Word Segmentation and Transliteration in Chinese and Japanese

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Who am I?

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Senior Scientist at Rakuten Institute of Technology, New York

- Ph.D. from Nagoya University (2009)
- Internship at Google and Microsoft Research (2005, 2008)
- R&D Engineer at Baidu, Japan (2009-2010)

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Agenda

Word Segmentation

Transliteration

Integrated Models

Word Segmentation in Chinese and Japanese

Maximum Forward Match

Greedily match longest lexicon items from the beginning (or from the end)

日 文 章 鱼 怎 么 说

How do you say octopus in Japanese?

日 文	章 鱼	怎 么	说
Japanese	octopus	how	say

lexicon

日	(day)
日文	(Japanese)
文章	(article)
章鱼	(octopus)
鱼	(fish)
怎么	(how)
说	(say)

楽R天 RRakuten [Wong and Chan 1996]

Examples Where Maximum Match Fails

警 察 枪 杀 了 那 个 逃 犯

警 察	枪 杀	了	那	个	逃 犯
Police	gun-kill	(*perf*.)	that	(*mes*.)	escapee

警 察 用 枪 杀 了 那 个 逃 犯

Police with gun kill (*perf.*) that escapee

警 察	用	枪 杀
Police	with	gun-kill

？？？

- Heuristic rules
- “Word Binding” Scores

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Heuristic Approaches – Minimum Bunsetsu Number

今 日 本 当 に 良 い 天 気 で す ね

今 日	本 当 に	良 い	天 気	で す	ね
Today	really	good	weather	is	(*part.*)

# of Bunsetsu = 4

今	日 本	当 に	良 い	天 気	で す	ね
Now	Japan	really	good	weather	is	(*part.*)

# of Bunsetsu = 5

今　　n. (now)
今日　　n (today)
...

lexicon

Optimizes for a whole sentence

楽R天　RRakuten　[Yoshimura et al. 1983]

What is Bunsetsu?

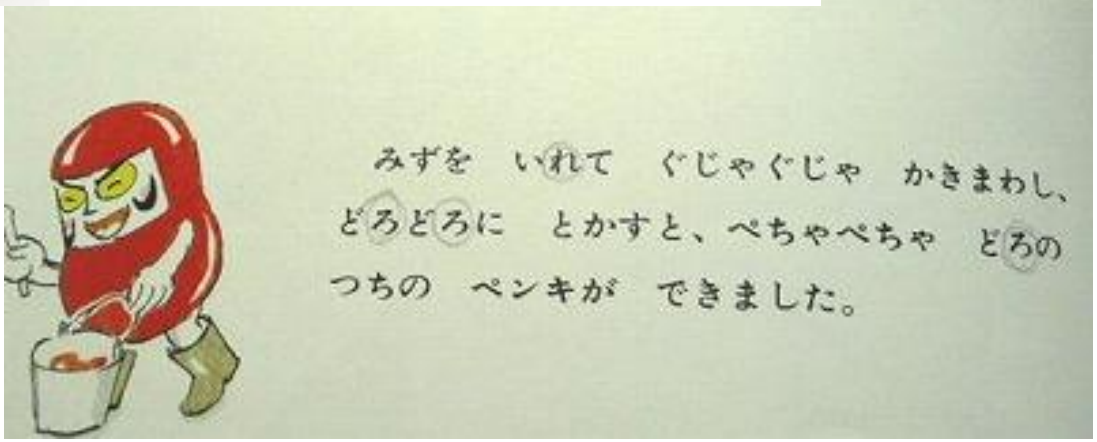
'용베어'는, 병실의 도어를 살그머니 열었습니다.
작은 아기가,
신체중에 관을 가득 붙여 자고 있습니다.

침대의 옆에는,
걱정일 것 같은 얼굴을 하고 있는 아버지와 엄마.
'마아훈'이 눈을 뜨는 것을
지금인가 지금일까하고 기다리고 있습니다.

수술은 끝났지만,
의사는 어려운 얼굴을 하고 있었습니다.

앞으로도 쭉,
'마아훈'은 병과 함께
살아가지 않으면 안 됩니다.

6



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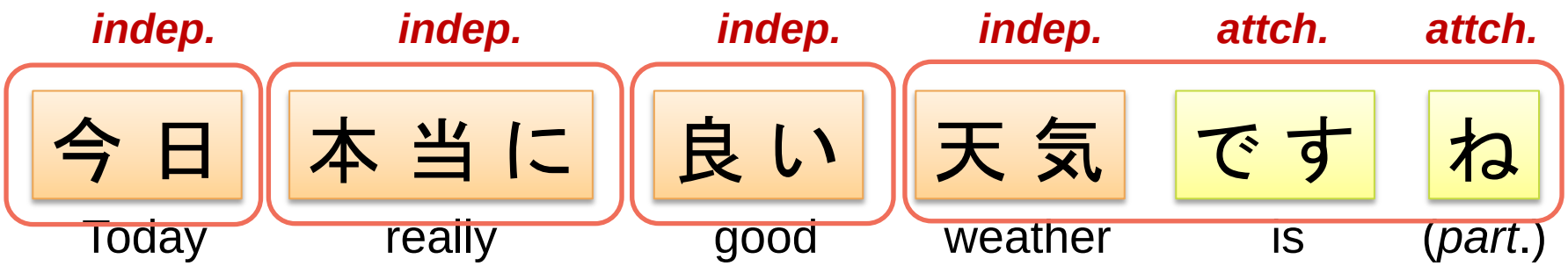
Minimum Bunsetsu Number

Bunsetsu (文節) = [indep. word] [attch. word]*



# of Bunsetsu = 4

$$\min \sum_{w} cost(w)$$

where

$$cost(w) = \begin{cases} 1 & w \text{ is an indep. word} \\ 0 & w \text{ is an attch. word} \end{cases}$$

A Special Case of Minimum Cost Methods

楽天 Rakuten [Yoshimura et al. 1983]

Word-based Models

lexicon

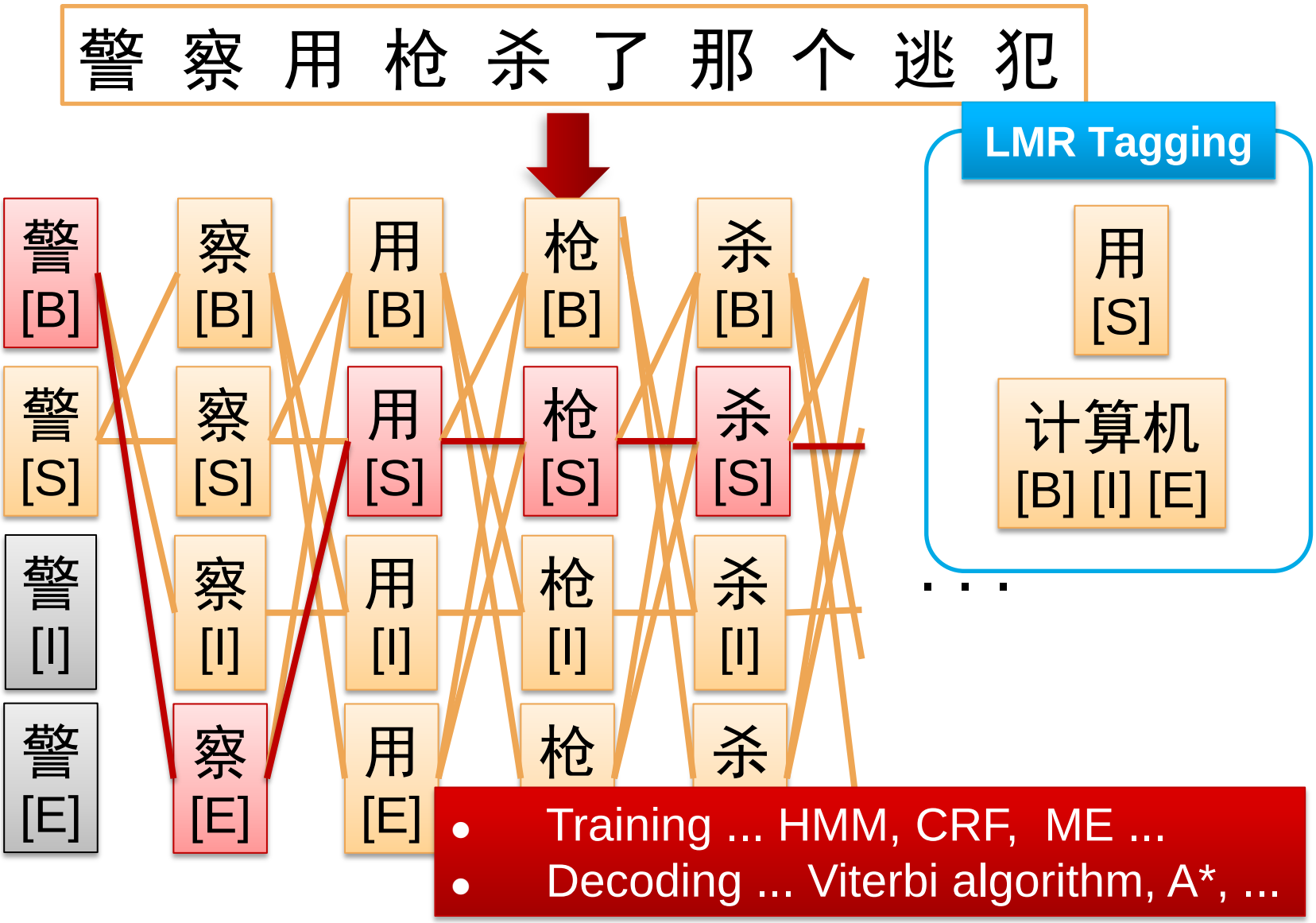
東 (east) pre.
東京 (Tokyo) n.
京 (capital) n.
京都 (Kyoto) n.
都 (Pref.) suf.
に (in) p.
住む (live) v.

