Machine Translation with Diverse Data Sources

Huda Khayrallah

This talk was presented at JHU CLSP seminar on March 29, 2019
and at the UPenn Computational Linguistics Seminar on April 8, 2019

It is based on the following papers:

https://aclweb.org/anthology/W18-2705

(bibtex: https://aclweb.org/anthology/W18-2705)

https://aclweb.org/anthology/W18-2709

(bibtex: https://aclweb.org/anthology/W18-2709.bib)

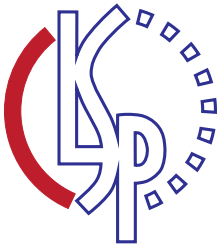
Machine Translation with Diverse Data Sources

Huda Khayrallah

Work with:

Brian Thompson, Kevin Duh & Philipp Koehn

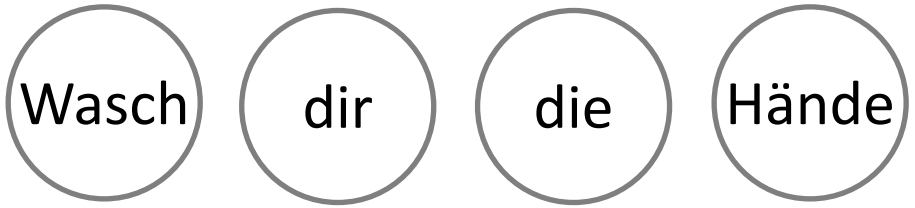
JOHNS HOPKINS
UNIVERSITY



Overview

- Review of Neural Machine Translation (NMT)
- Review of Domain Adaptation
- Improving Domain Adaptation
  - Regularized Training Objective for Continued Training for Domain Adaptation in Neural Machine Translation [Khayrallah, Thompson, Duh & Koehn 2018]
- Analysis of Noisy Corpora
  - On the Impact of Various Types of Noise on Neural Machine Translation [Khayrallah & Koehn 2018]

