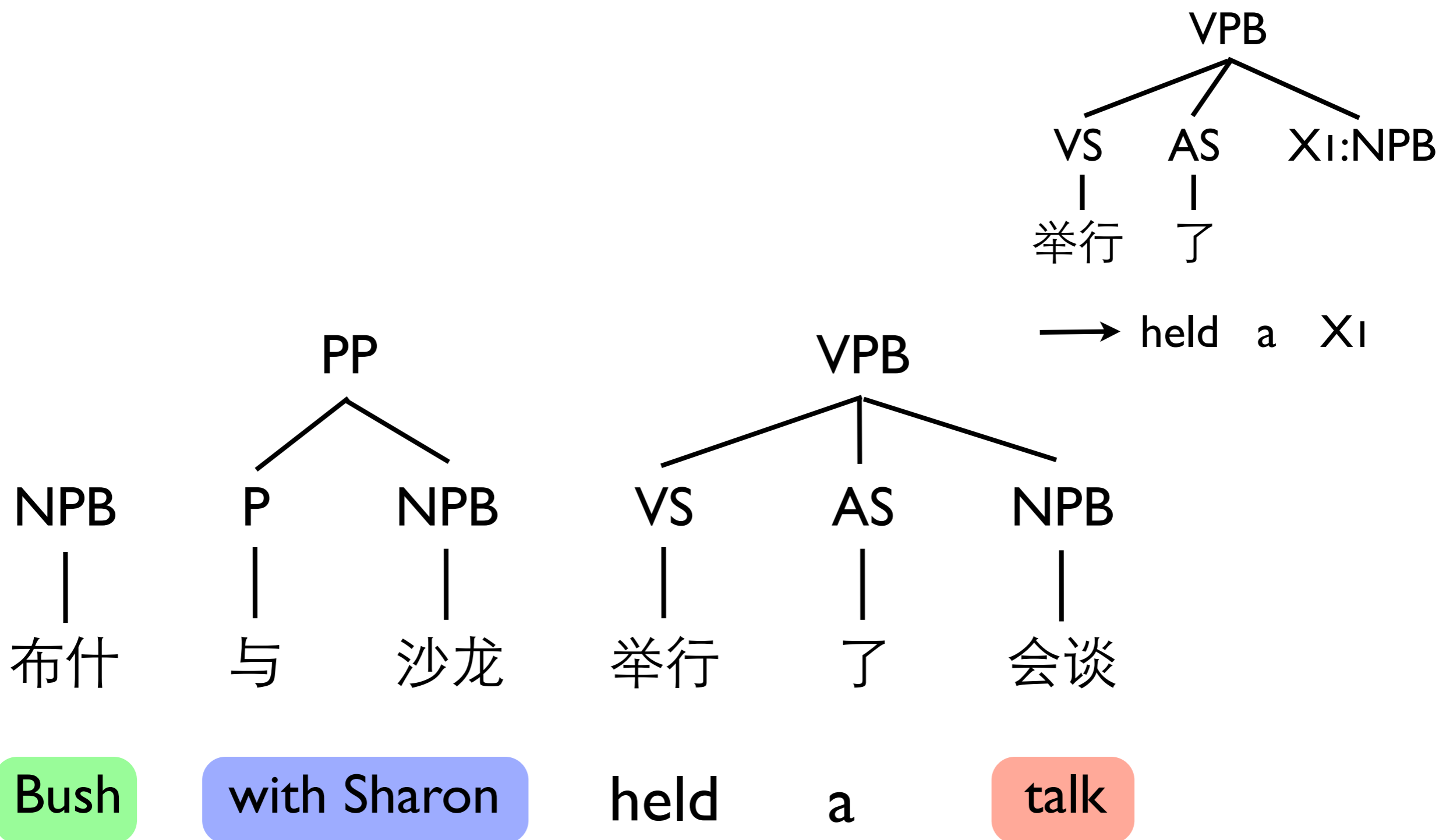
会谈

talk

# 联合句法分析和翻译

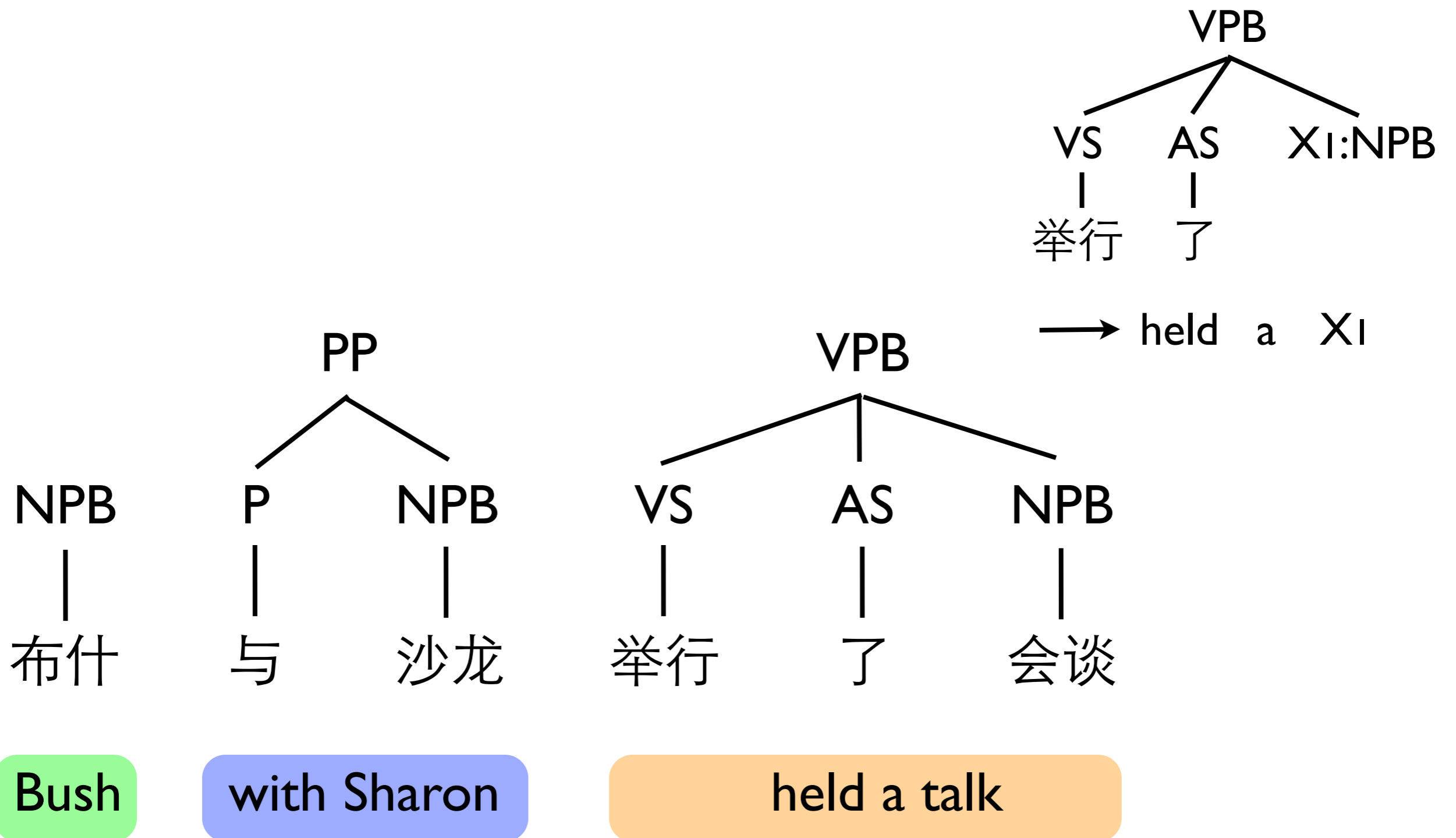


# 联合句法分析和翻译



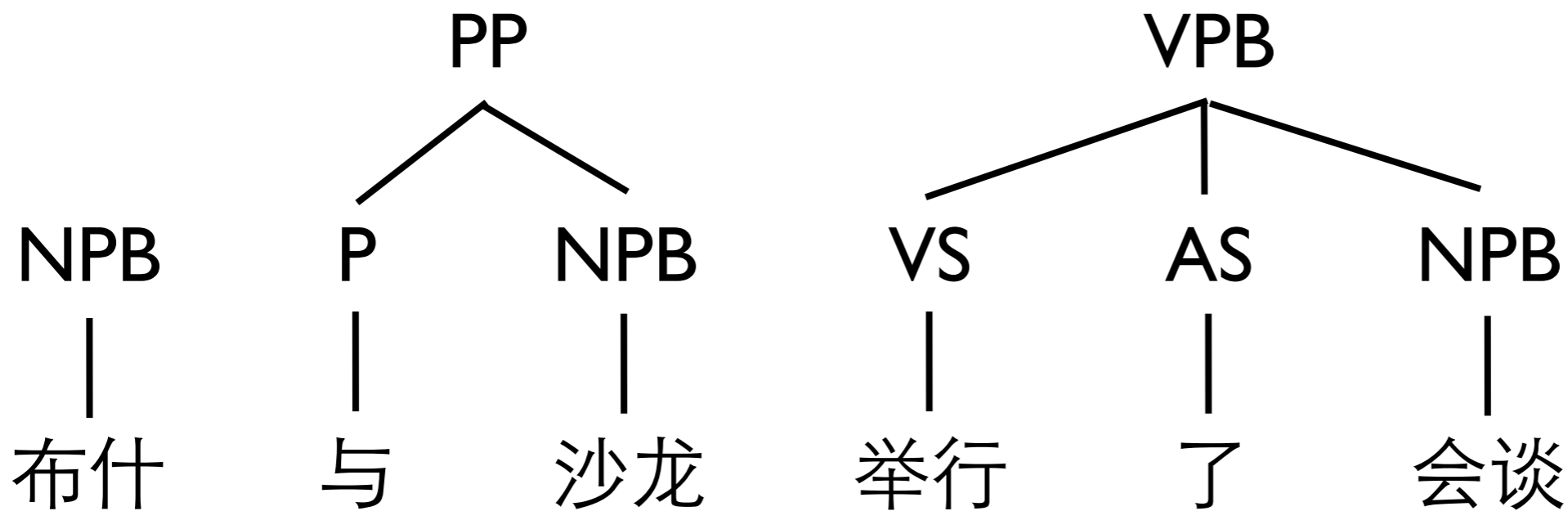