$$\min \sum_{i=1}^{N} [cost_1(w_i) + cost_2(w_{i-1}, w_i)]$$

- Training ... HMM, Perceptron, CRF, ...
- Decoding ... Viterbi algorithm, A*, ...

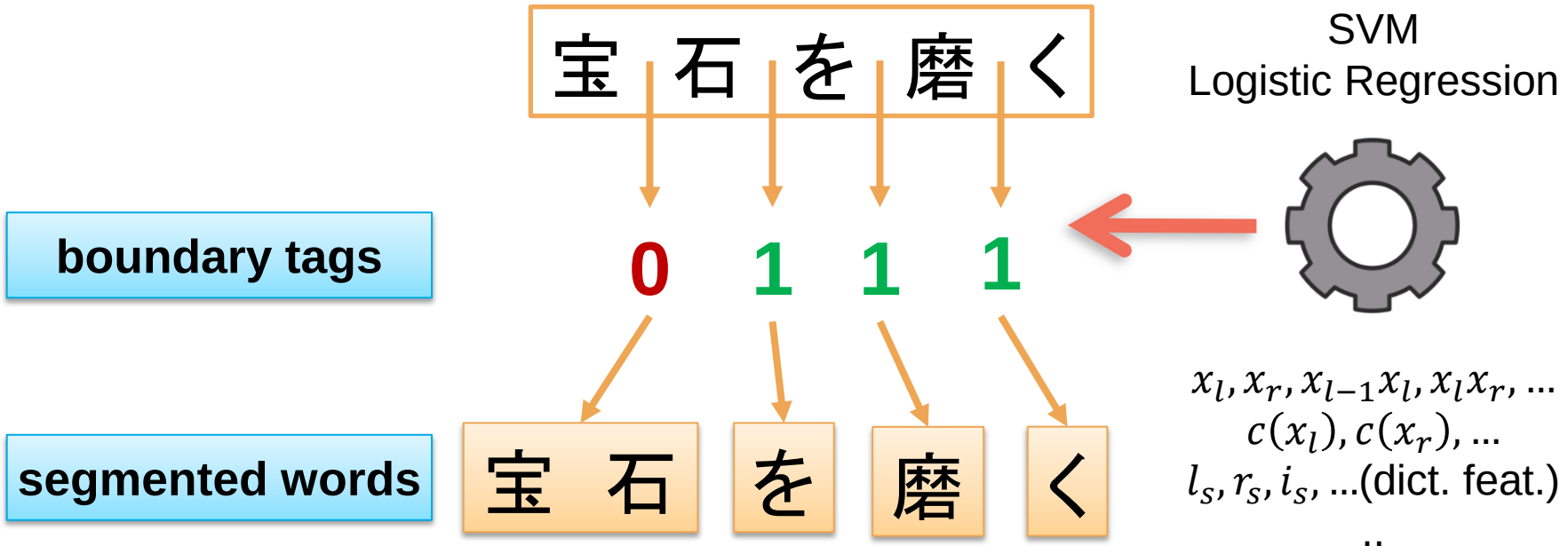
楽天 Rakuten [Kudo et al. 2004]

Character-based Models 1 – Character Tagging



[Xue and Shen 2003] [Peng et al. 2004]

Character-based Models 2 – “Boundary” Tagging

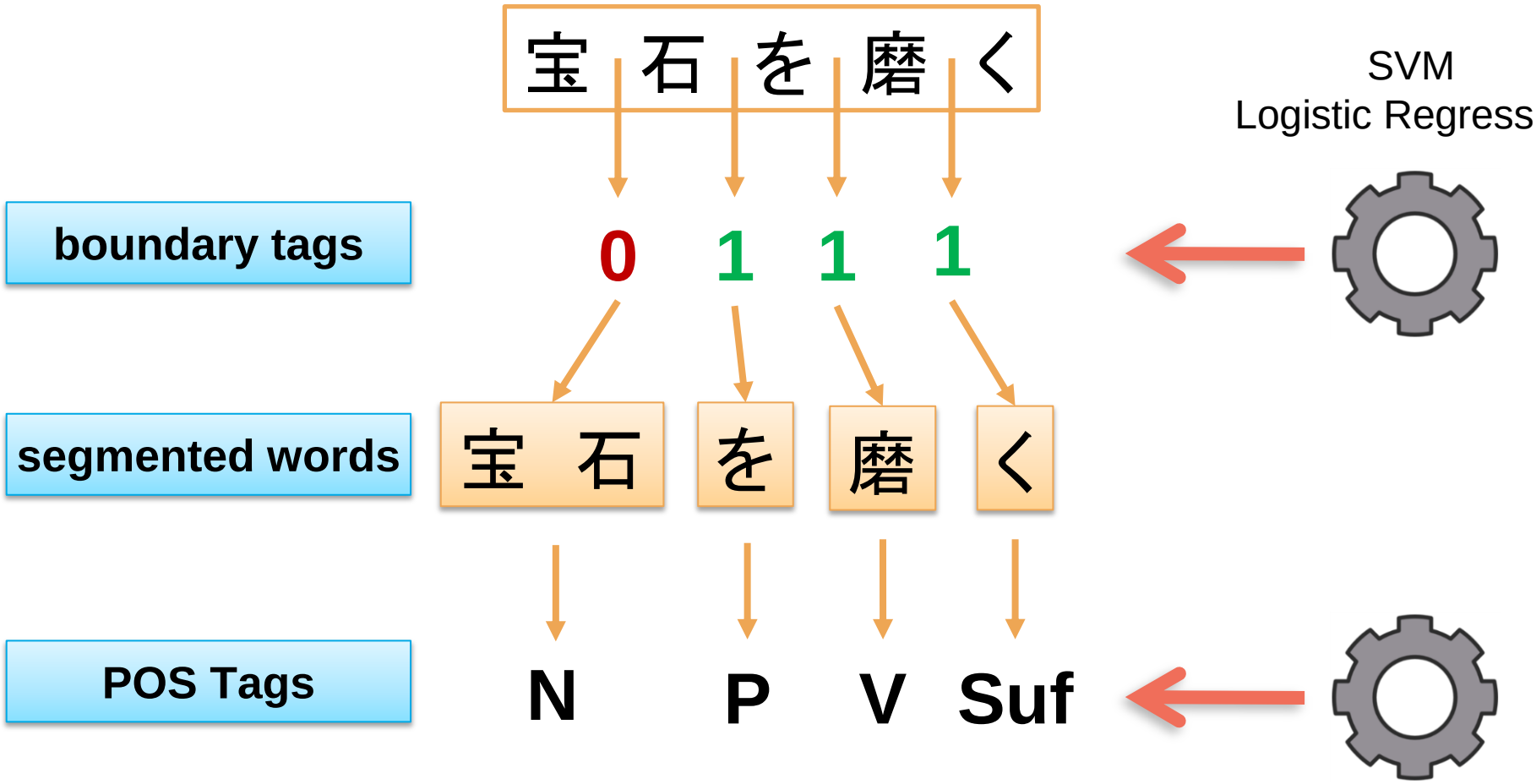


Boundary Decisions ... Independent from each other

“Gains provided by structured prediction can be largely recovered by using a richer feature set.” [Liang et al. 2008]