Neural Machine Translation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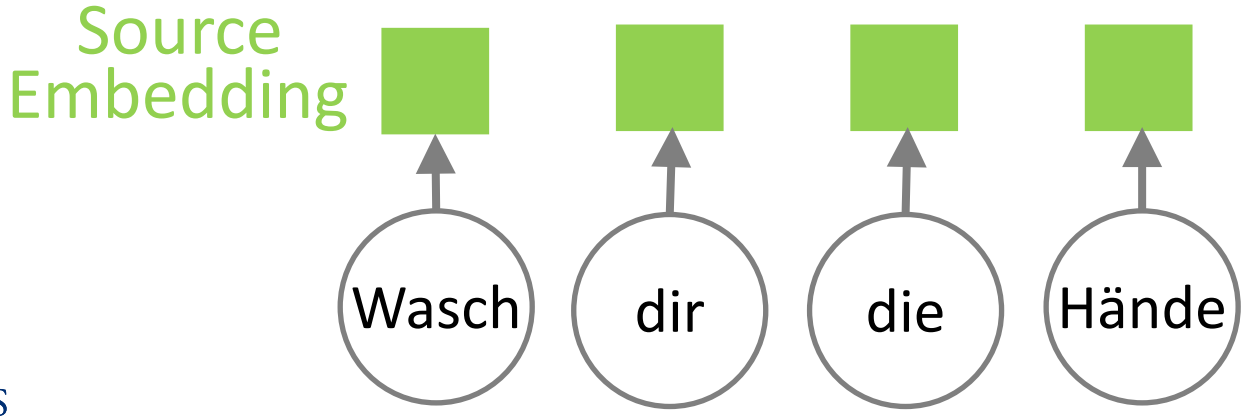
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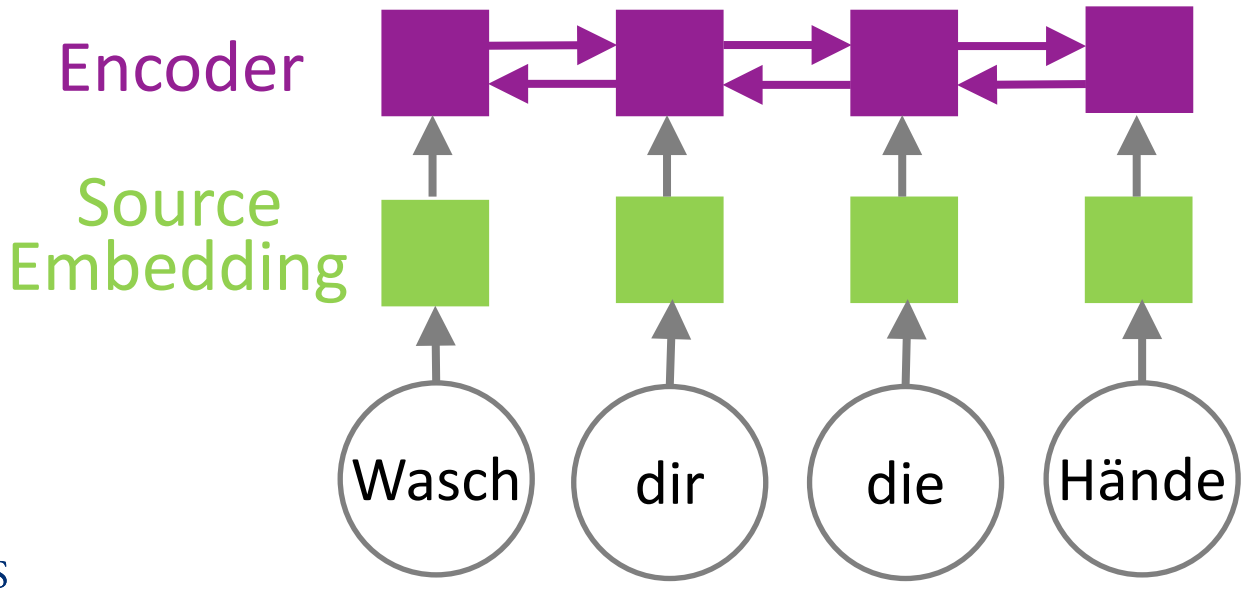
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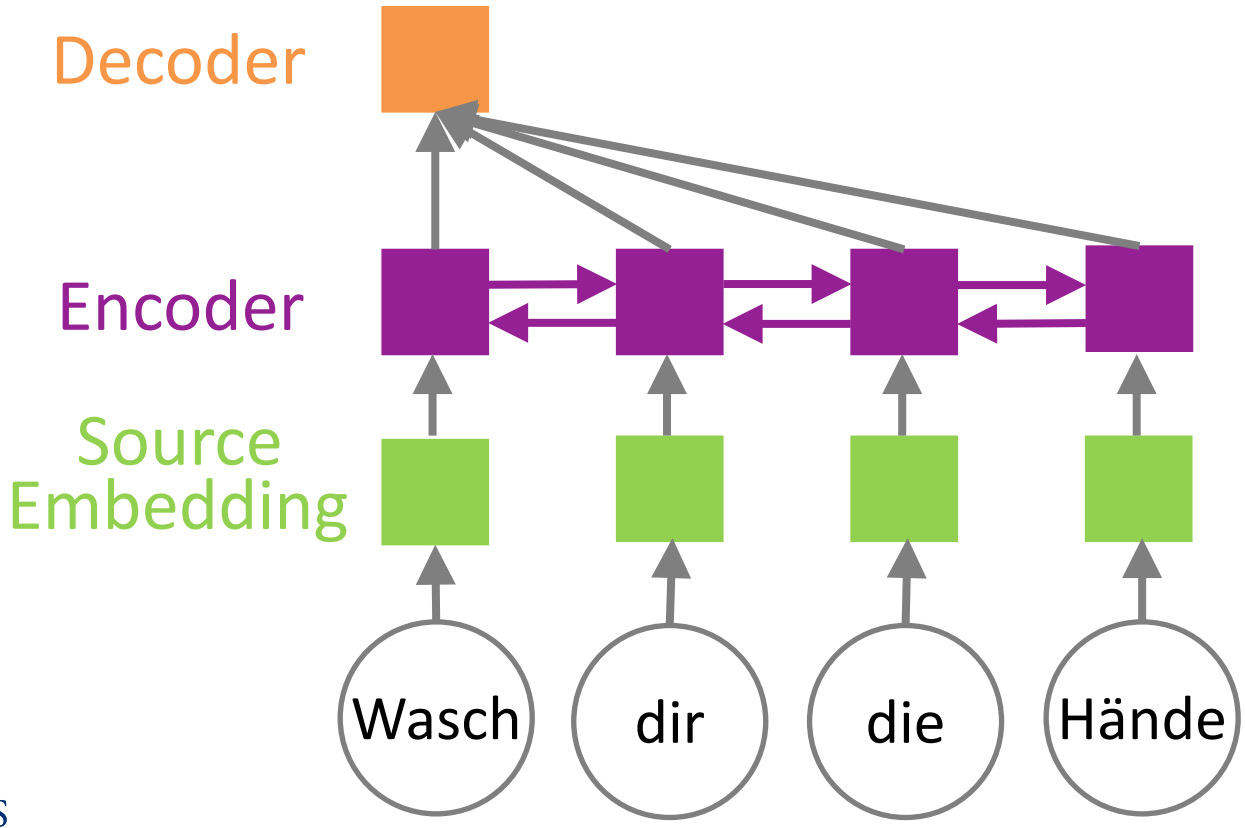
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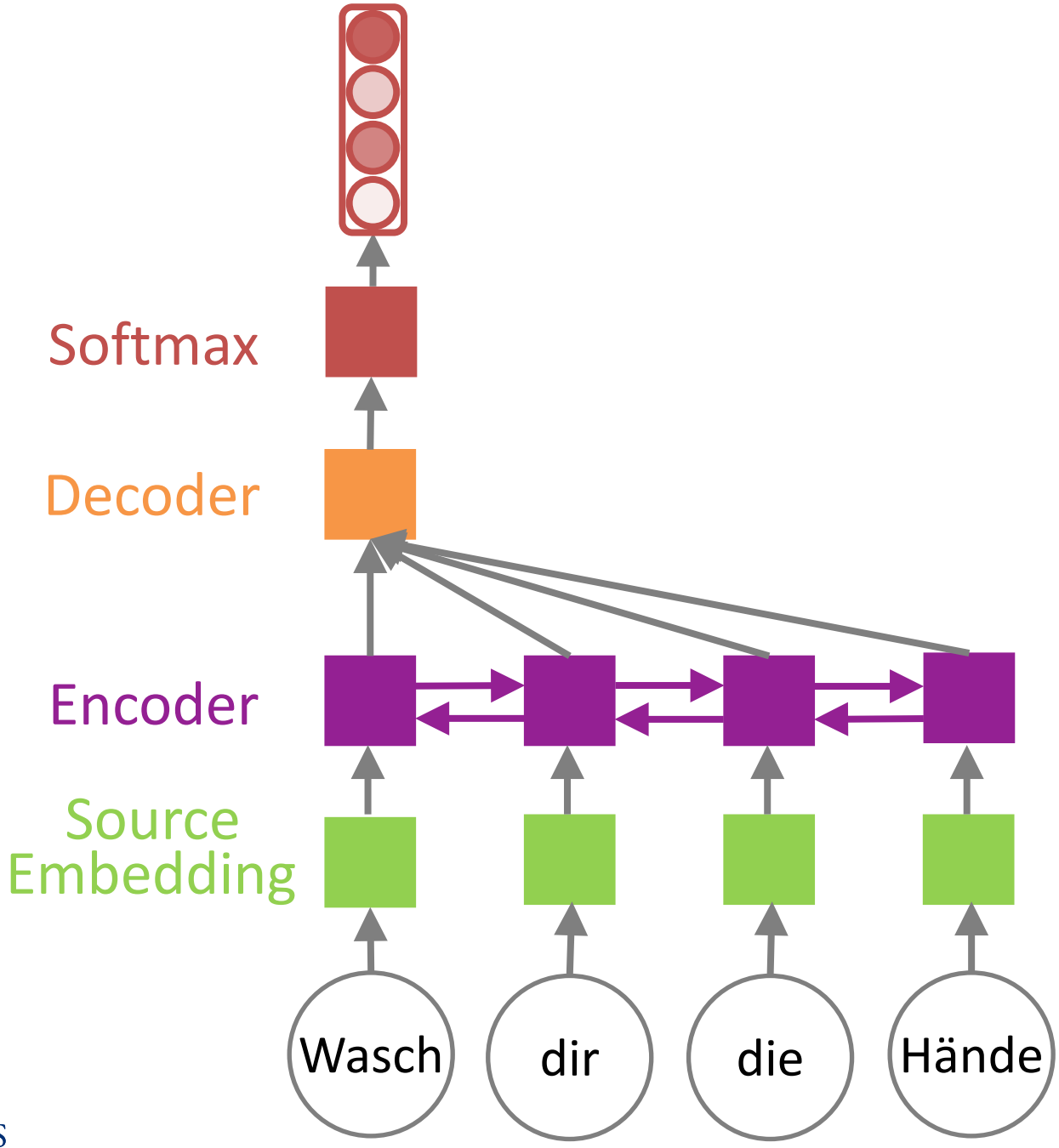
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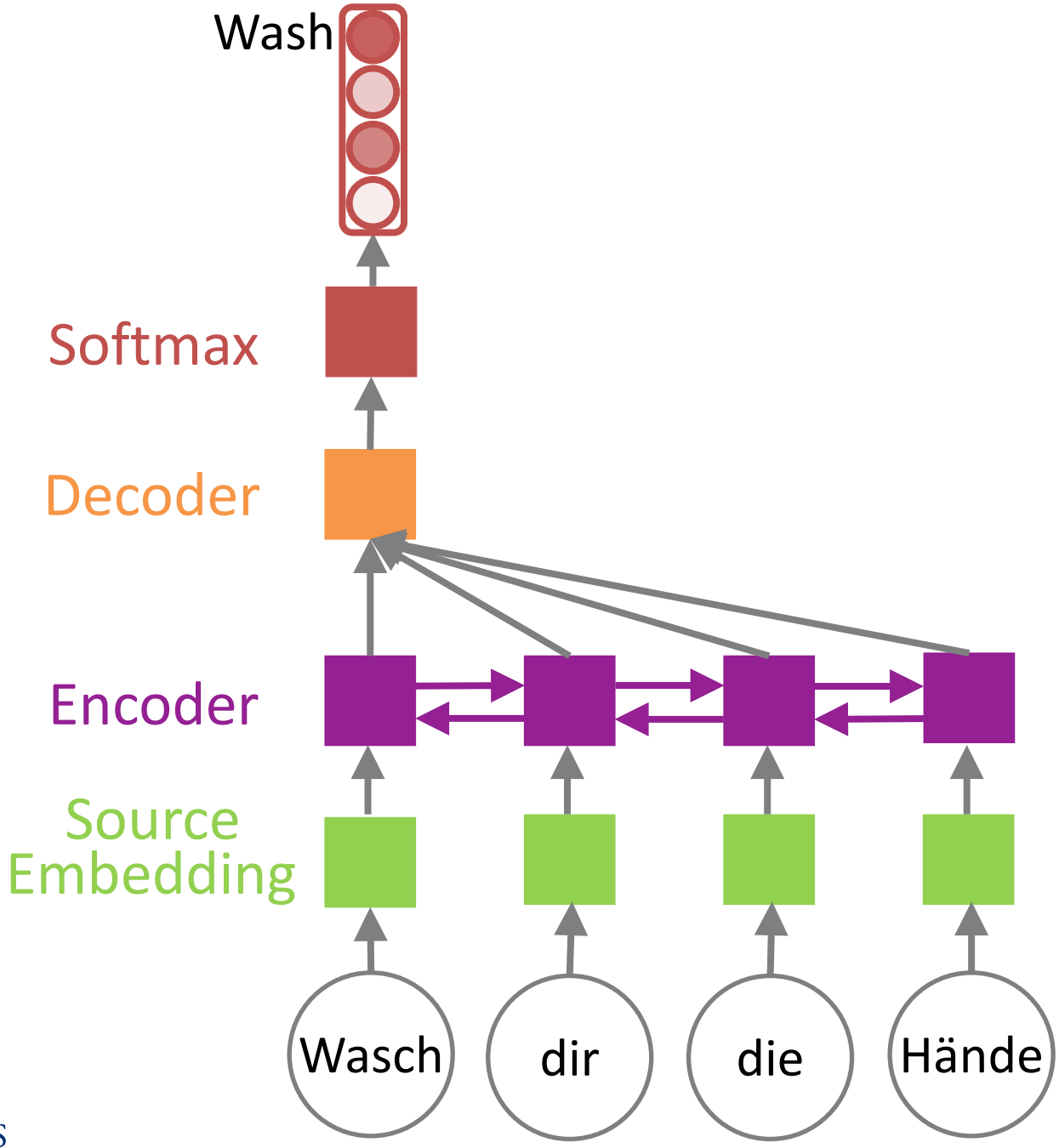
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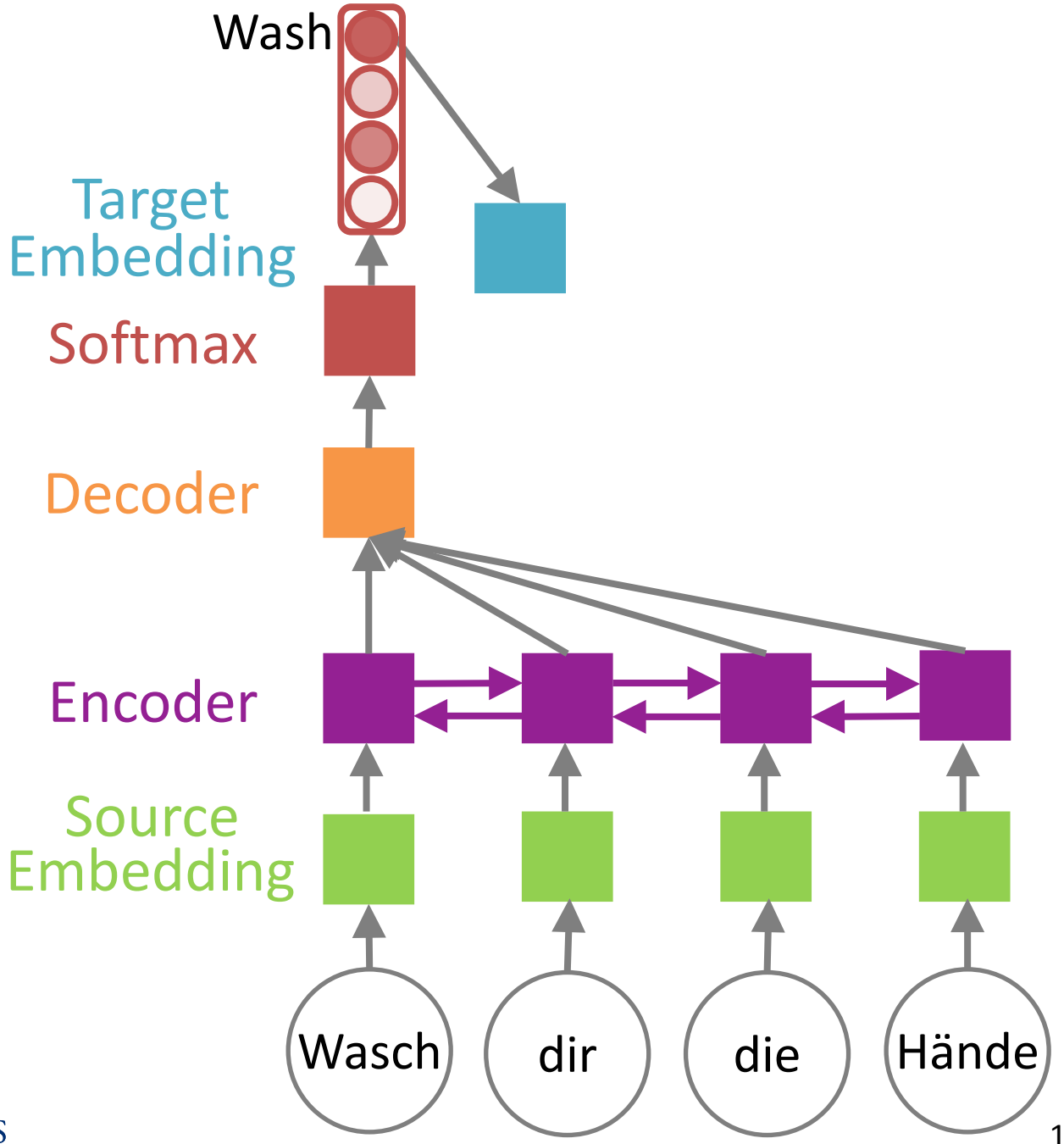
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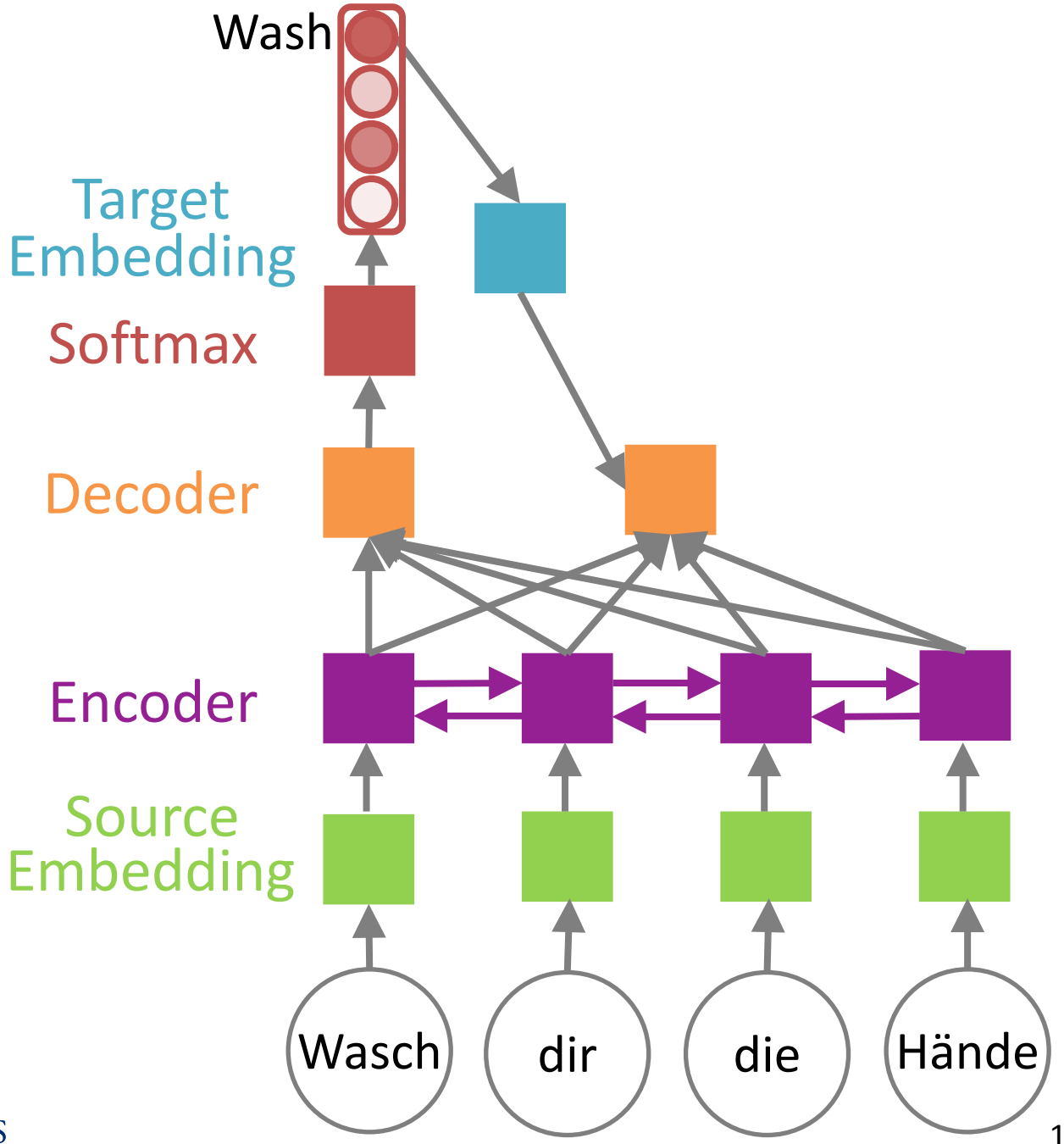
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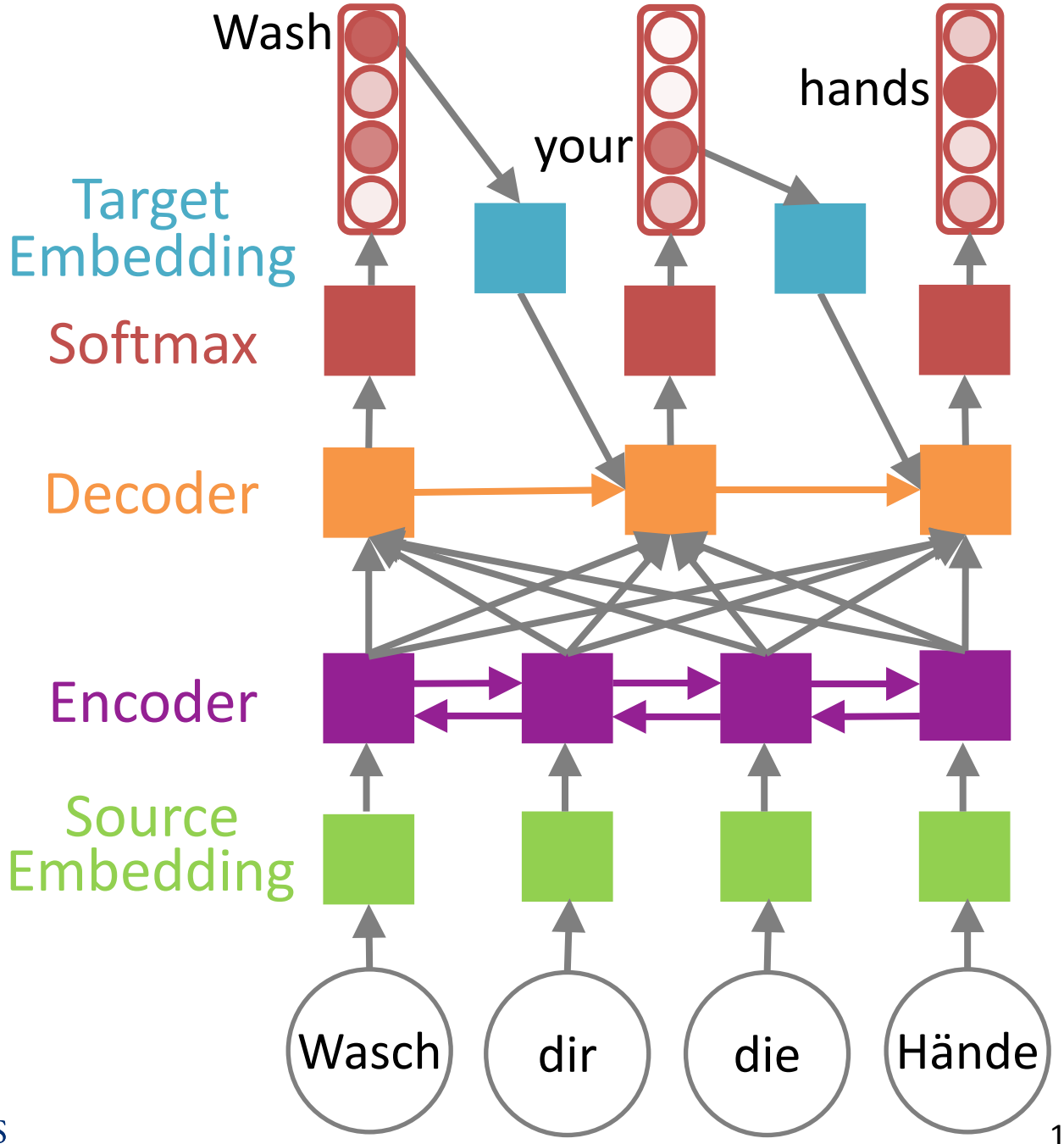
Wash
your
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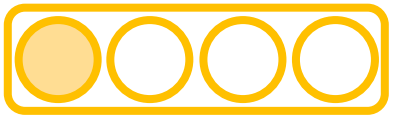
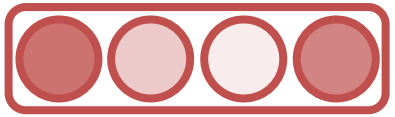
Target Embedding
Softmax
Decoder
Encoder
Source Embedding
Wasch
dir
die
Hände