# 联合句法分析和翻译



(Liu and Liu, 2010)

# 联合句法分析和翻译

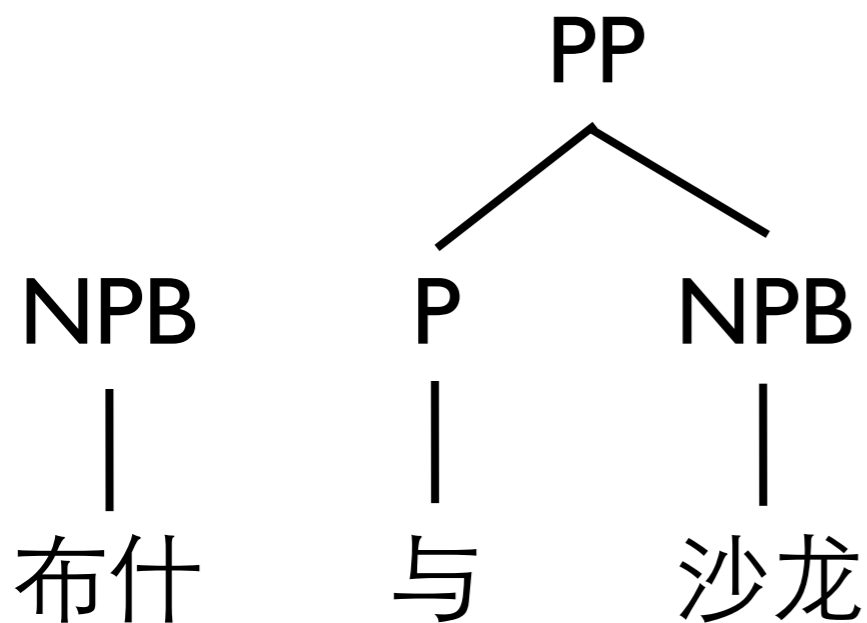
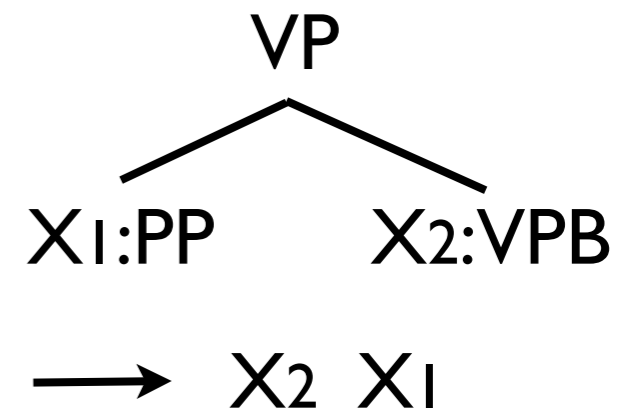