楽天 Rakuten [Neubig et al. 2011]

One-at-a-Time PoS Tagging Models



Enables Domain Adaptation through Partial Annotation

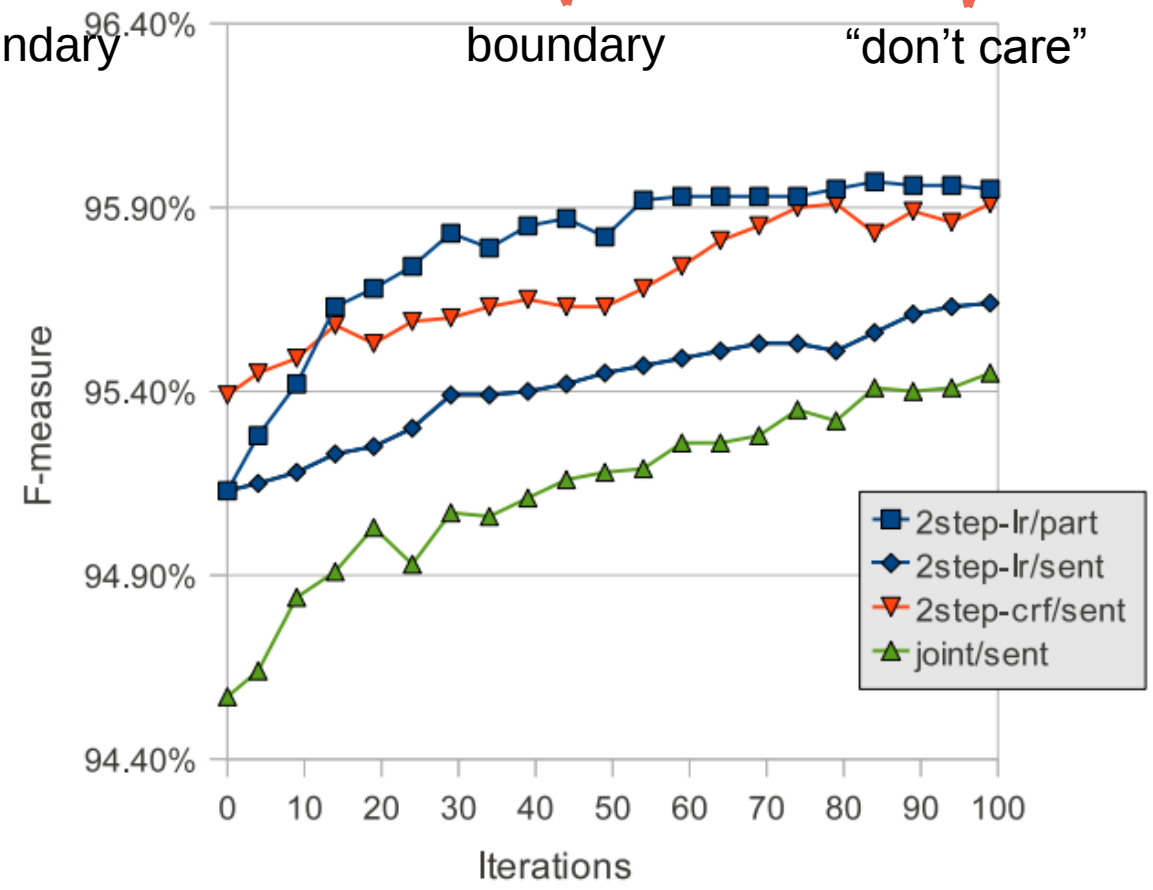
楽天 Rakuten [Neubig et al. 2011]

Pointwise Approaches and Active Learning

partial annotation

| ア-ク-チ-ン|フ-ィ-ラ-メ-ン-ト|は|細 胞 内 小 器 官|の|1|つ|だ|

non-boundary　　boundary　　“don’t care”