NMT loss function

$$\mathcal{L}_{\text{NLL}}(\theta) = -\sum_{v \in \mathcal{V}} \left(\mathbb{1}\{y_i = v\} \times \log p(y_i = v \mid x; \theta; y_{j<i}) \right)$$

Gold Target

Model output

Cross Entropy( , )

Gold Target Model output

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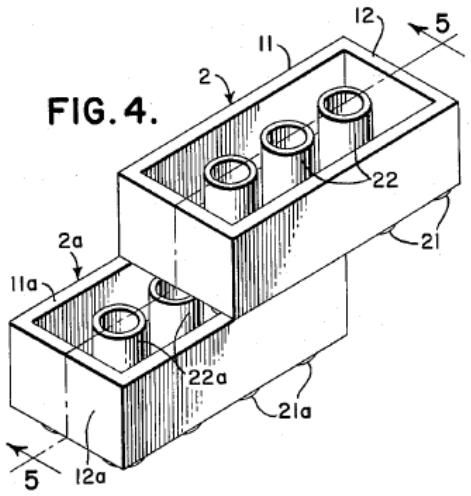
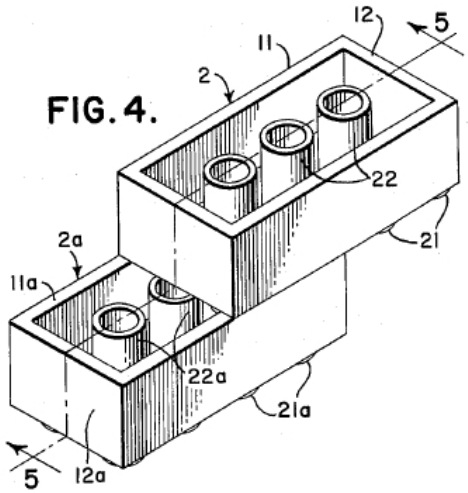
What do we want to translate?

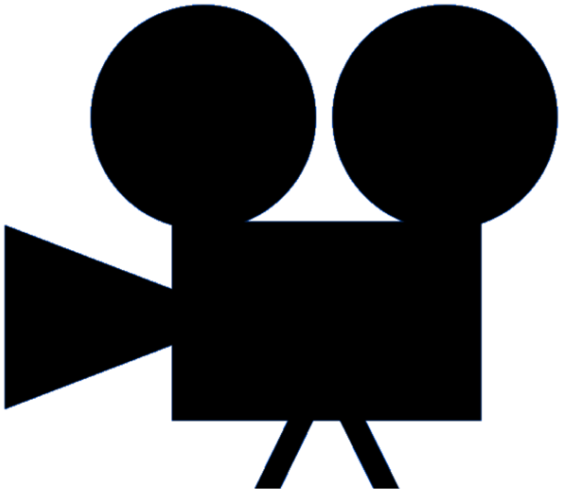


Developmental toxicity, including dose-dependent delayed foetal ossification and possible teratogenic effects, were observed in rats at doses resulting in subtherapeutic exposures (based on AUC) and in rabbits at doses resulting in exposures 3 and 11 times the mean steady-state AUC at the maximum recommended clinical dose.



The films coated therewith, in particular polycarbonate films coated therewith, have improved properties with regard to scratch resistance, solvent resistance, and reduced oiling effect, said films thus being especially suitable for use in producing plastic parts in film insert molding methods.