Bush

with Sharon

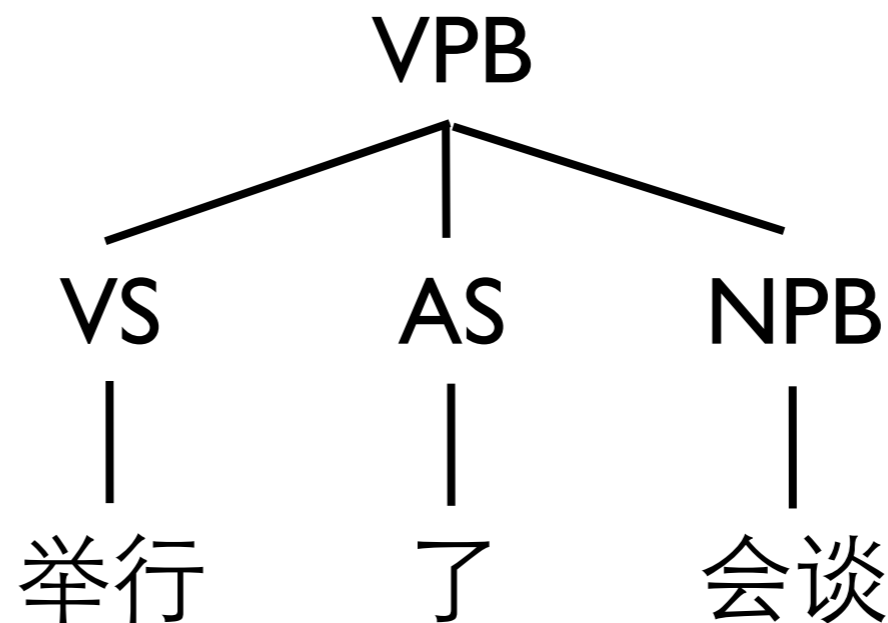
held a talk

# 联合句法分析和翻译



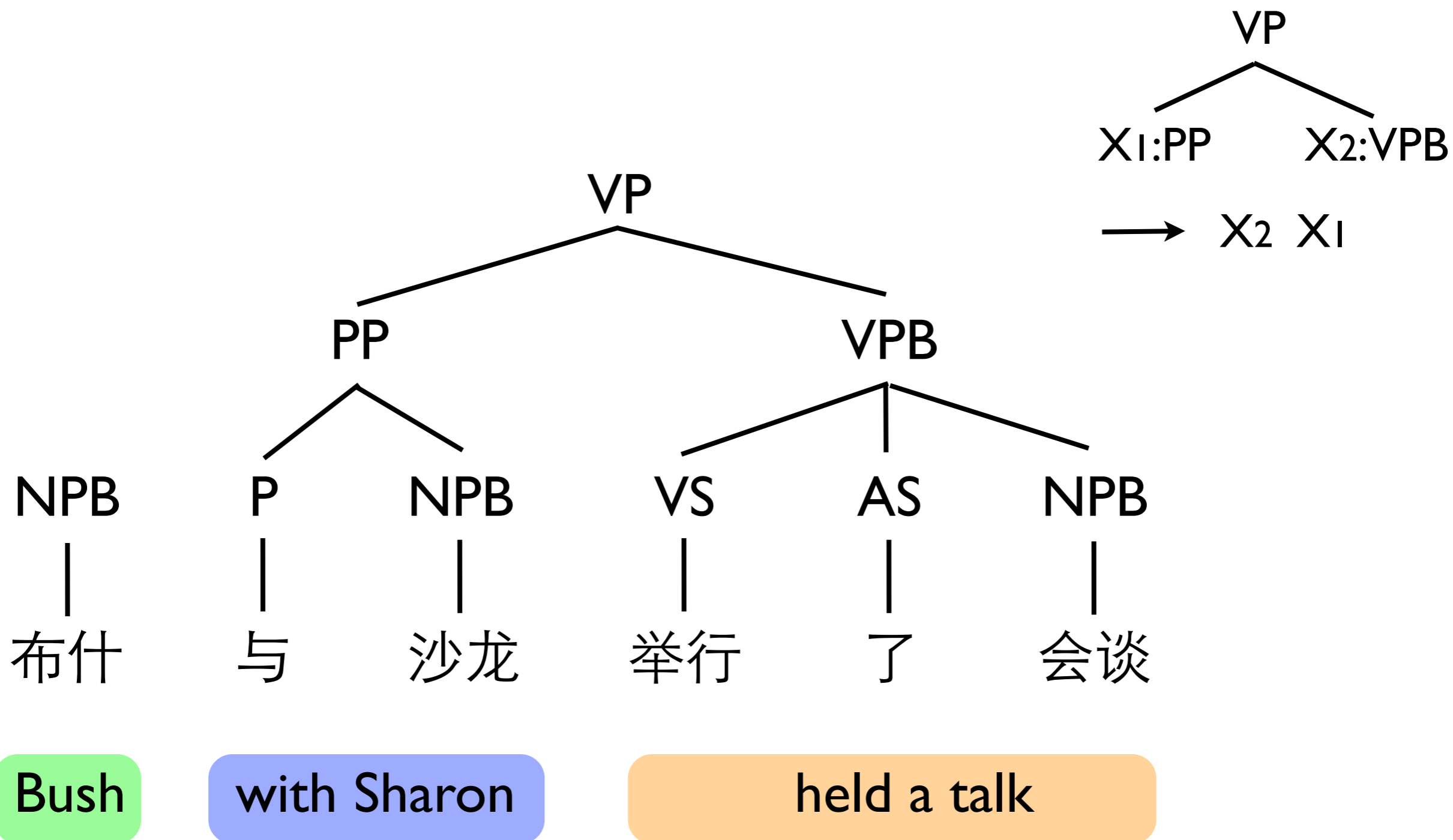
Bush

with Sharon