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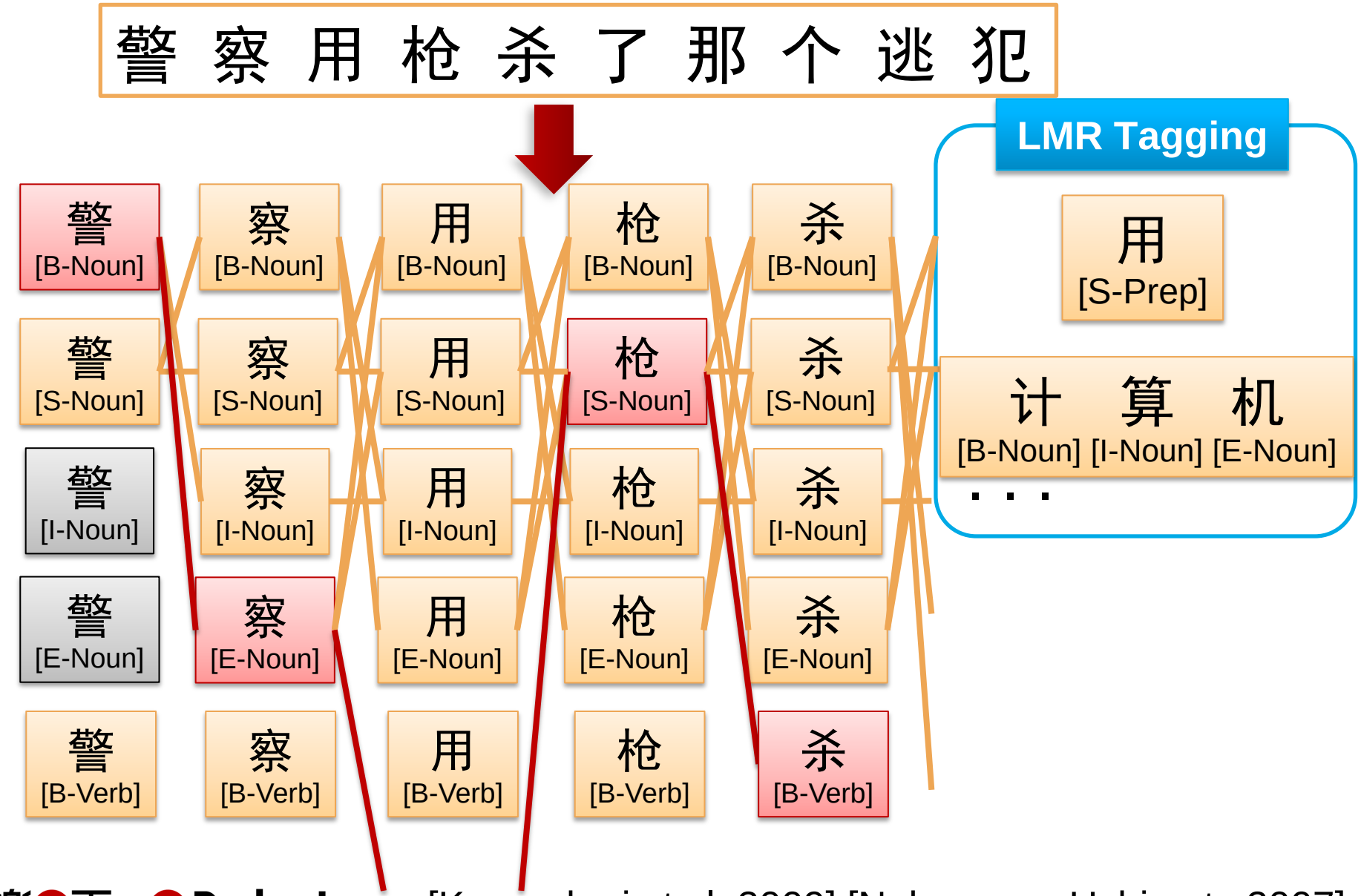
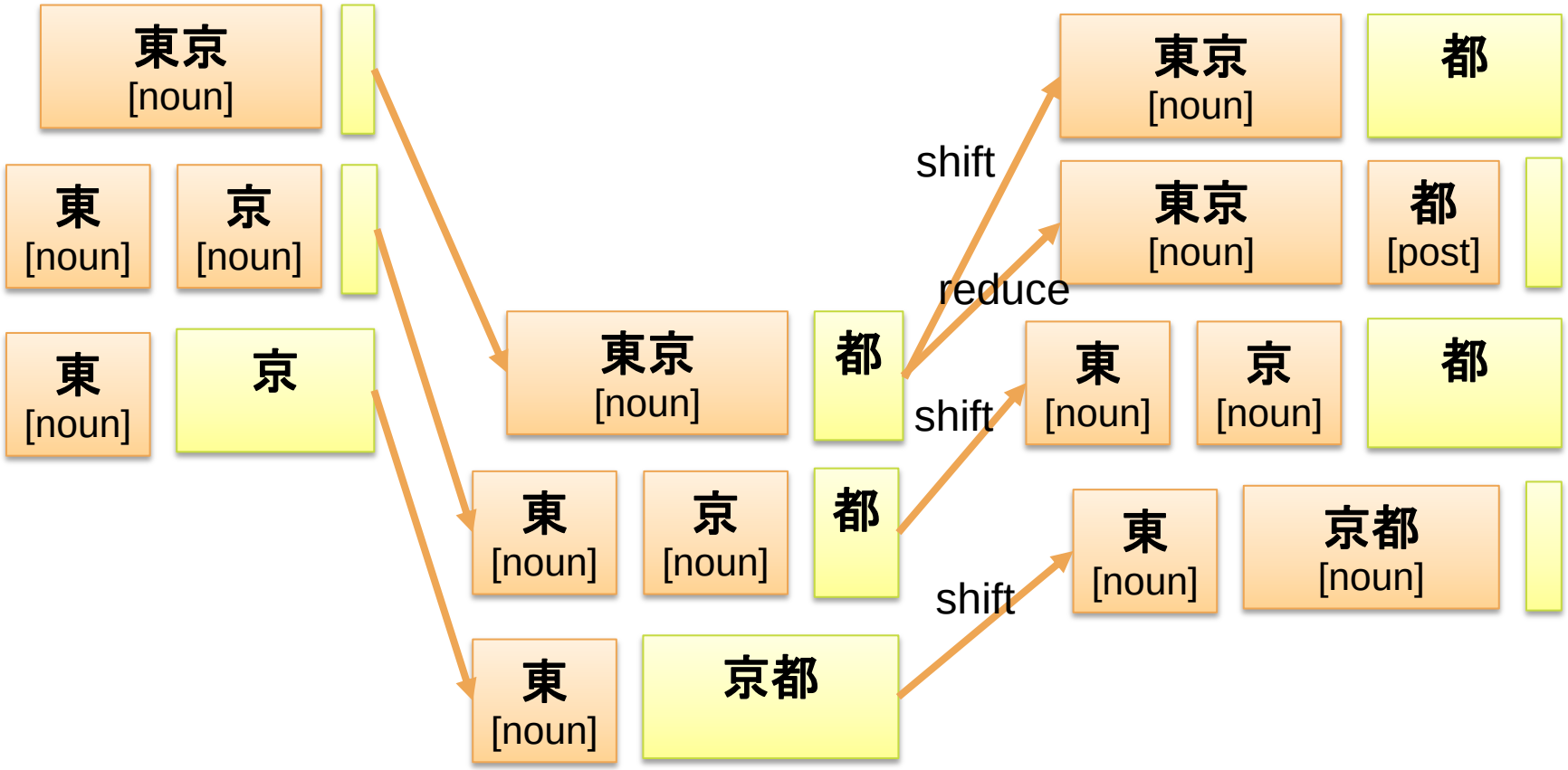
Character-based Joint Models



楽天 Rakuten [Kruengkrai et al. 2009] [Nakagawa+Uchimoto 2007]

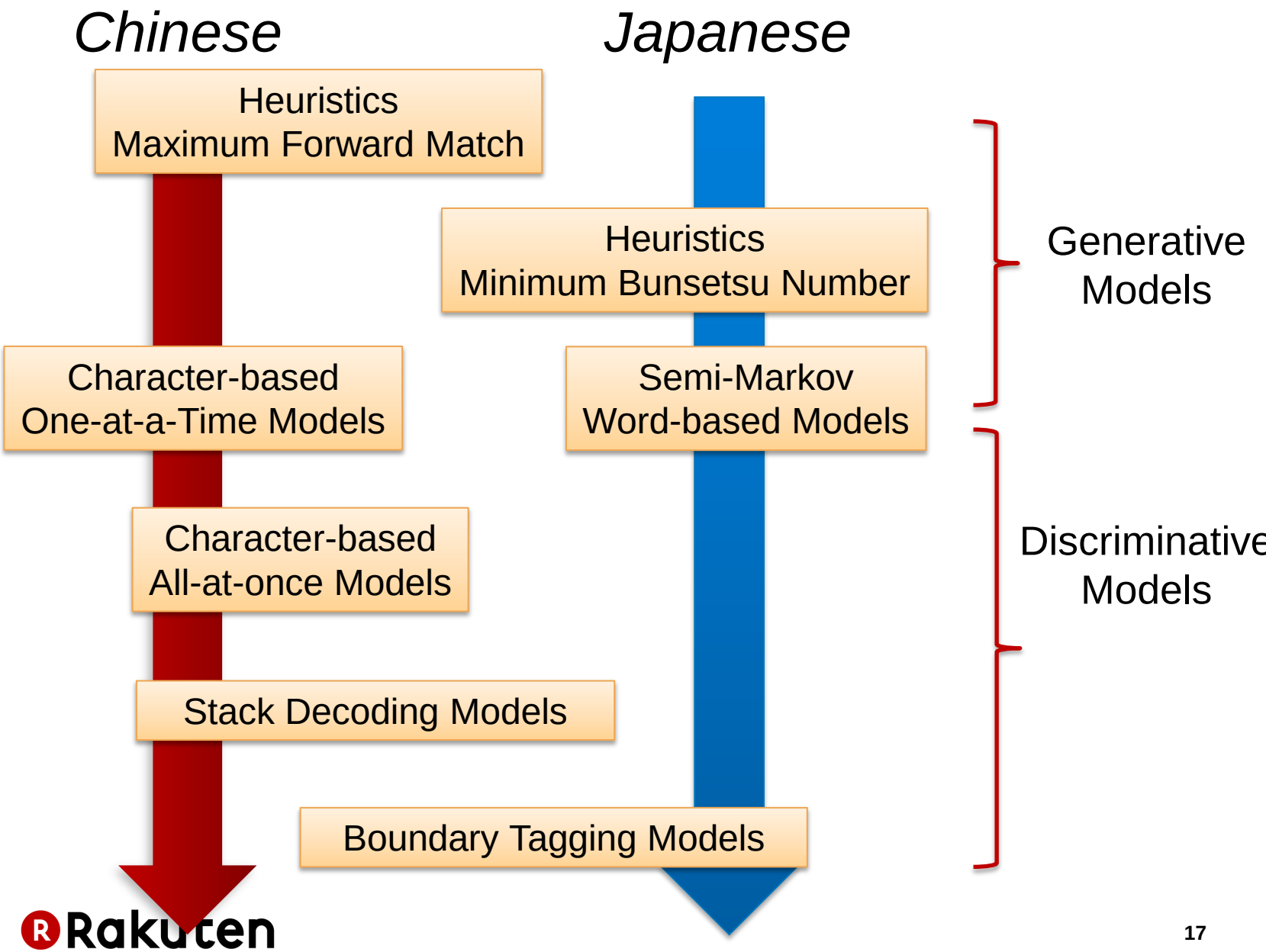
Stack Decoding Models



- No distinction between known and unknown words
- Flexible sets of features (e.g., long distance constraints)