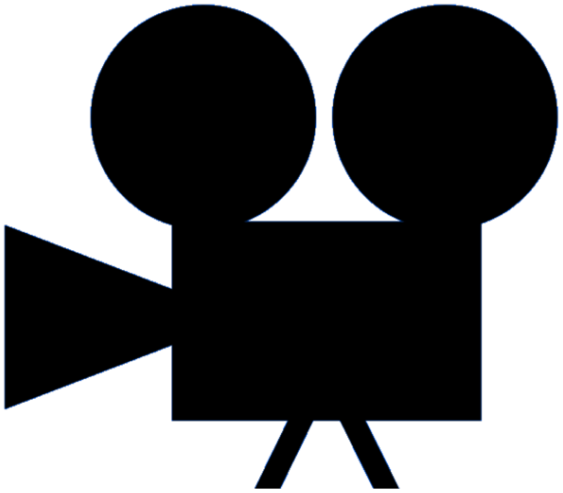
General Domain Data



General Domain Data

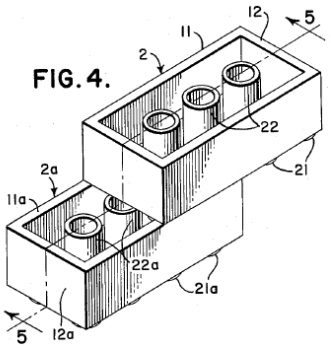
Would it not be beneficial, in the short term, following the Rotterdam model, to inspect according to a points system in which, for example, account is taken of the ship's age, whether it is single or double-hulled or whether it sails under a flag of convenience.

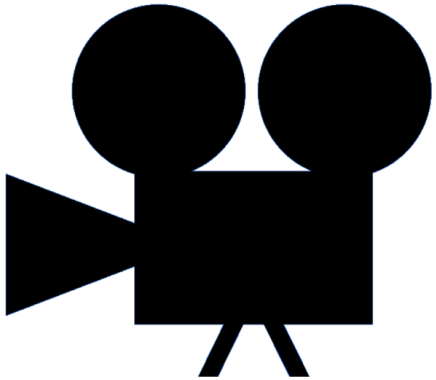
General Domain Data



Mama always said there's an awful lot you can tell about a person by their shoes.