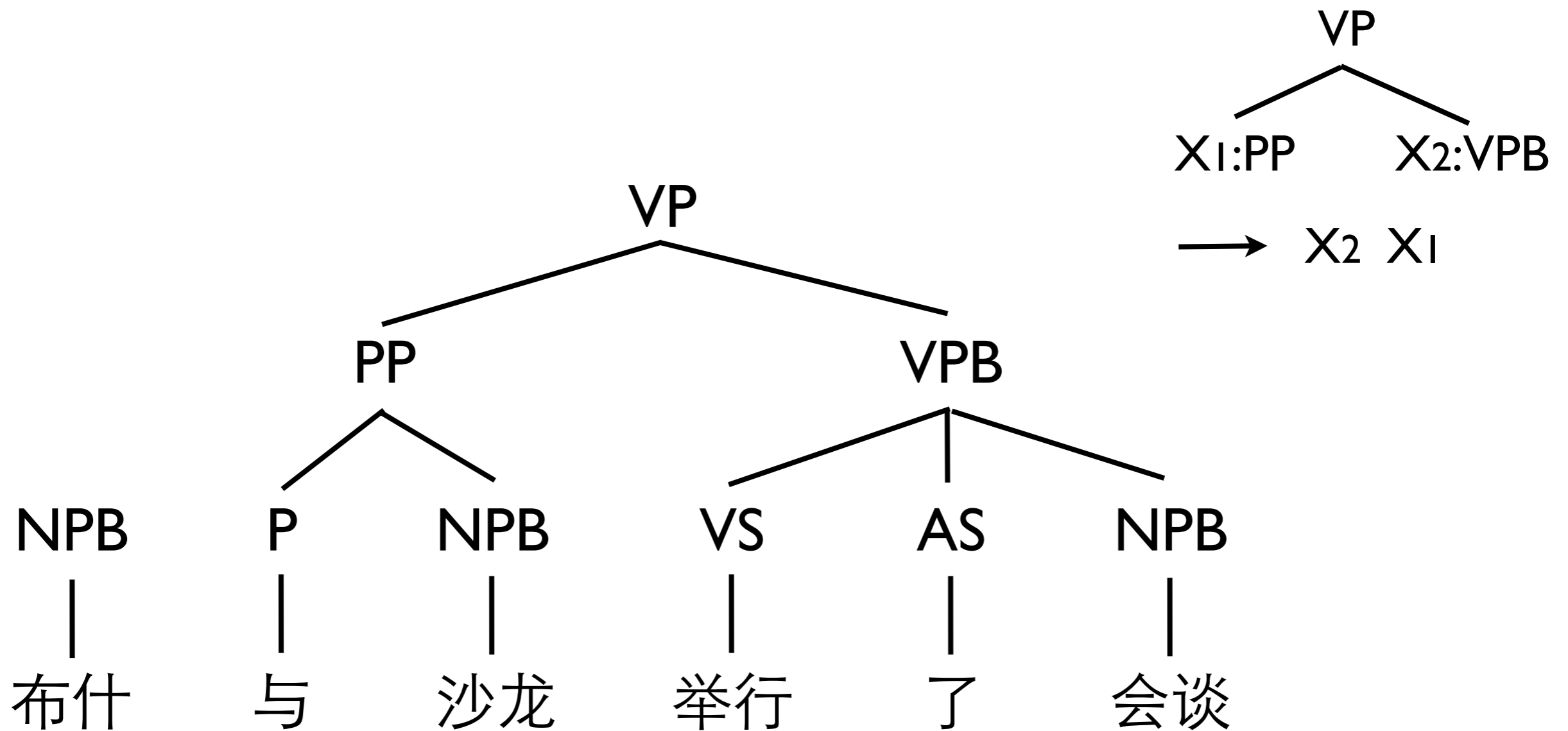


held a talk

# 联合句法分析和翻译

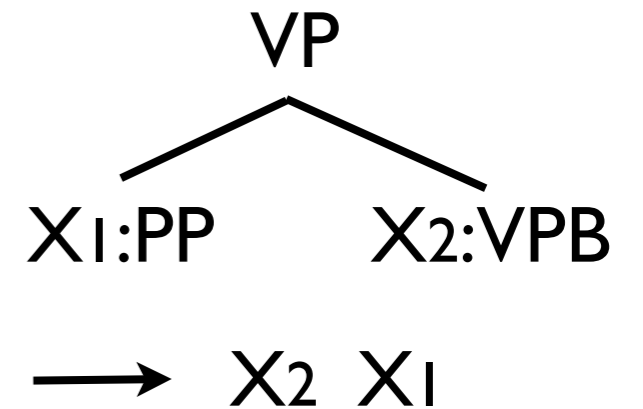
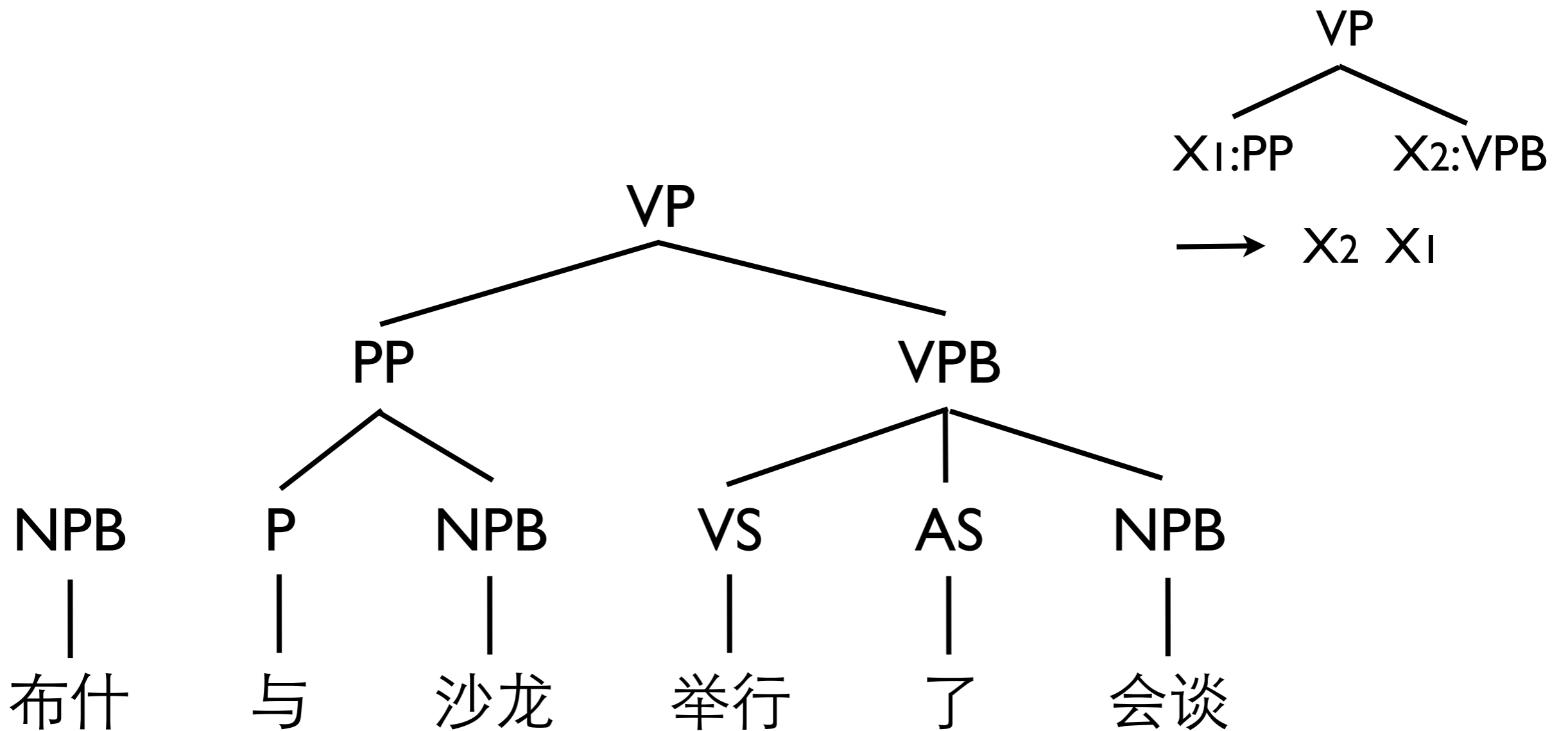