楽天 Rakuten [Zhang, Clark 2008] [Okanohara, Tsujii 2008]

Chinese/Japanese WS Evolution



Chinese/Japanese WS Evolution

Heuristics	*Statistics*
	→ ***Statistics***
Word-based	*Character-based*
	→ ***Ja: word, Zh: character***
Pipeline	*Joint*
(One-at-a-time)	*(All-at-Once)*
	→ ***Joint***
Generative	*Discriminative*
	→ ***Discriminative***
Viterbi	*Stack Decoding*
	→ ***Pros and Cons***

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Transliteration
(“Semantic” Transliteration Models)

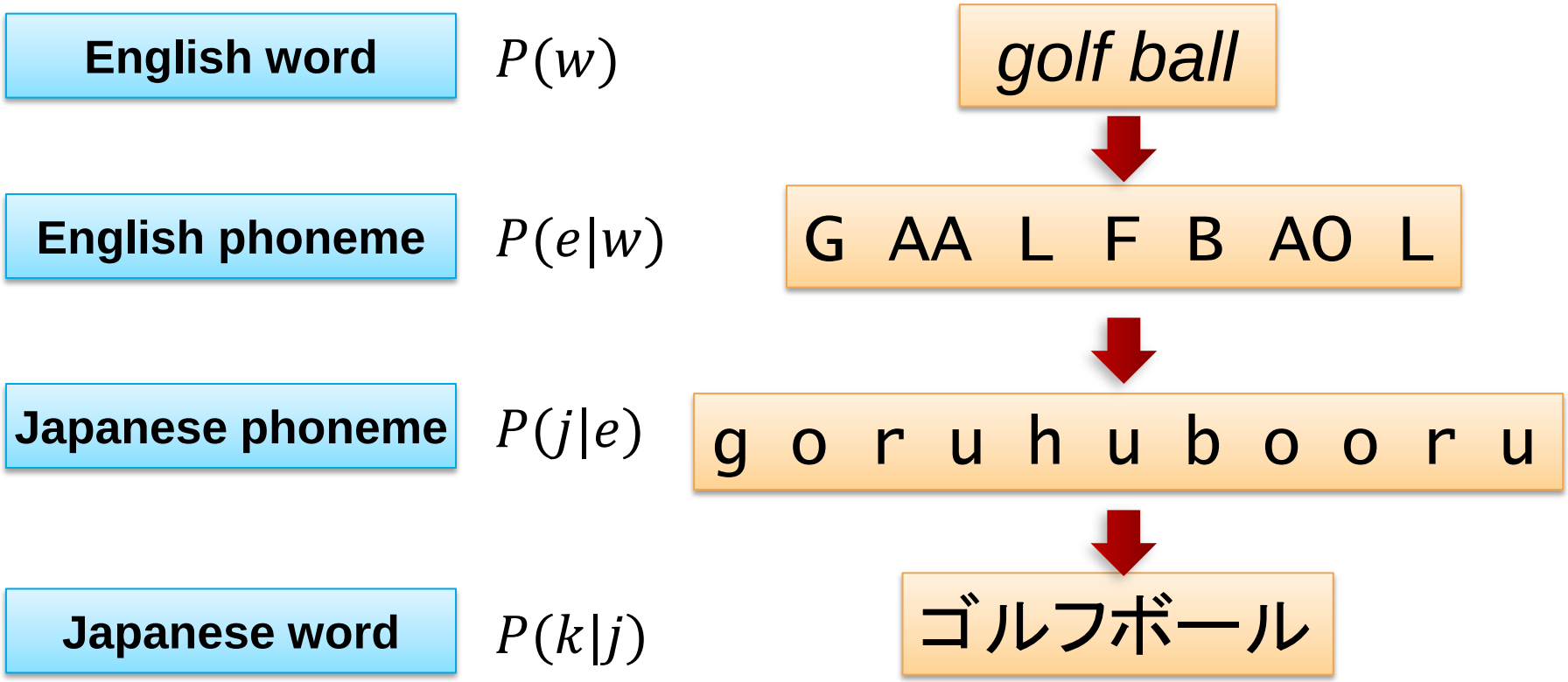
Transliteration

Phonetic translation between languages with different writing systems

New York / 纽约 *niuyue* / ニューヨーク *nyuuyooku*

Obama / 奥巴马 *aobama* / オバマ *obama*

Phoneme-based Methods



Trains a large WFST (from Japanese to English words)

$$P(w)P(e|w)P(j|e)P(k|j)$$

楽天 Rakuten [Knight and Graehl 1998]

Direct Orthographical Mapping

Joint Source Channel Model

Transliteration Prob. = Prod. of TU n-gram probs.

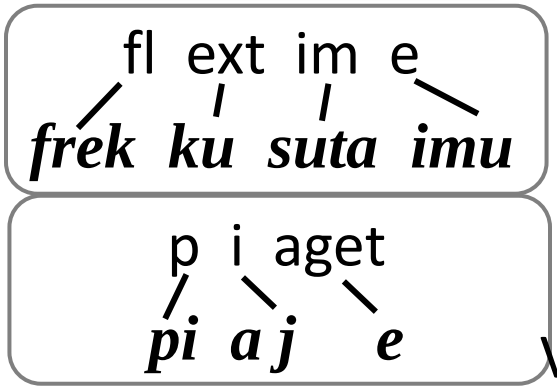
$$P_{JSC}(\langle s,t\rangle) = \prod_{i=1}^{f} P(u_i|u_{i-n+1},\ldots,u_{i-1})$$

P(flextime→***furekkusutaime***)

= P(f→***fu***|BOW) × P(le→***re***|f→***fu***) × P(x→***kkusu***|le→***re***) × …

TU Probability Estimation

Current Alignment



Freq.→Prob.

EM Algorithm

Viterbi Algorithm

TU Probability Table

P(fl→***flek*** | ▪) = XXX

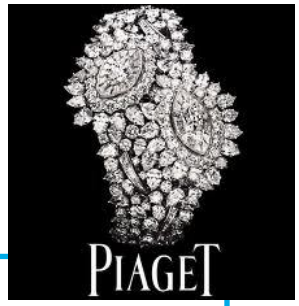
P(ext→***ku*** | ▪) = YYY

P(p→***pi*** | ▪) = ZZZ

…

楽天 Rakuten [Li et al. 2004]

Multiple Language Origins



piaget / *piaje* ピアジェ
target / *taagetto* ターゲット

→ French origin / English origin → French model / English model

亚历山大 Yalishanda / Alexander
山本 Yamamoto / Yamamoto

→ Indo-European origin / Japanese origin → Chinese Transliteration Model / Japanese Reading Model

Marian / Malian 玛丽安
Marino / Malinuo 马里诺

→ Female name / Male name → Female model / Male model

楽天 Rakuten [Li et al. 2007]

Latent Class Transliteration

Class transliteration [Li et al. 2007]

$$P_{LI}(\boldsymbol{t}|\boldsymbol{s}) = \sum_{c} P(\boldsymbol{t}, c|\boldsymbol{s}) = \sum_{c} P(c|\boldsymbol{s}) P(\boldsymbol{t}|c, \boldsymbol{s})$$

Explicit language detection

s: source

t: target

Latent Class Transliteration [Hagiwara&Sekine 2011]

$$P_{\mathrm{LST}}(\langle \boldsymbol{s}, \boldsymbol{t} \rangle) = \sum_{z=1}^{K} P(z) \prod_{i=1}^{f} P(u_i|z)$$