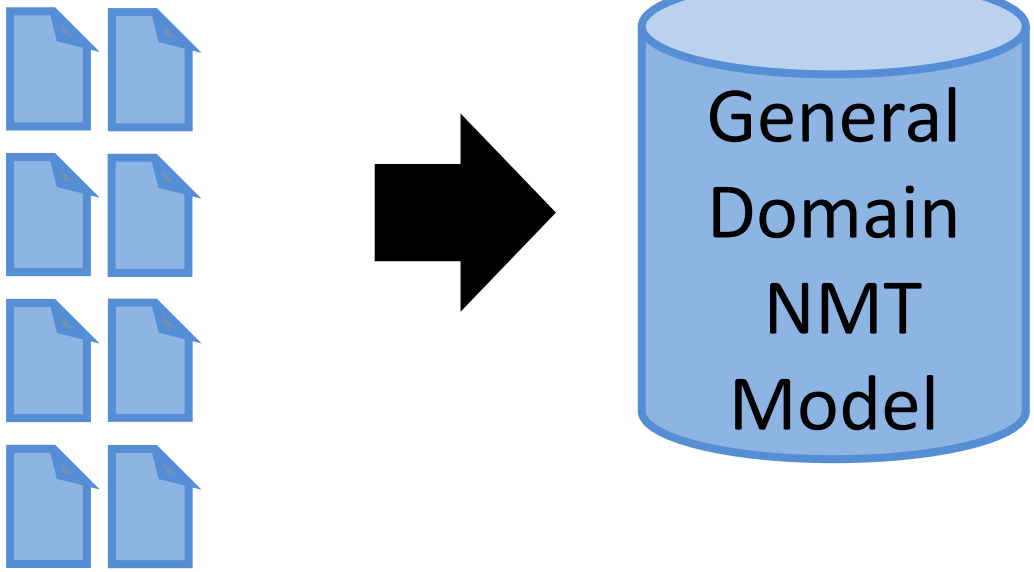
Domain Mismatch





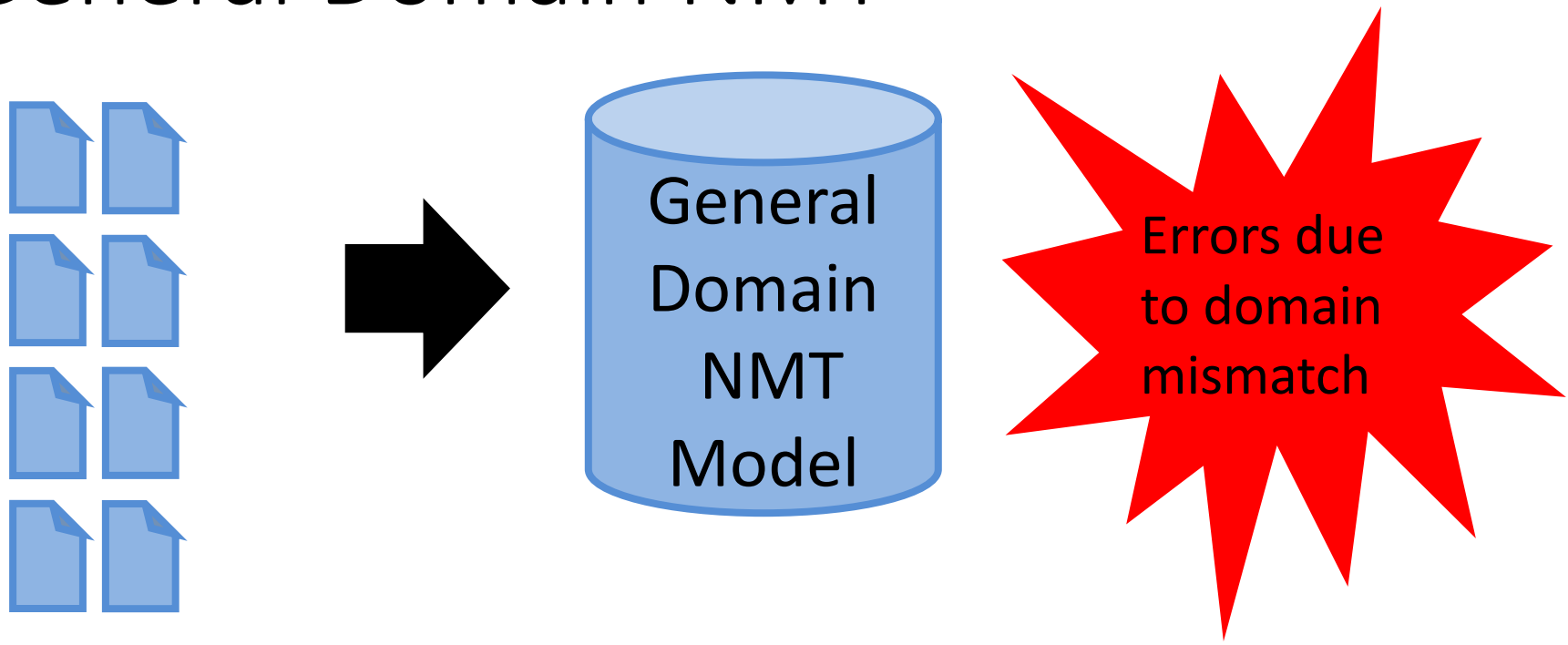
Translating Russian Patents

General Domain NMT



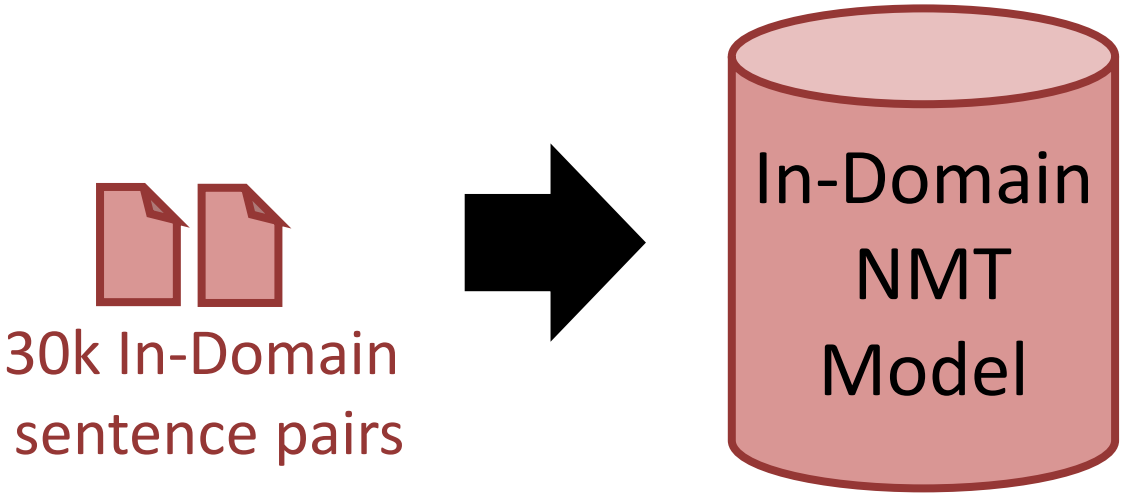
50m General Domain sentence pairs

General Domain NMT

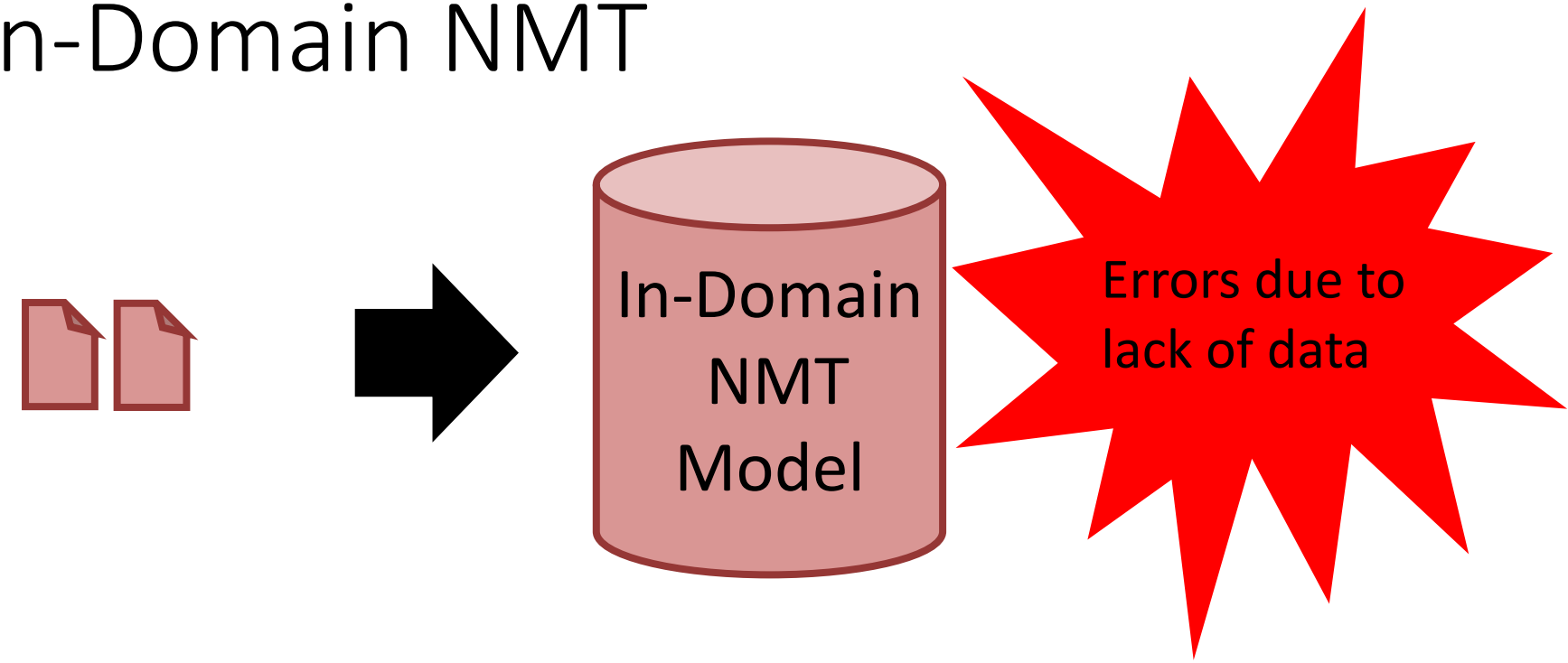


дверной замок повышенной степени защищенности от взлома
Human: door lock with increased degree of security against burglary
System: door security door security door

In-Domain NMT



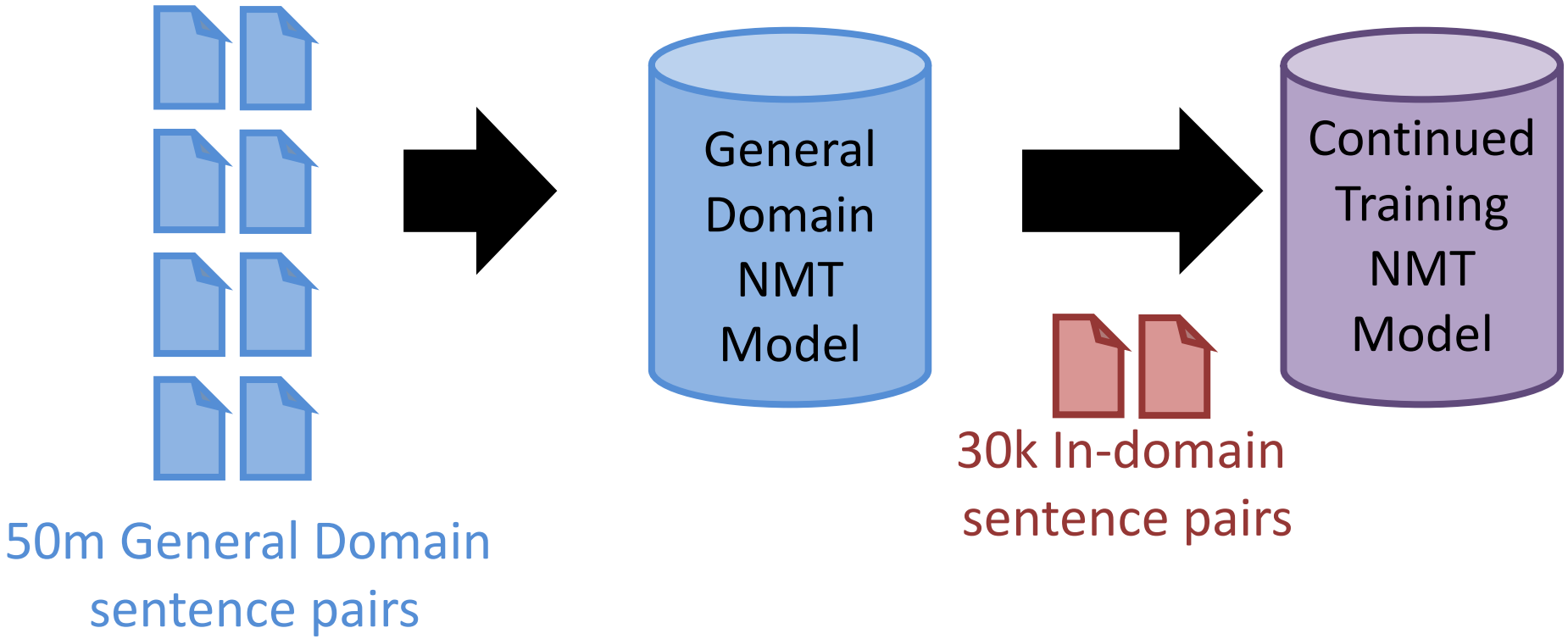
In-Domain NMT



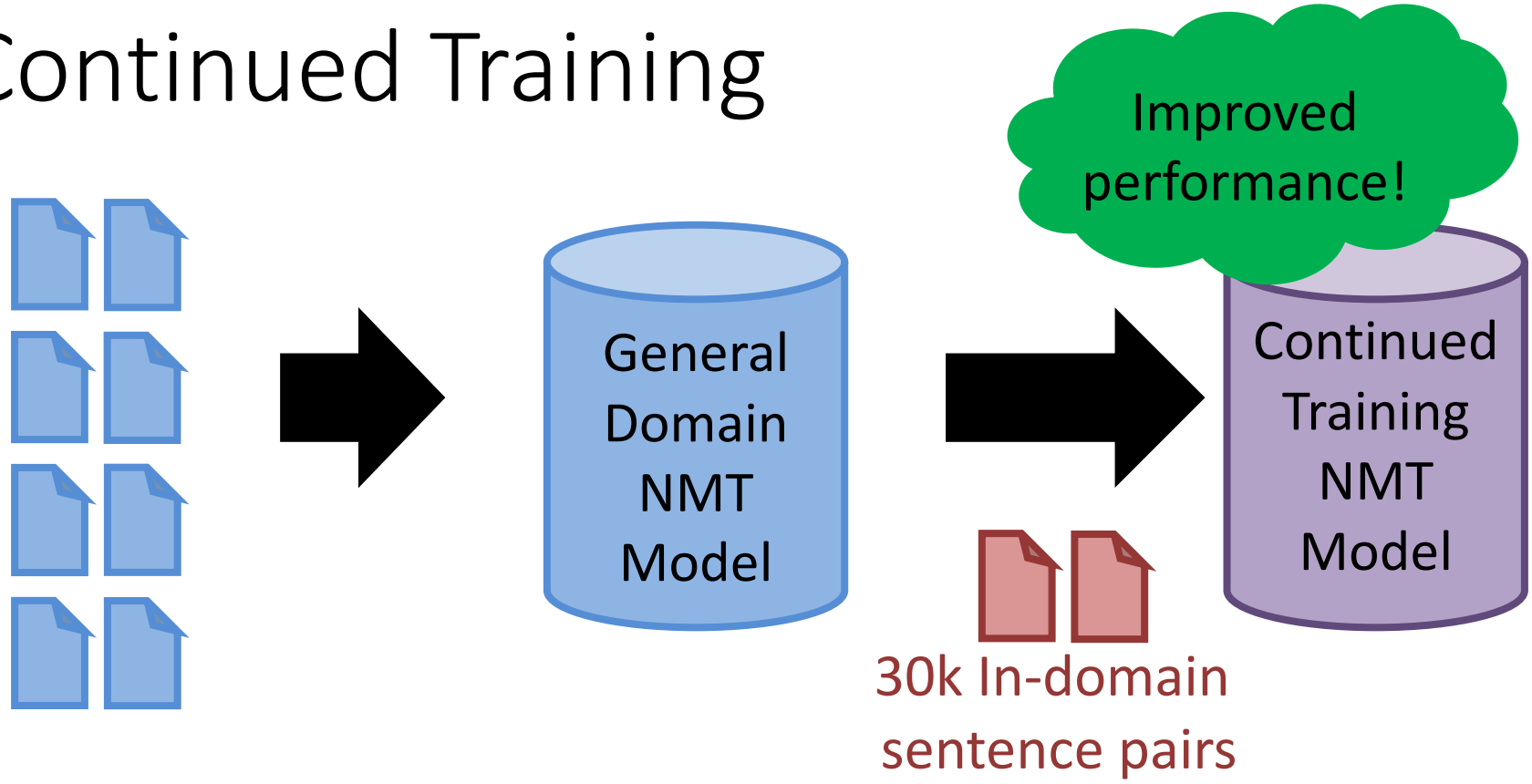
дверной замок повышенной степени защищенности от взлома
Human: door lock with increased degree of security against burglary
System: door lock for a high degree of protection against coke