# 联合句法分析和翻译



Bush

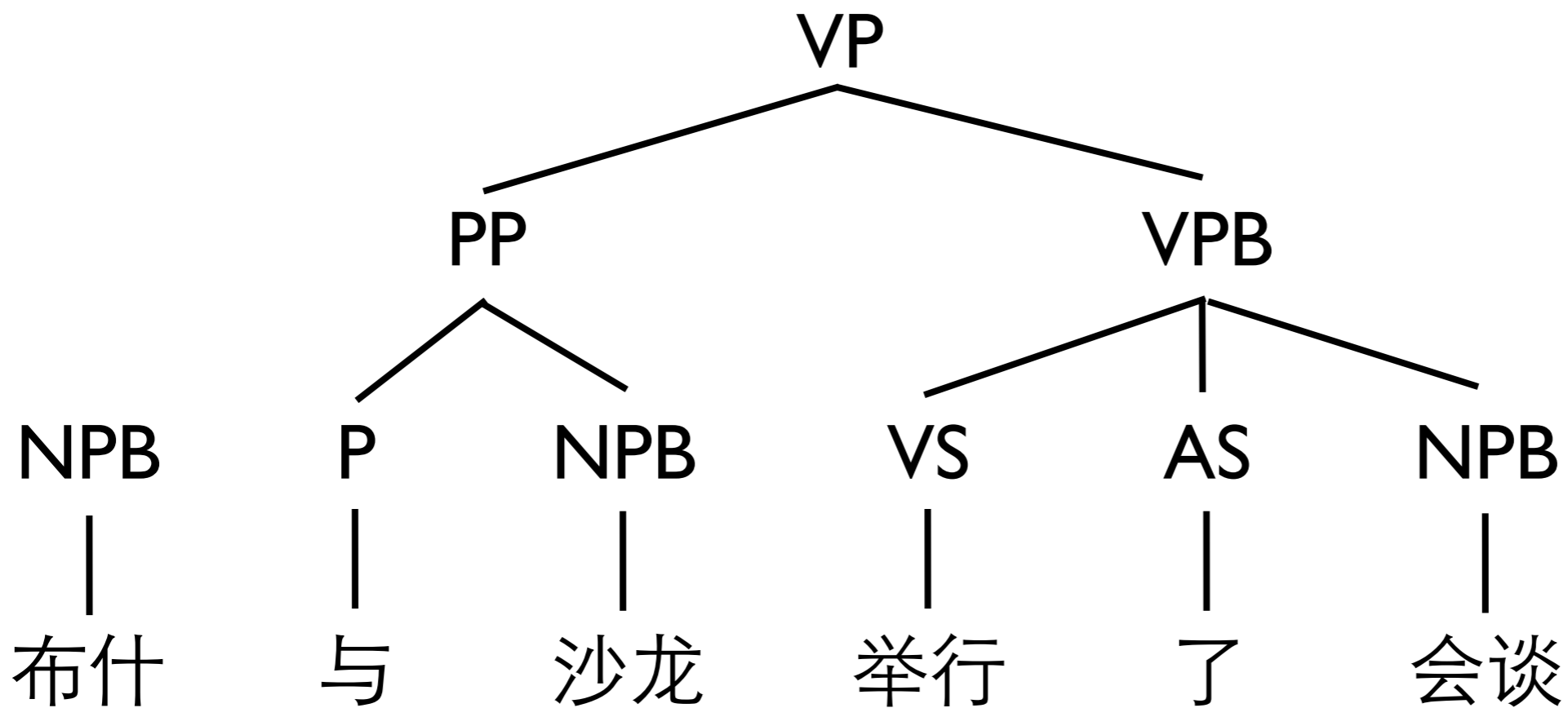
# 联合句法分析和翻译



Bush

held a talk with Sharon

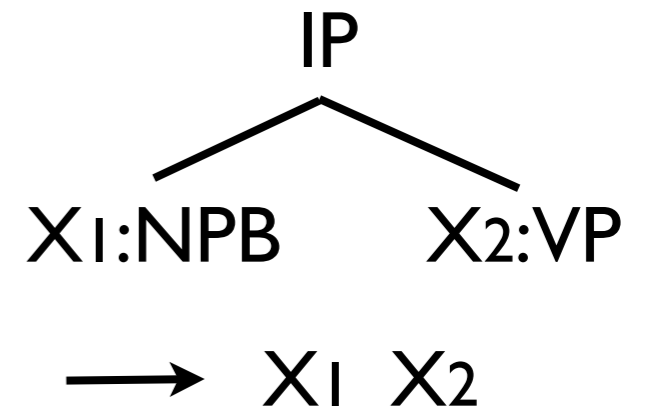
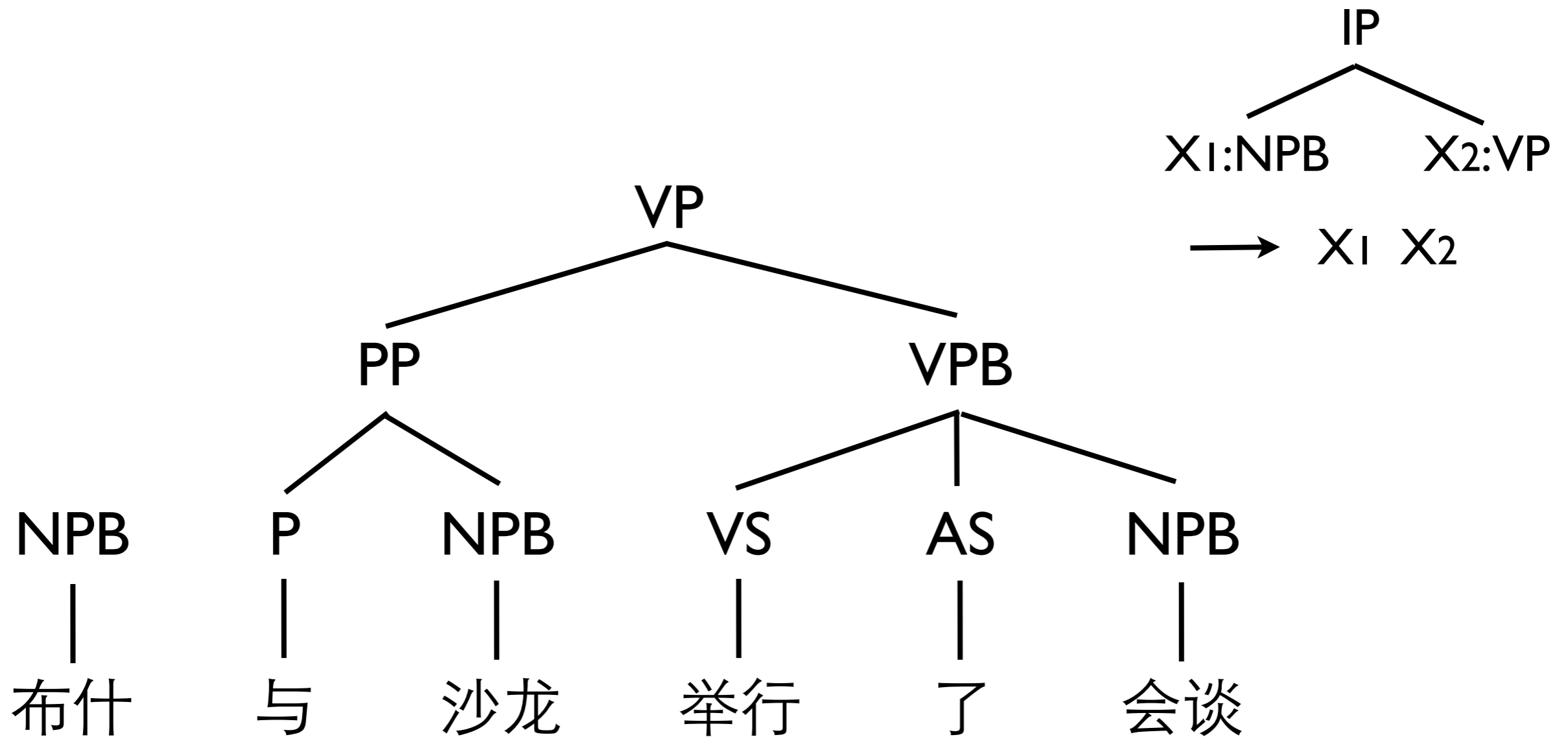
# 联合句法分析和翻译