Latent class distribution

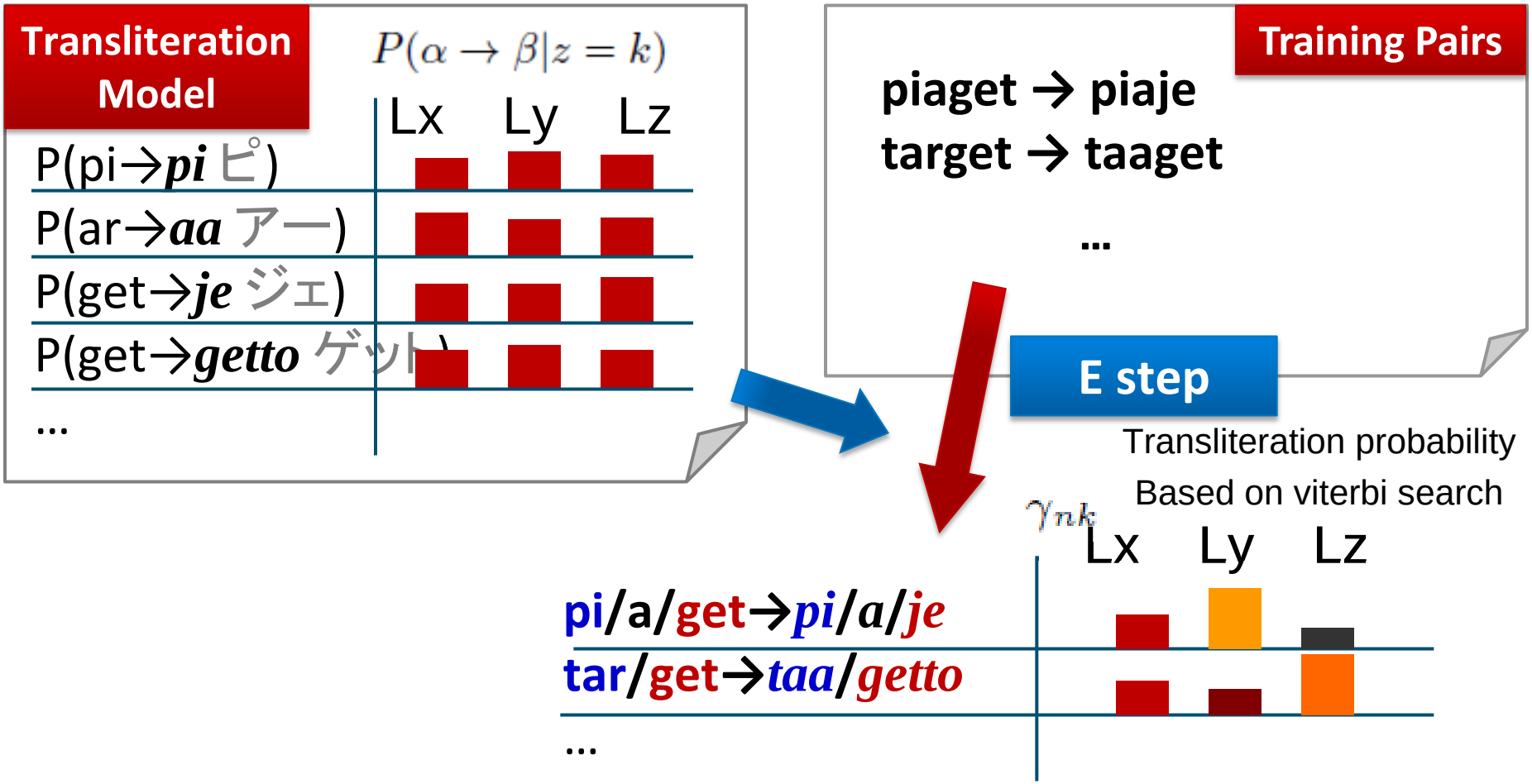
z: latent class

K: # of latent classes

(determined using dev. sets)

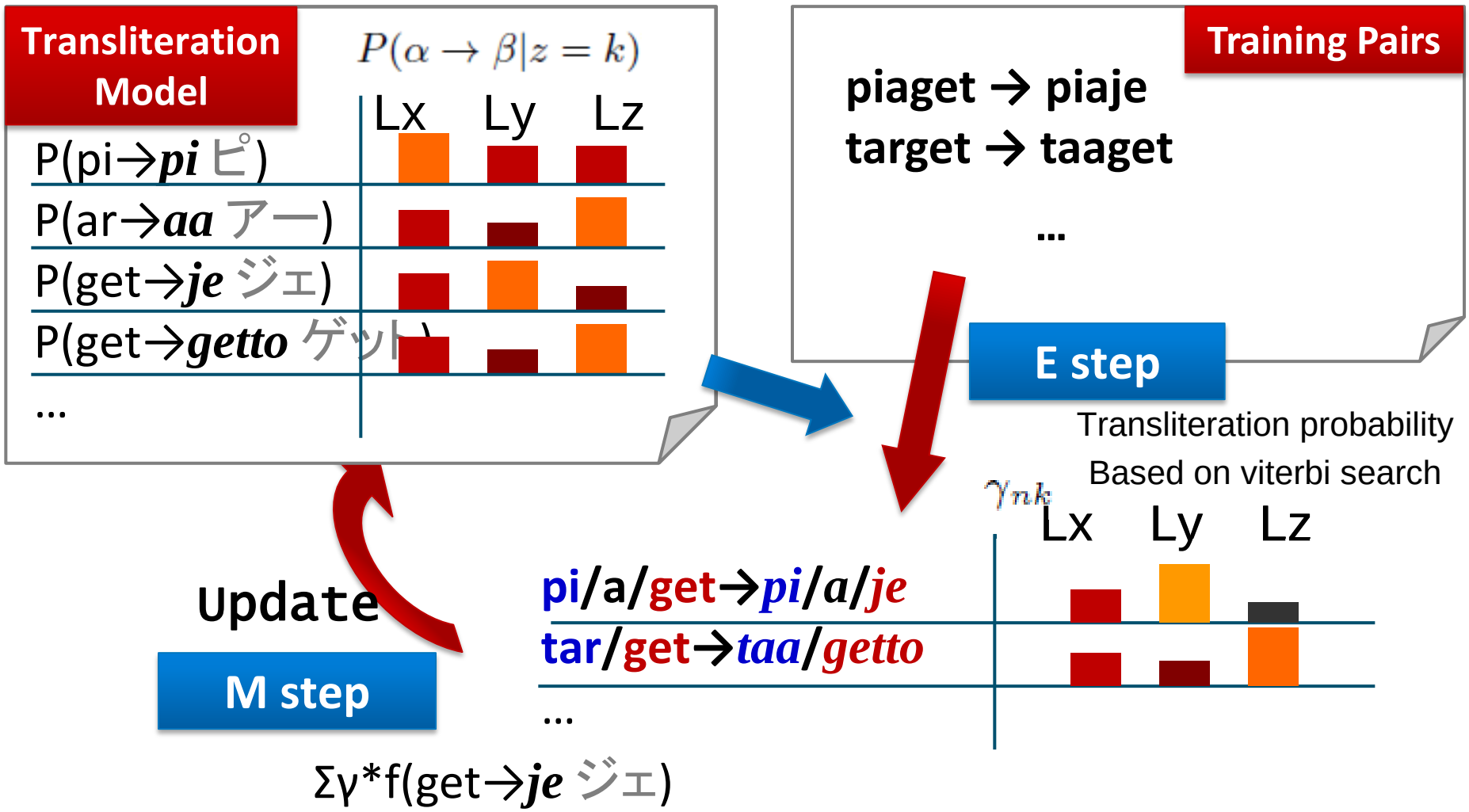
楽天 Rakuten [Hagiwara and Sekine 2011]

Iterative Learning via EM Algorithm



楽天 Rakuten [Hagiwara and Sekine 2011]