Domain Adaptation

Continued Training

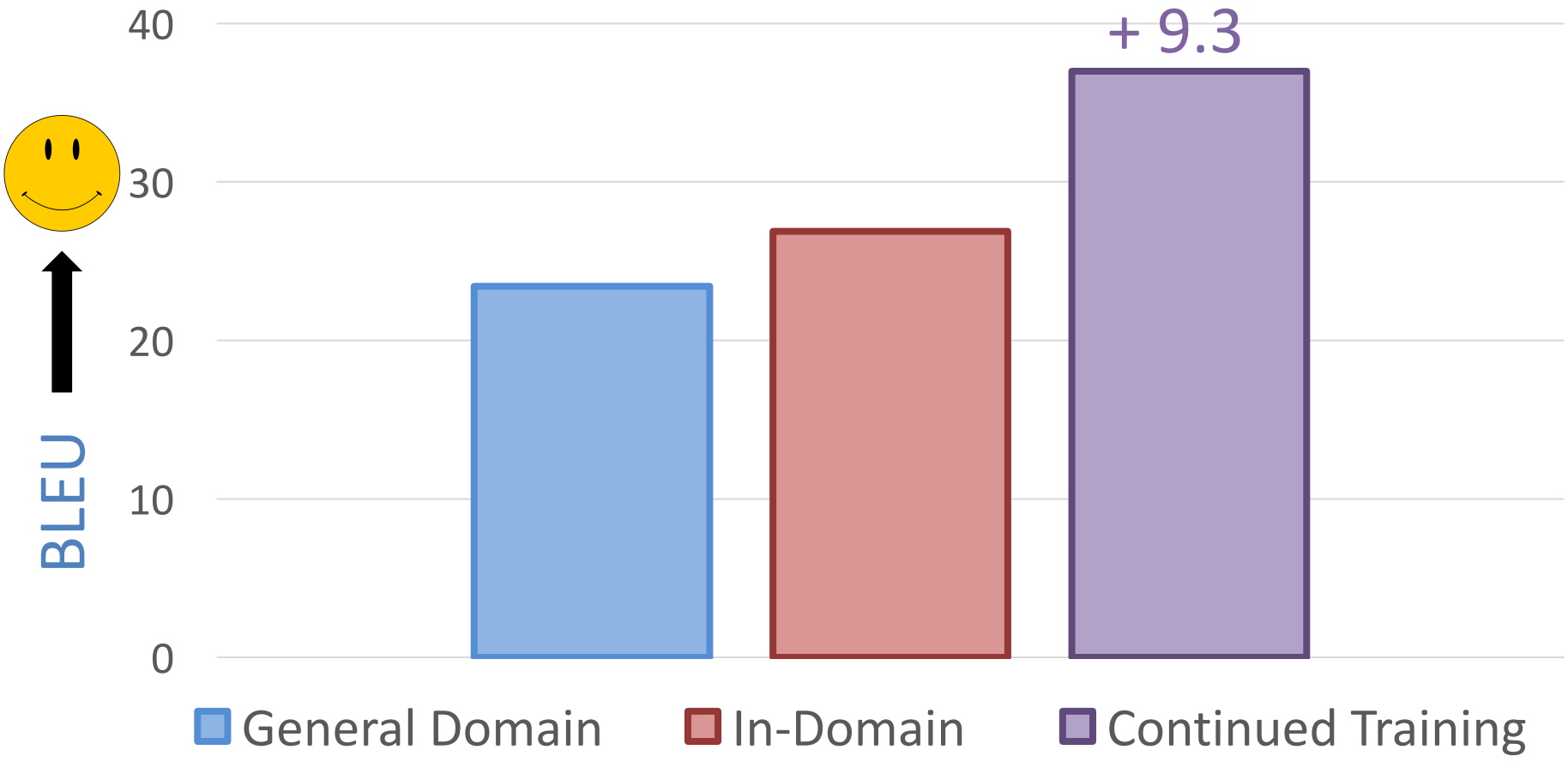


Continued Training



дверной замок повышенной степени защищенности от взлома
Human: door lock with increased degree of security against burglary
System: door lock with increased penetration protection

Russian → English Patents



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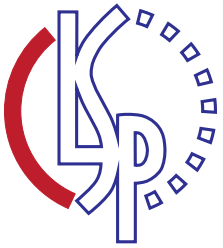
Regularized Training Objective for Continued Training for Domain Adaptation in Neural Machine Translation

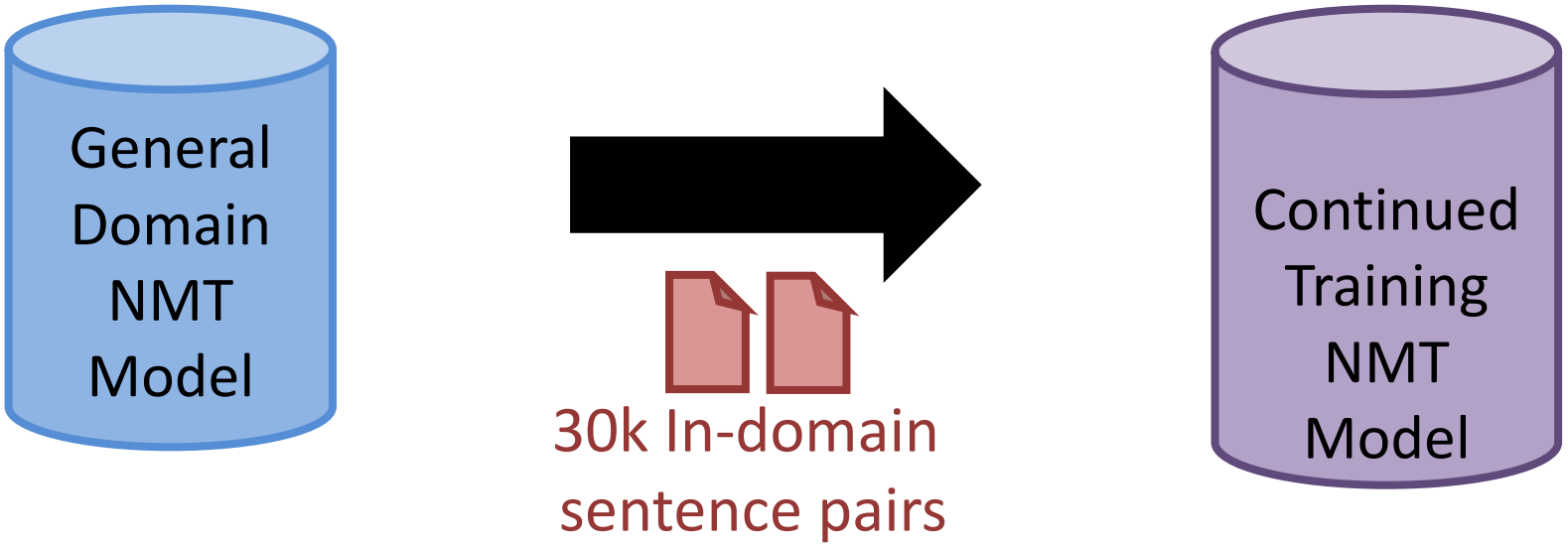
Huda Khayrallah, Brian Thompson,
Kevin Duh & Philipp Koehn