Bush

held a talk with Sharon

# 联合句法分析和翻译

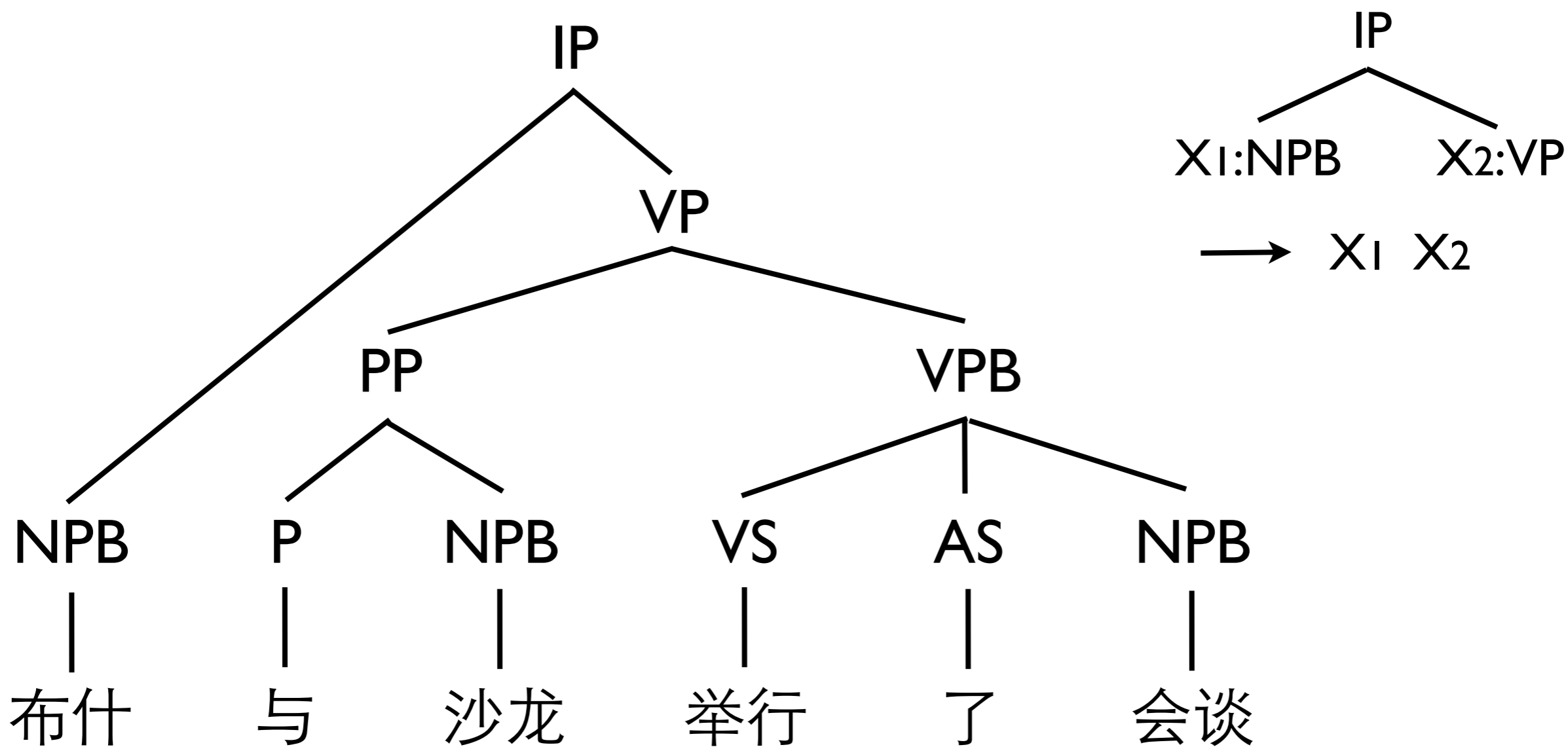


Bush

held a talk with Sharon