Iterative Learning via EM Algorithm

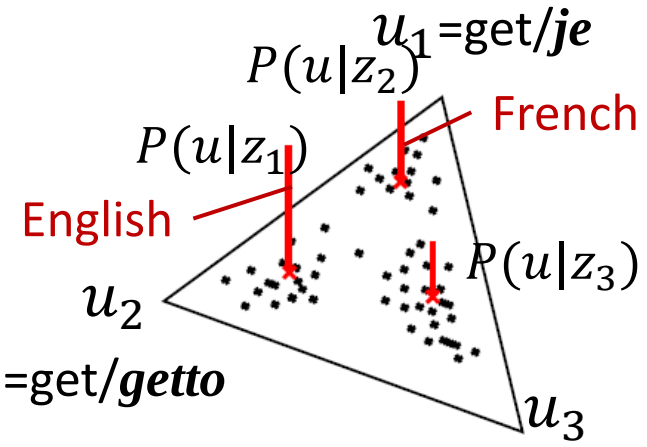


楽天 Rakuten [Hagiwara and Sekine 2011]

Latent Semantic Transliteration Model using Dirichlet Mixture

Latent Class Transliteration [Hagiwara&Sekine 11]

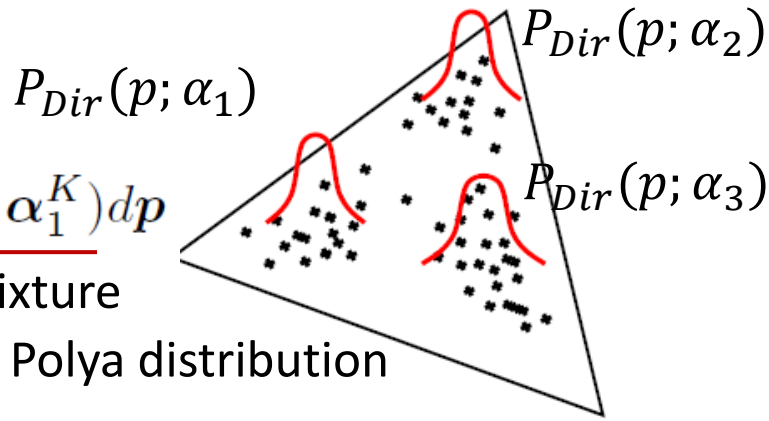
$$P_{\mathrm{LST}}(\langle \boldsymbol{s}, \boldsymbol{t} \rangle) = \sum_{z=1}^{K} P(z) \prod_{i=1}^{f} P(u_i|z)$$



Latent Semantic Transliteration using Dirichlet Mixture (Proposed)

$$P_{DM}(\langle \boldsymbol{s}, \boldsymbol{t} \rangle) = \int_{K} \underbrace{P_{Mul}(\langle \boldsymbol{s}, \boldsymbol{t} \rangle; \boldsymbol{p})}_{\text{Multinomial}} \underbrace{P_{DM}(\boldsymbol{p}; \boldsymbol{\lambda}, \boldsymbol{\alpha}_1^K)}_{\text{Dirichlet Mixture}} d\boldsymbol{p}$$

$$\propto \sum_{k=1} \lambda_k P_{Polya}(\langle \boldsymbol{s}, \boldsymbol{t} \rangle; \boldsymbol{\alpha}_1^K) \quad \text{Polya distribution}$$



楽天 Rakuten [Hagiwara and Sekine 2012]

Discriminative Transliteration Model

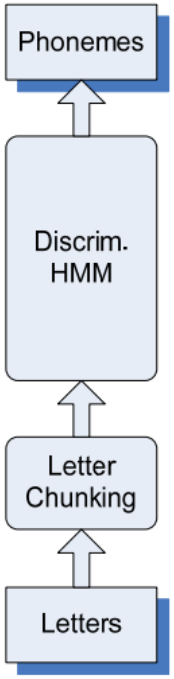
construct [kænstrʌkt]

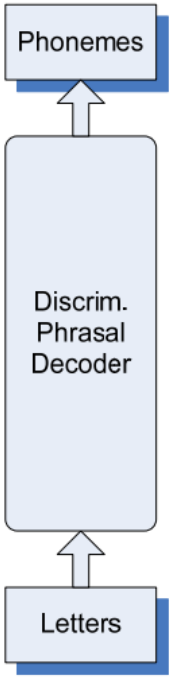
features:

(s, s), (ns, s), (st, s), (ons, s), (nst, s) ...

(n, s)

(s, ns), (ns, ns), (st, ns), (ons, ns), (nst, ns), ...



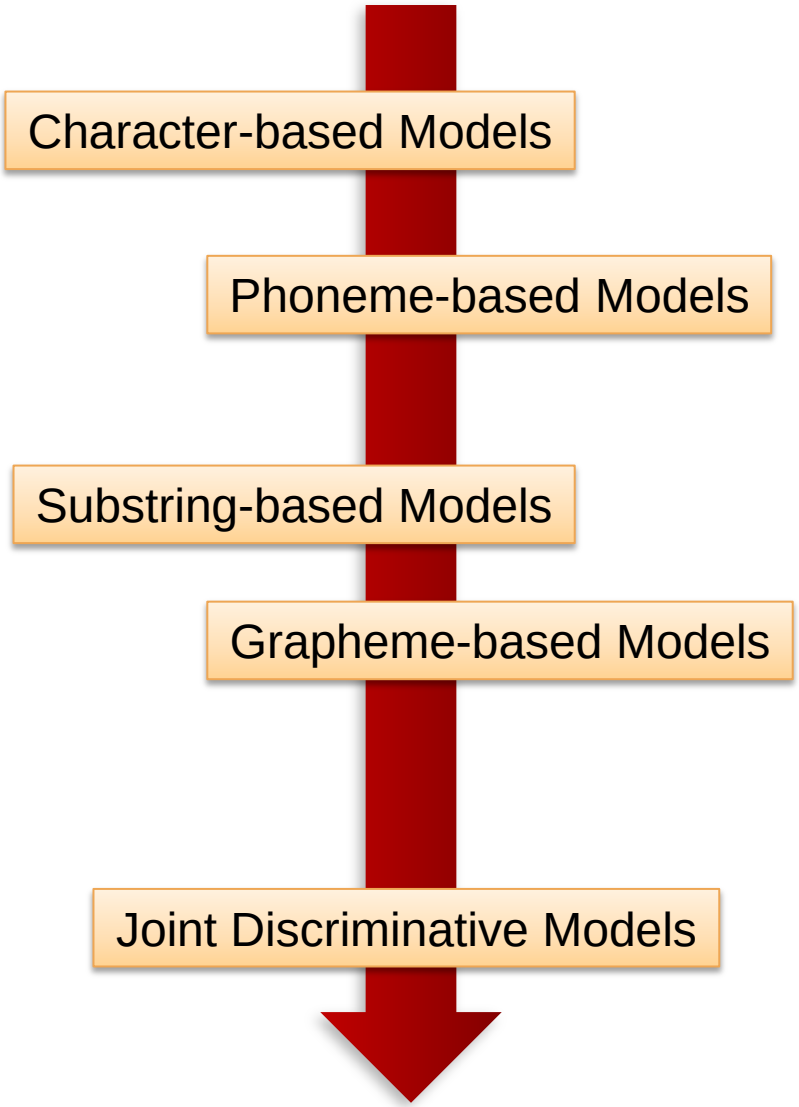


Predicting: $\hat{y} = \arg\max_{y'} [\alpha \cdot \Phi(x, y')]$

search: monotone search for phrasal decoder

楽天 Rakuten [Jiampojamarn et al. 2008] [Cherry and Suzuki 2009]

Transliteration Evolution



Transliteration Model Evolution

Character	*Substring* → ***Substring***
Phoneme	*Grapheme* → ***Grapheme***
Uniform	*Semantic* → ***Semantic***
Generative	*Discriminative* → ***Discriminative***

Integrated Models

Compound Noun and Transliteration

ブラキッシュレッド
(*burakissyureddo*)

ブラキッ　シュレッド

*bracki　shred

ブラキッシュ　レッド

blackish　red

Transliteration Model

贝拉克奥巴马
(*beilakeaobama*)