WNMT at ACL 2018

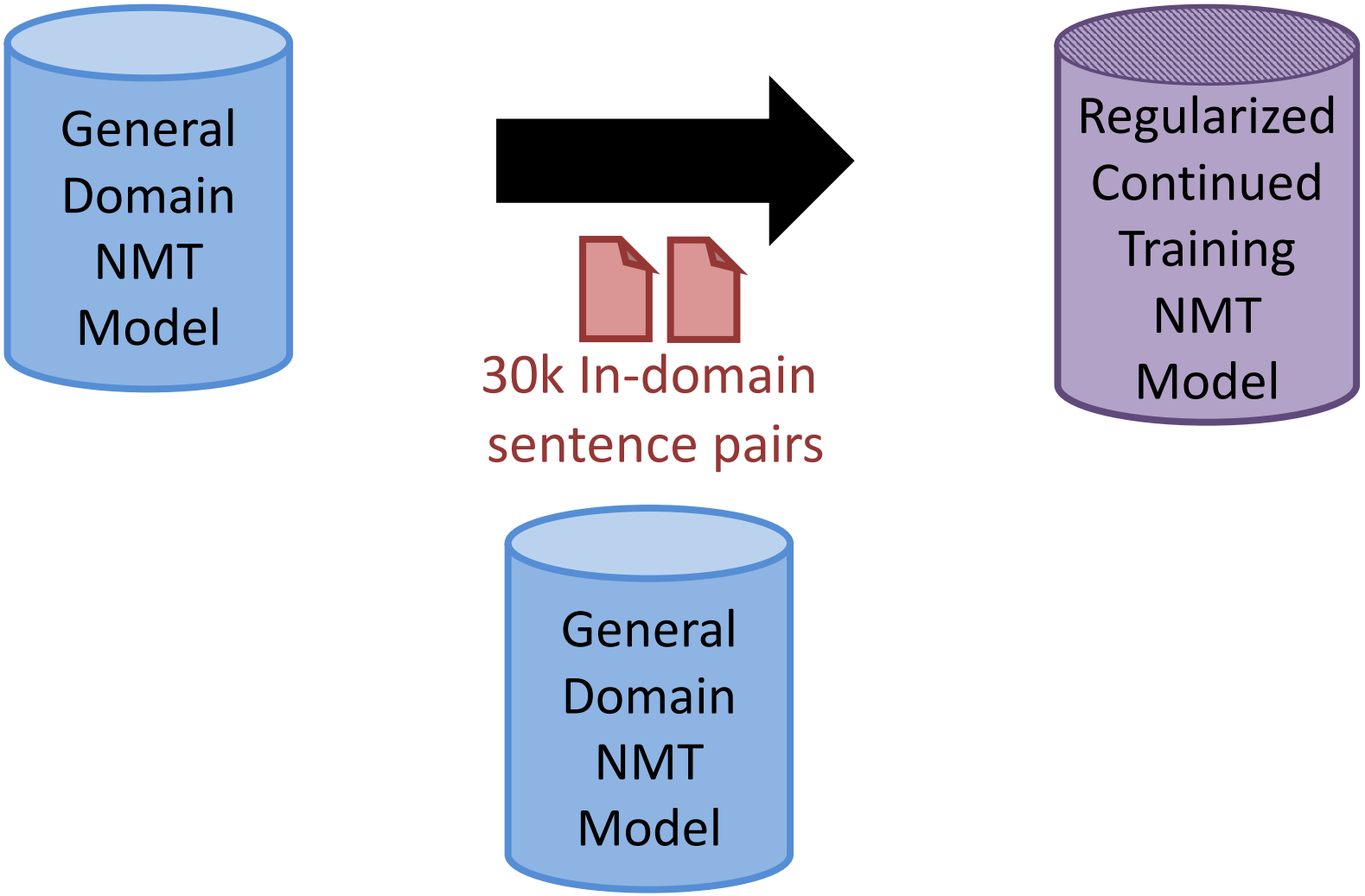
JOHNS HOPKINS
UNIVERSITY



Continued Training



Regularized Continued Training

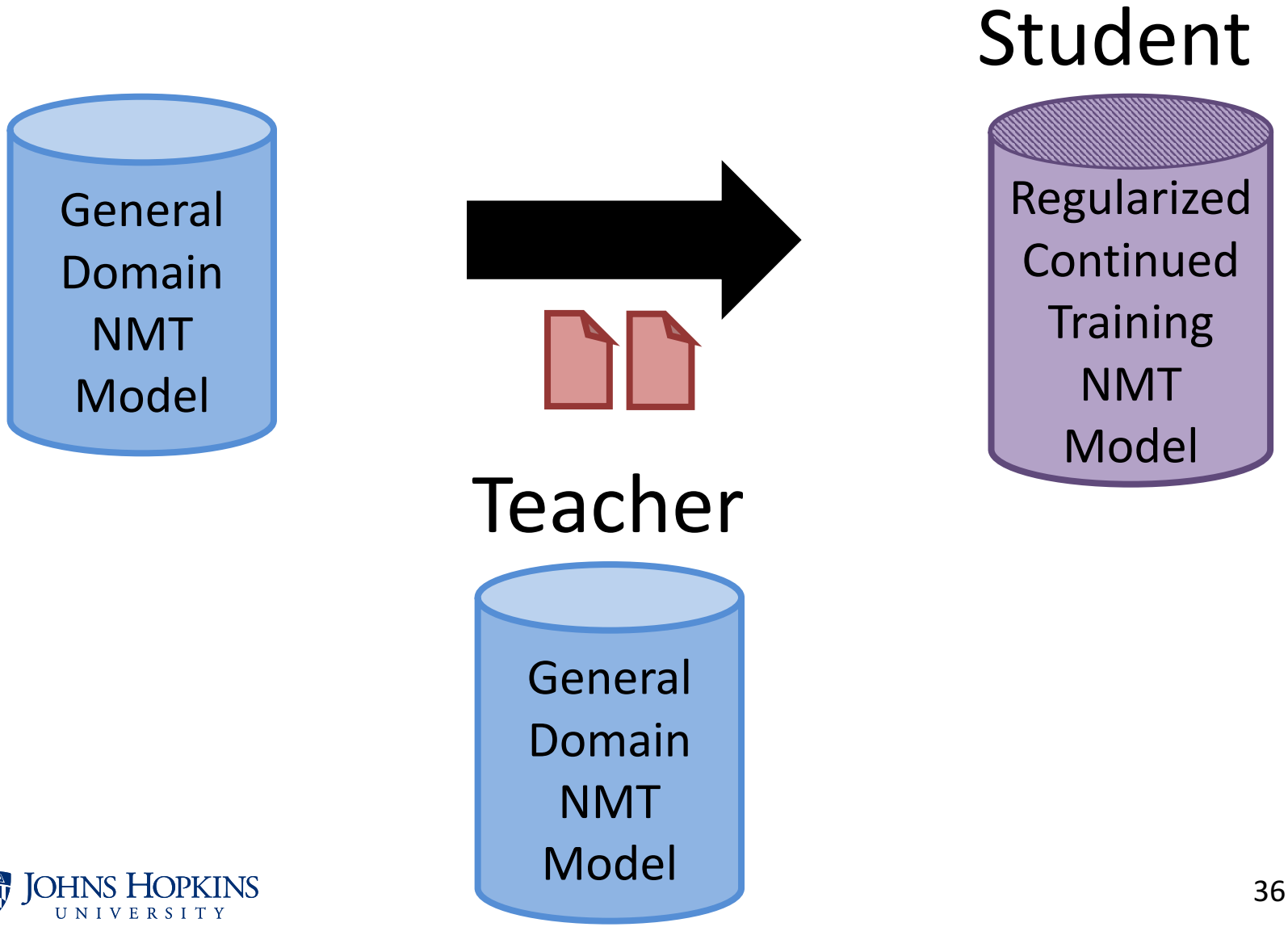


Teacher/Student Models

- Word Level Knowledge distillation

- Often used to make smaller/faster models
- Train one model; use it to ‘teach’ another

Regularized Continued Training

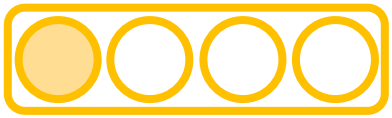
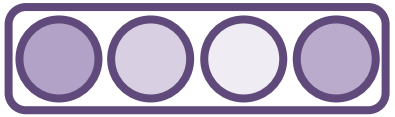


NMT loss function

$$\mathcal{L}_{\text{NLL}}(\theta) = -\sum_{v \in \mathcal{V}} \left(\mathbb{1}\{y_i = v\} \times \log p(y_i = v \mid x; \theta; y_{j<i}) \right)$$

Gold Target

CT Model output

Cross Entropy( , )

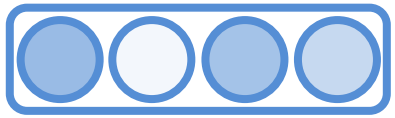
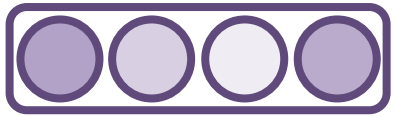
Gold Target CT Model output

Teacher/Student Loss Function

$$-\sum_{v \in \mathcal{V}} \left(p_{aux}(y_i = v \mid x; \theta_{aux}; y_{j<i}) \times \log p(y_i = v \mid x; \theta; y_{j<i}) \right)$$

General Model Output (teacher)

CT Model output (student)

Cross Entropy( , )

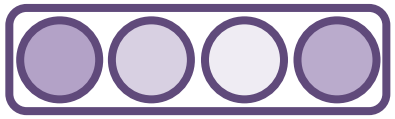
General Model Output (teacher)

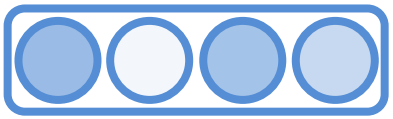
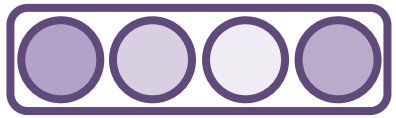
CT Model output (student)

This work: Combine Both

$$(1 - \alpha) \times \left(-\sum_{v \in \mathcal{V}} \left(\mathbb{1}\{y_i = v\} \times \log p(y_i = v \mid x; \theta; y_{j<i}) \right) \right) +$$

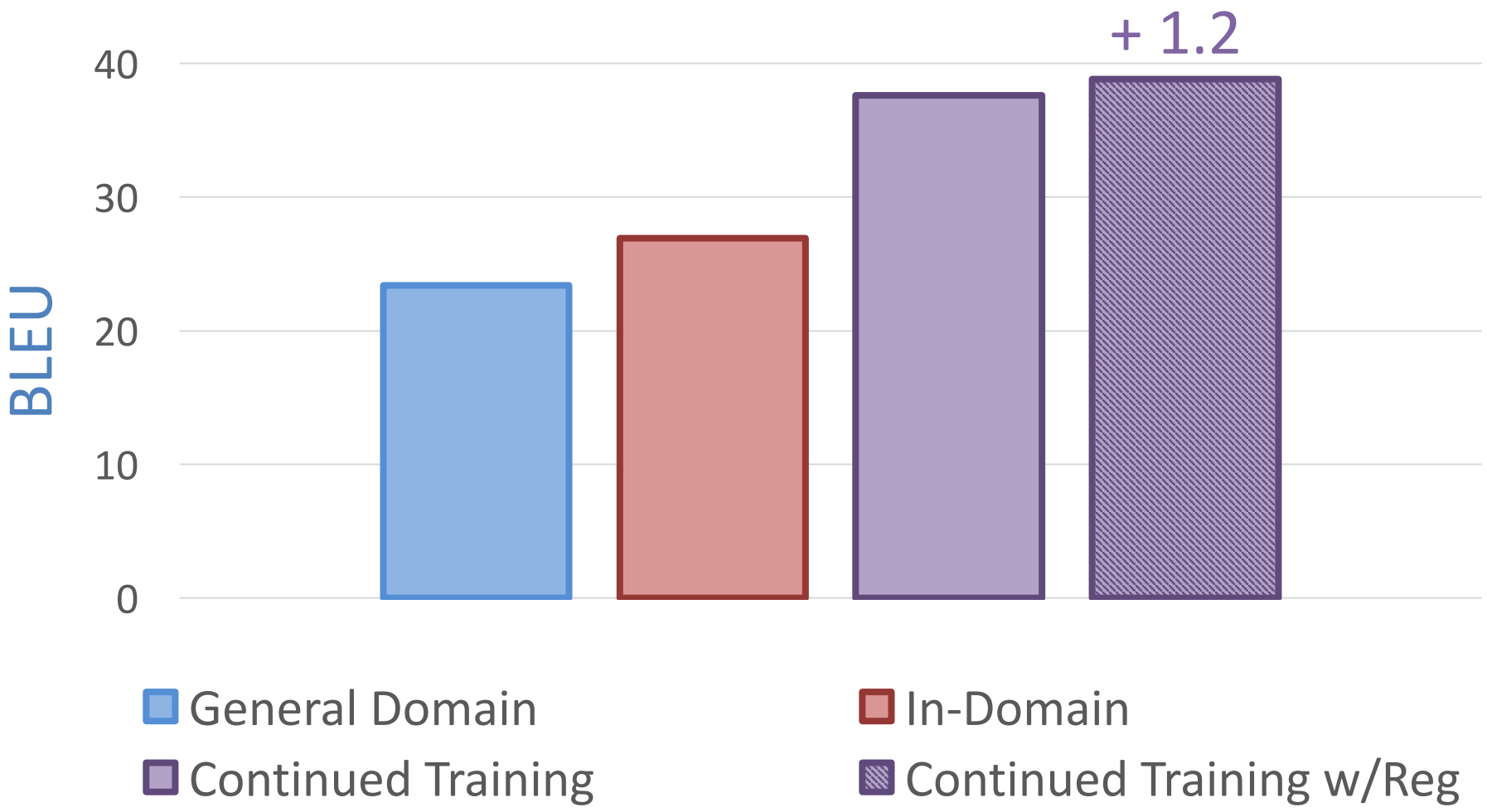
$$\alpha \times \left(-\sum_{v \in \mathcal{V}} \left(p_{aux}(y_i = v \mid x; \theta_{aux}; y_{j<i}) \times \log p(y_i = v \mid x; \theta; y_{j<i}) \right) \right)$$