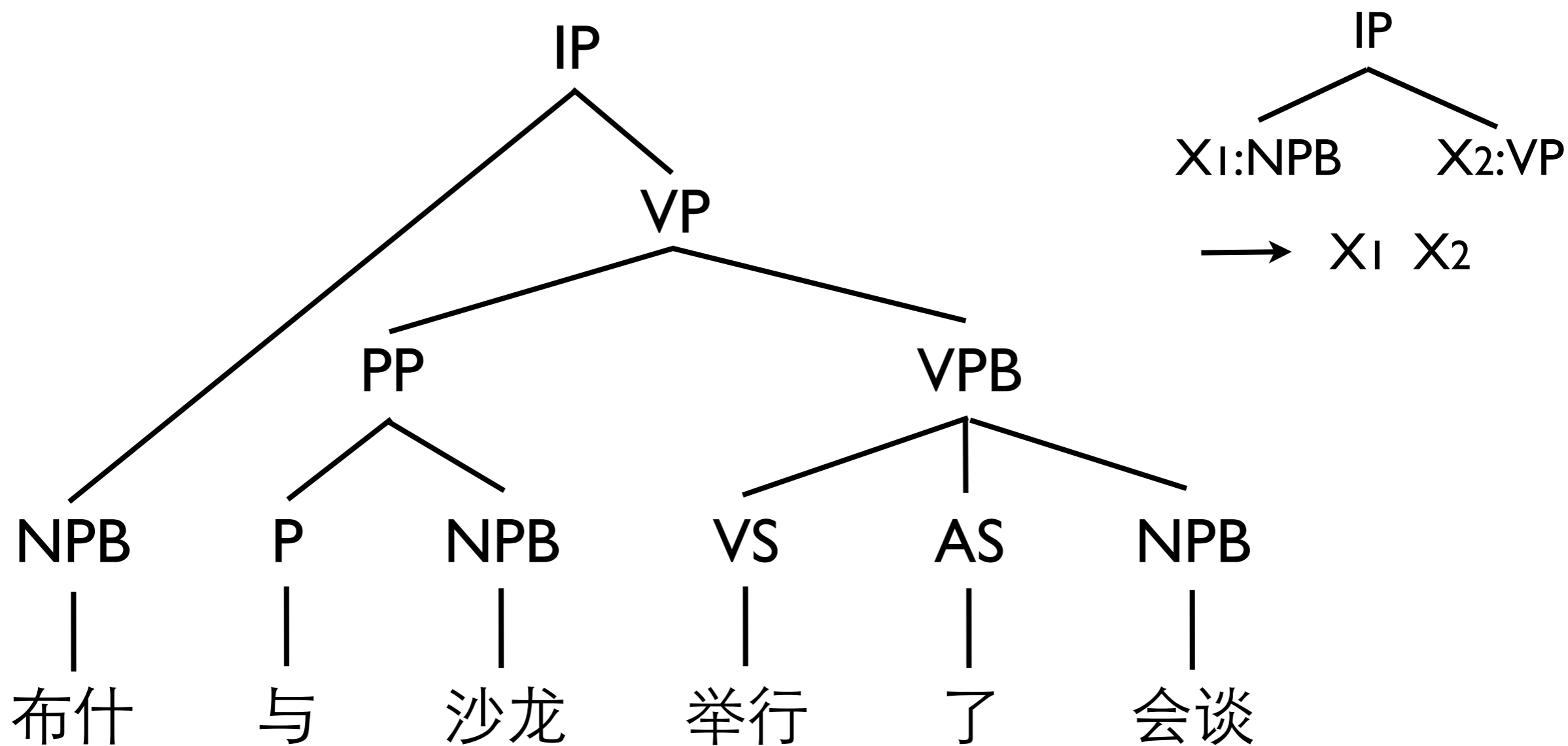
# 联合句法分析和翻译



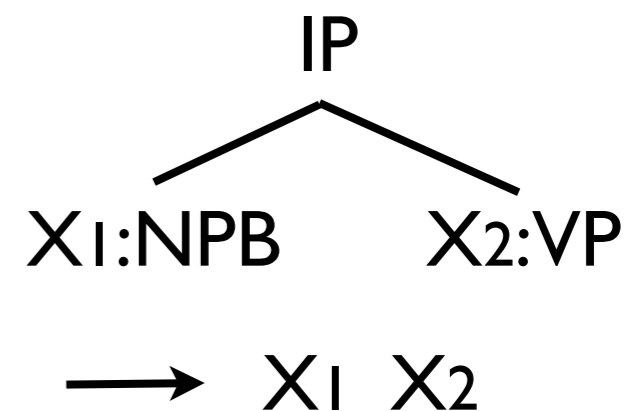
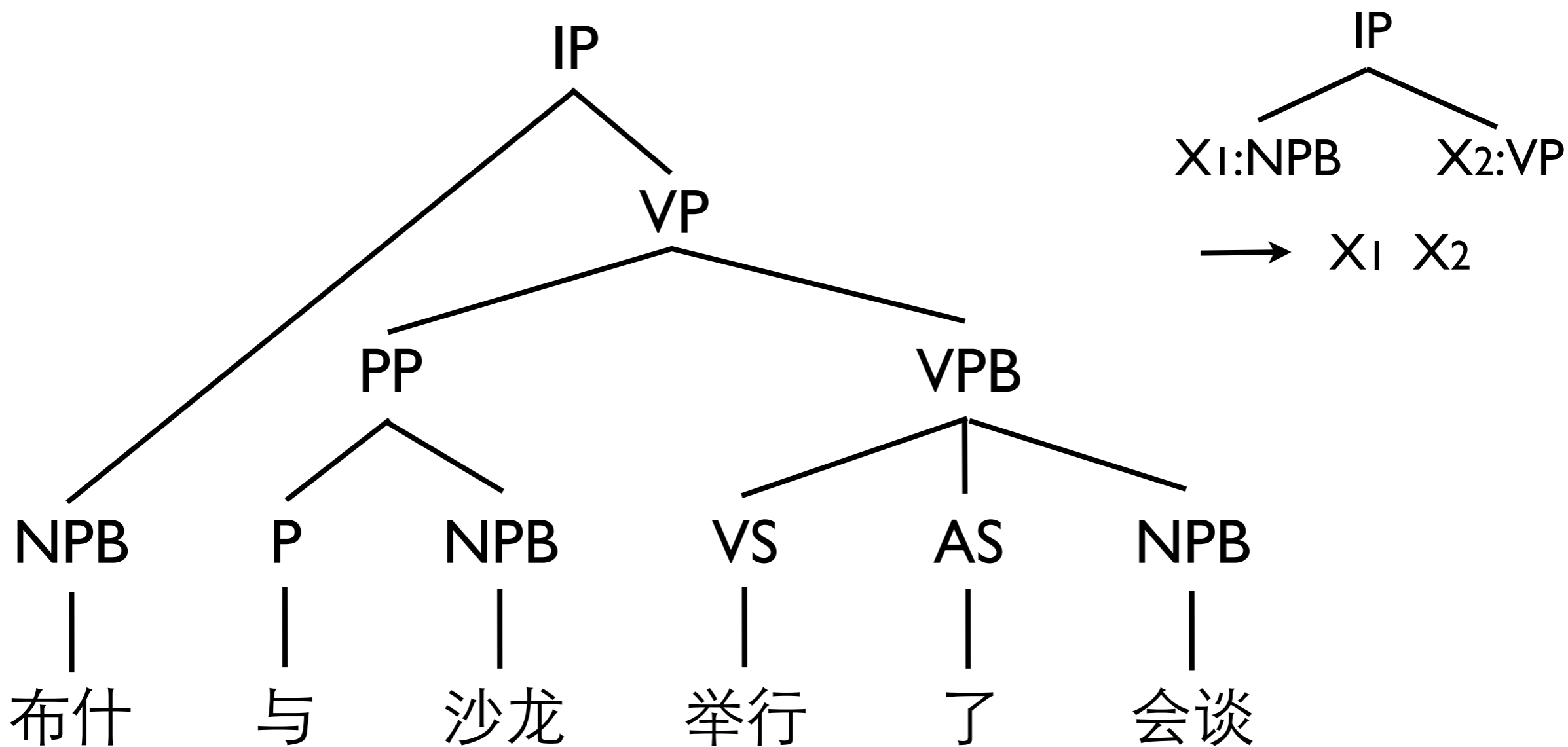
Bush