贝拉克　奥巴马

barack　obama

English Language Model

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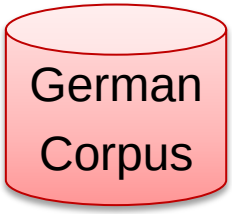
Source/Target Language Statistics

aktionsplan

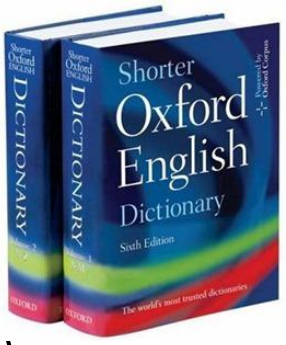


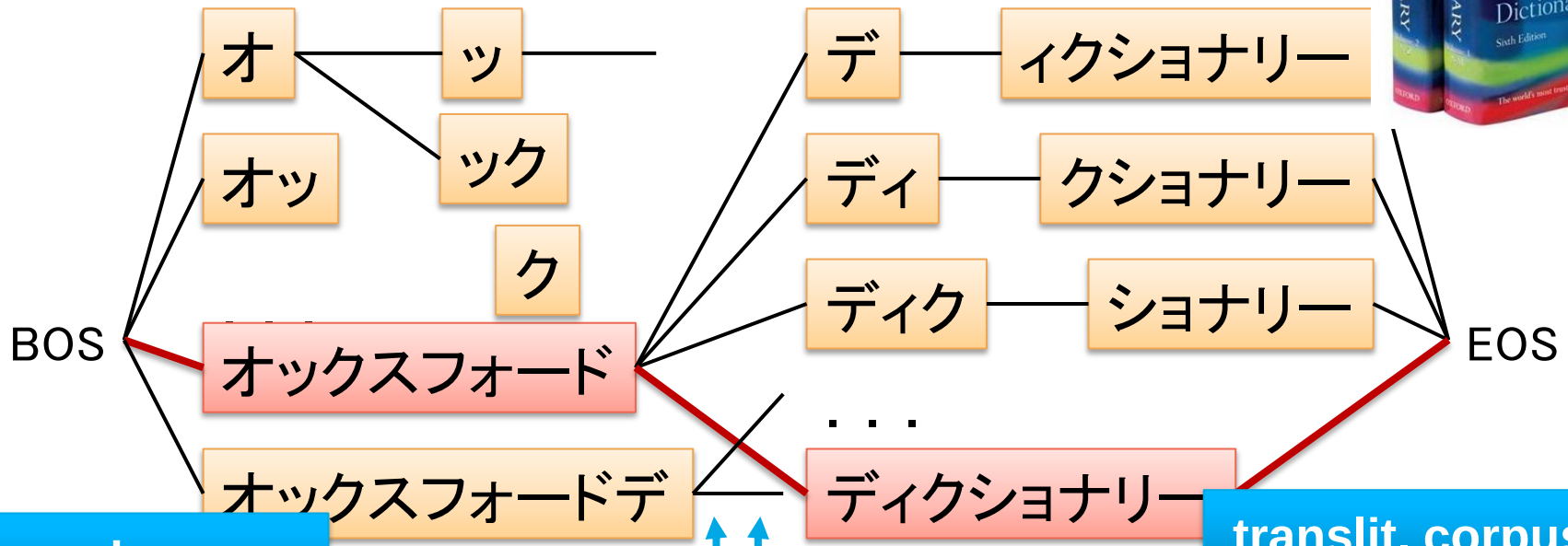
aktionsplan(852) ???		852	0
aktion(960) action	plan(710) plan	825.6	2
aktions(5) ???	plan(710) plan	59.6	1
akt(224) ???	ion(1) ???	plan(710) plan	54.2	1

楽天 Rakuten [Koehn and Knight 2003]

Use of Monolingual Paraphrase and Transliteration

オックスフォードディクショナリー
(*okkusufoododikushonarii*)





paraphrases

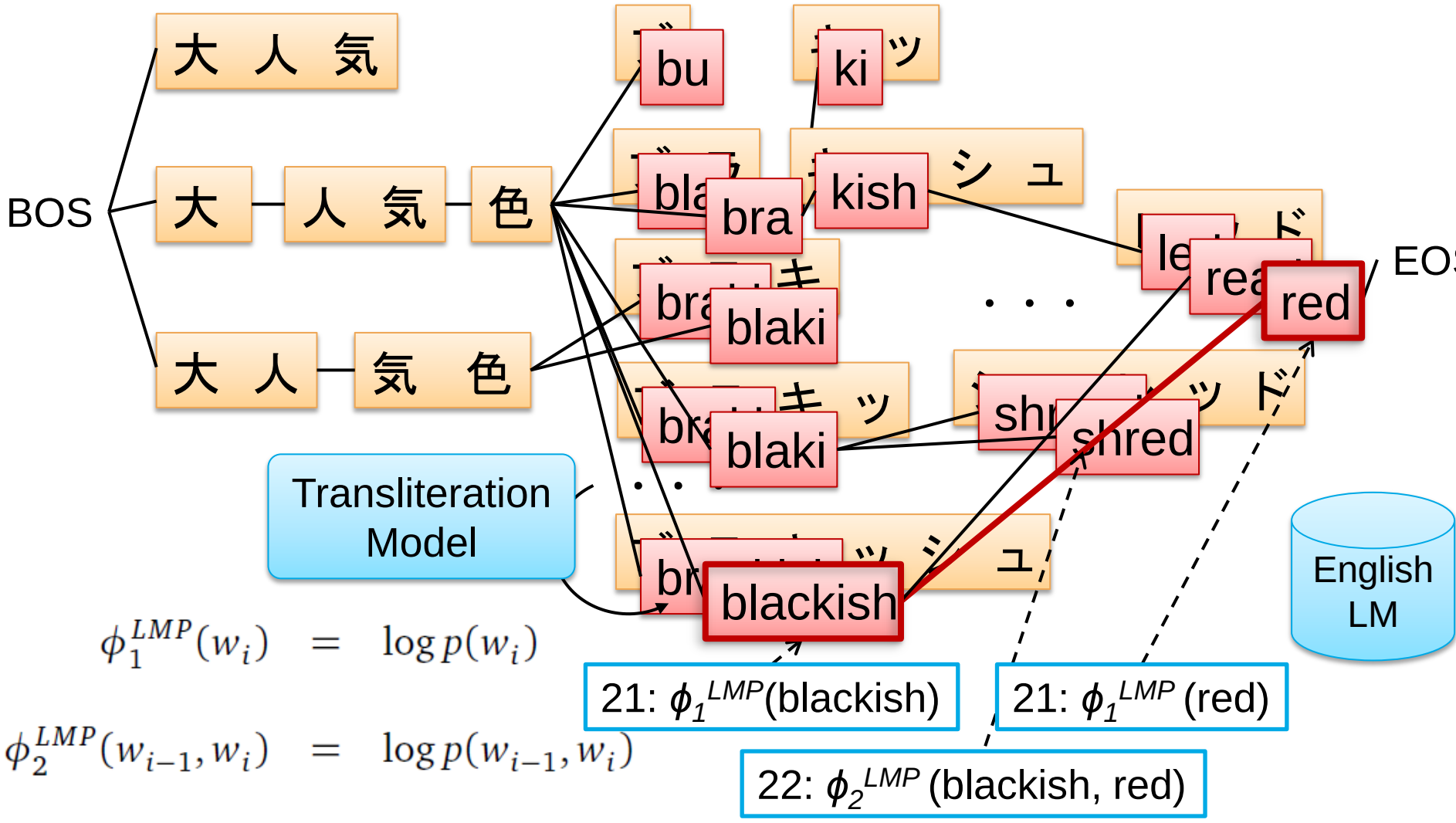
アンチョビパスタ anchovy pasta
アンチョビ・パスタ anchovy pasta
アンチョビのパスタ anchovy pasta

translit. corpus

オックスフォード oxford
ディクショナリー dictionary
ジャンク フード junk food

楽天 Rakuten [Kaji, Kitsuregawa 2011]

Language Projection via “Online” Transliteration



$$\phi_1^{LMP}(w_i) = \log p(w_i)$$

$$\phi_2^{LMP}(w_{i-1}, w_i) = \log p(w_{i-1}, w_i)$$

楽天 Rakuten [Hagiwara, Sekine 2013]

Agenda

Word Segmentation

Transliteration

Integrated Models

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