held a talk with Sharon

# 联合句法分析和翻译



# 联合句法分析和翻译



Bush held a talk with Sharon

# 树到串解码算法对比

输入	翻译质量	翻译速度
树	★☆☆	★★★
森林	★★☆	★★☆
串	★★★	★☆☆

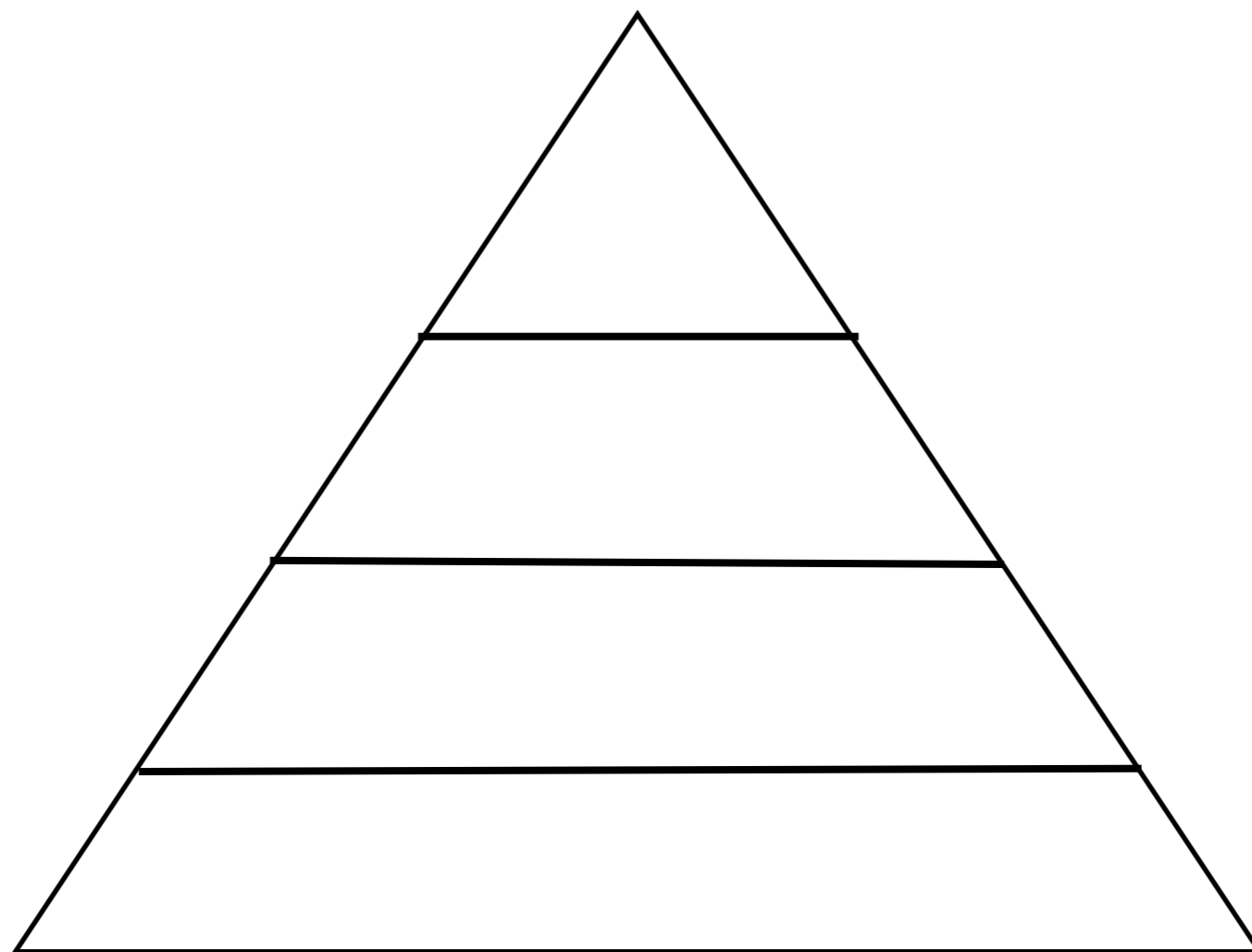
# 未来方向

源语言语义

源语言句法

源语言短语

源语言词语



目标语言语义

目标语言句法

目标语言短语

目标语言词语

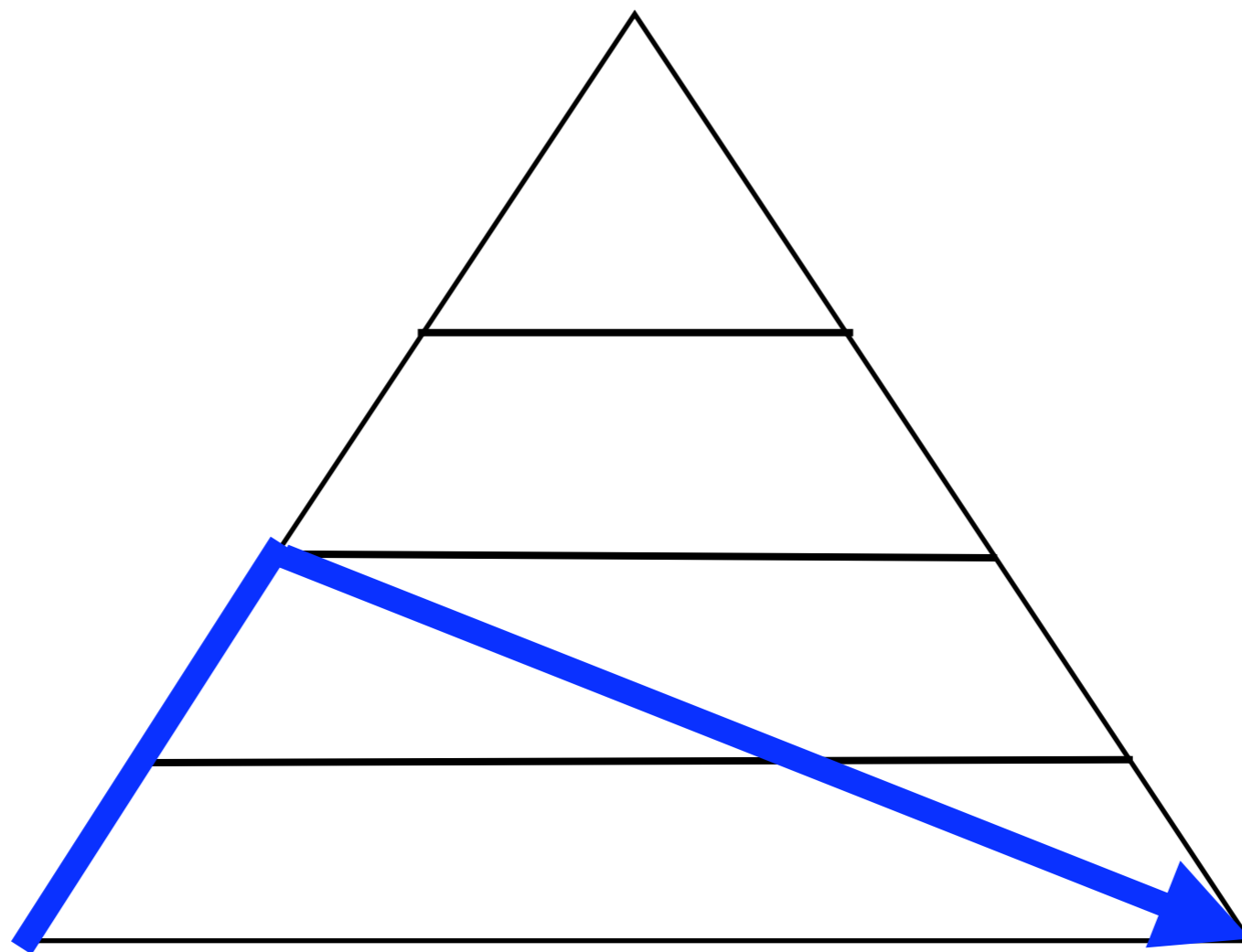
# 未来方向

源语言语义

源语言句法

源语言短语

源语言词语



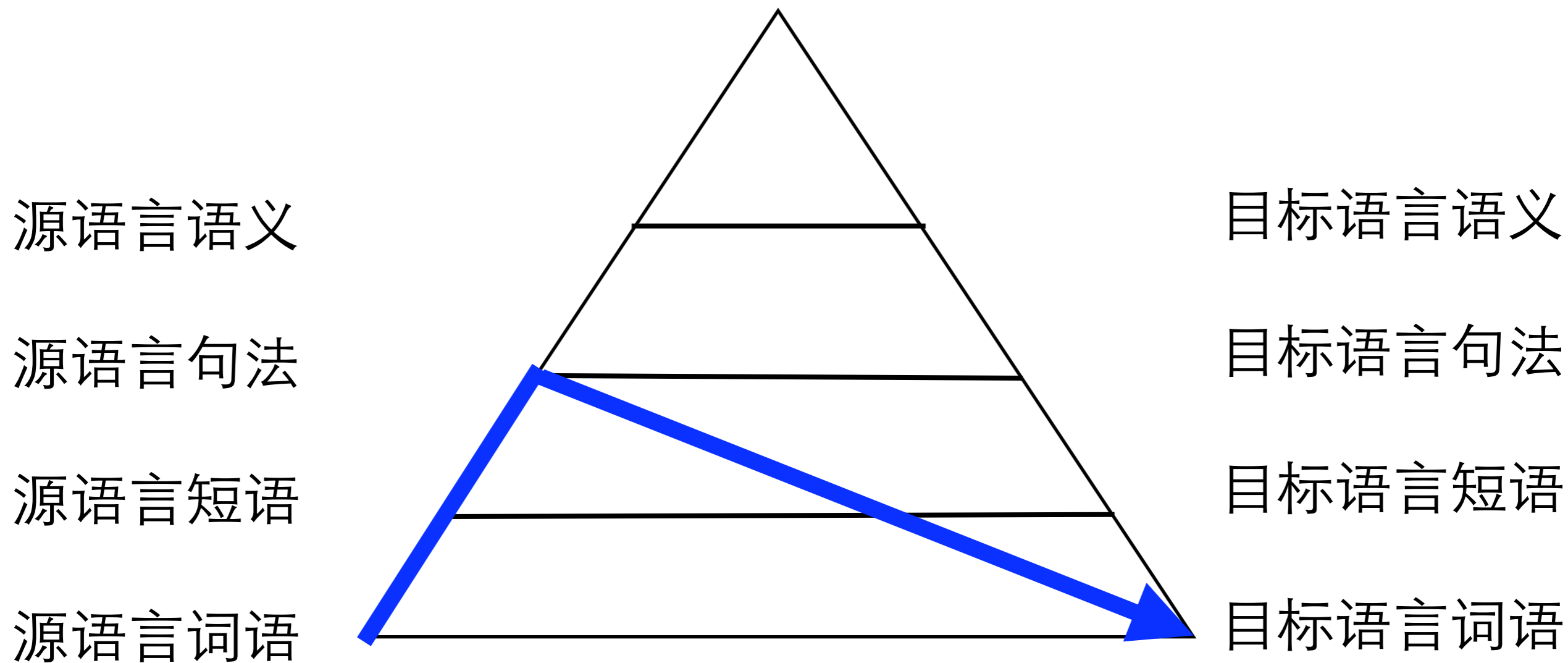
目标语言语义

目标语言句法

目标语言短语

目标语言词语

# 未来方向



在保持自动获取翻译知识的同时  
不断加深语言分析的层次

谢谢！