$(1 - \alpha) \times$ Cross Ent ( , ) +

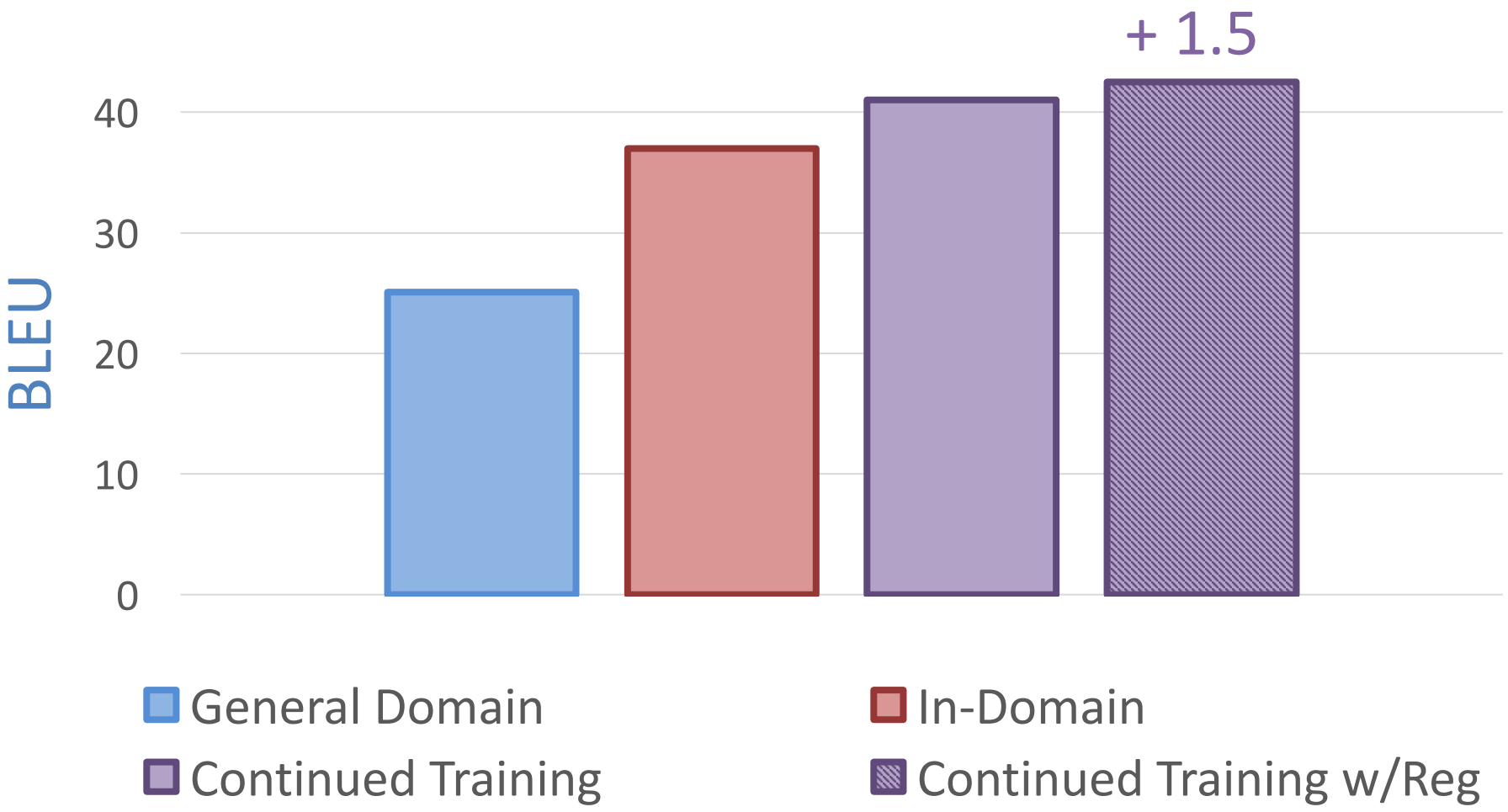
$\alpha \times$ Cross Ent ( , )

Results

Russian → English Patents

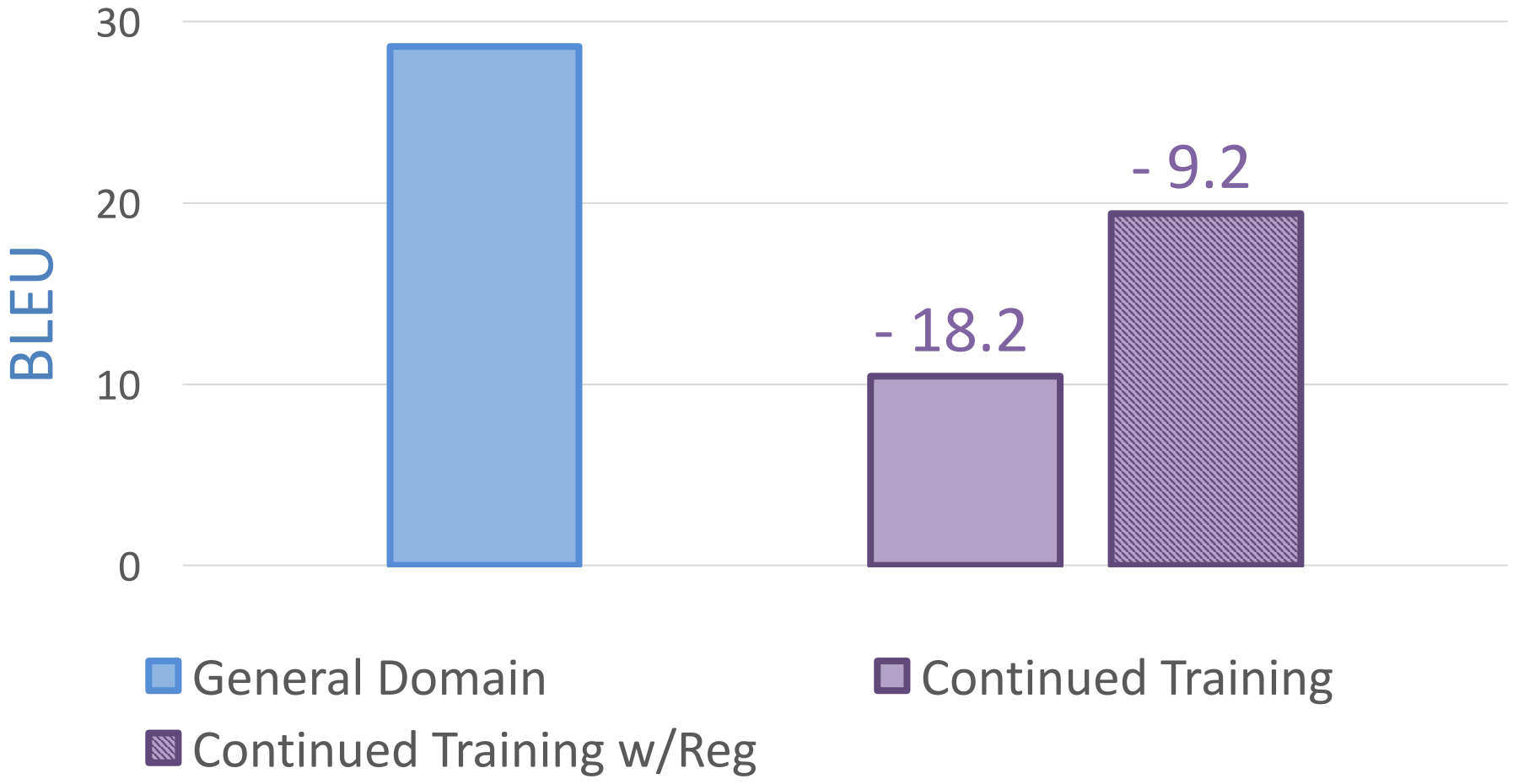


English → German Medical



Analysis

Russian → English General (patents)



NAACL 2019

Overcoming Catastrophic Forgetting During Domain Adaptation of Neural Machine Translation

Brian Thompson[†] **Jeremy Gwinnup**[°] **Huda Khayrallah**[†] **Kevin Duh**[†] **Philipp Koehn**[†]
[†]Johns Hopkins University, [°]Air Force Research Laboratory
{brian.thompson, huda, phi}@jhu.edu,
kevinduh@cs.jhu.edu,
jeremy.gwinnup.1@us.af.mil

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On the Impact of Various Types of Noise on Neural Machine Translation

Huda Khayrallah & Philipp Koehn

WNMT at ACL 2018 [Outstanding Contribution Award]

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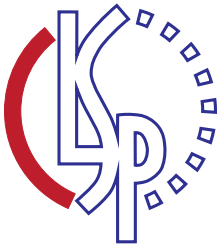
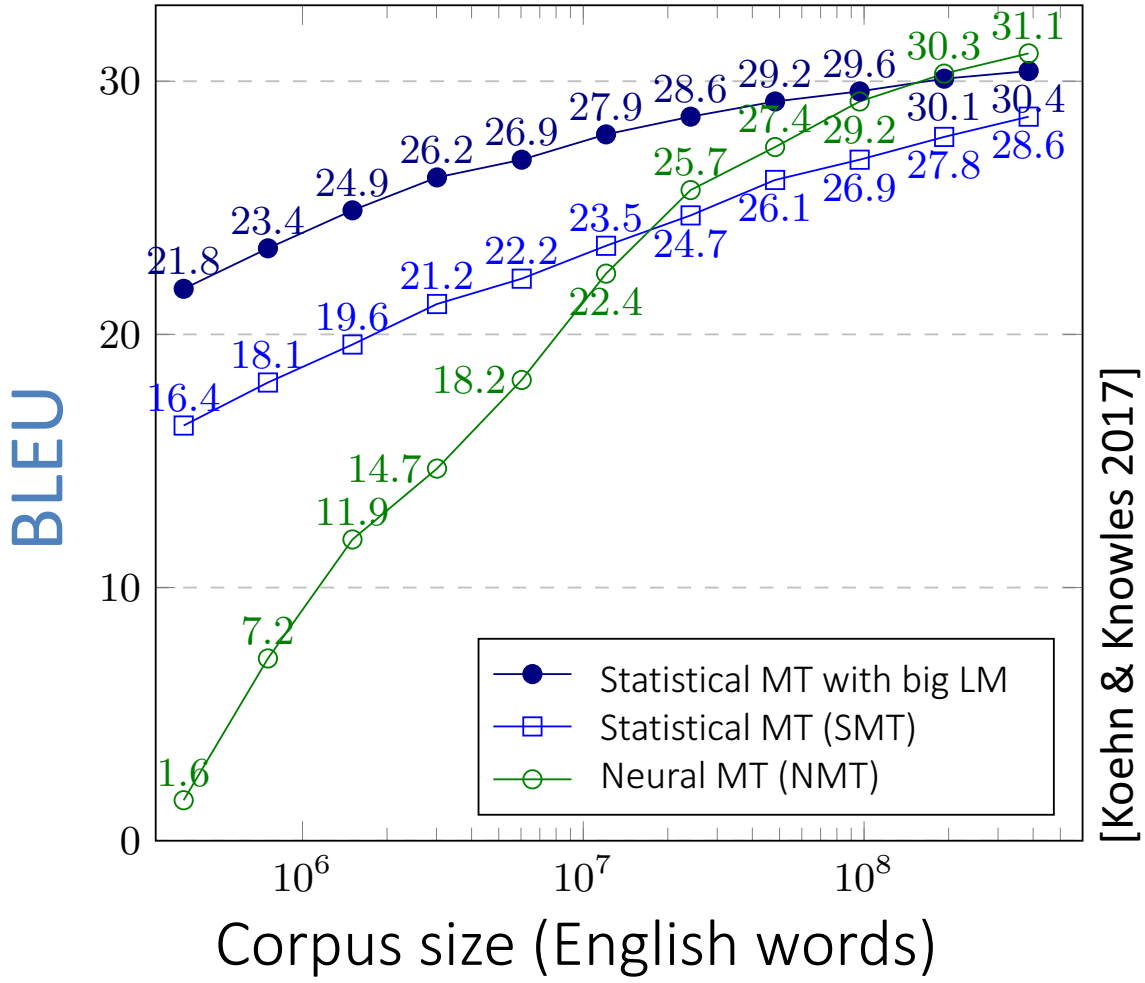


More data is better!

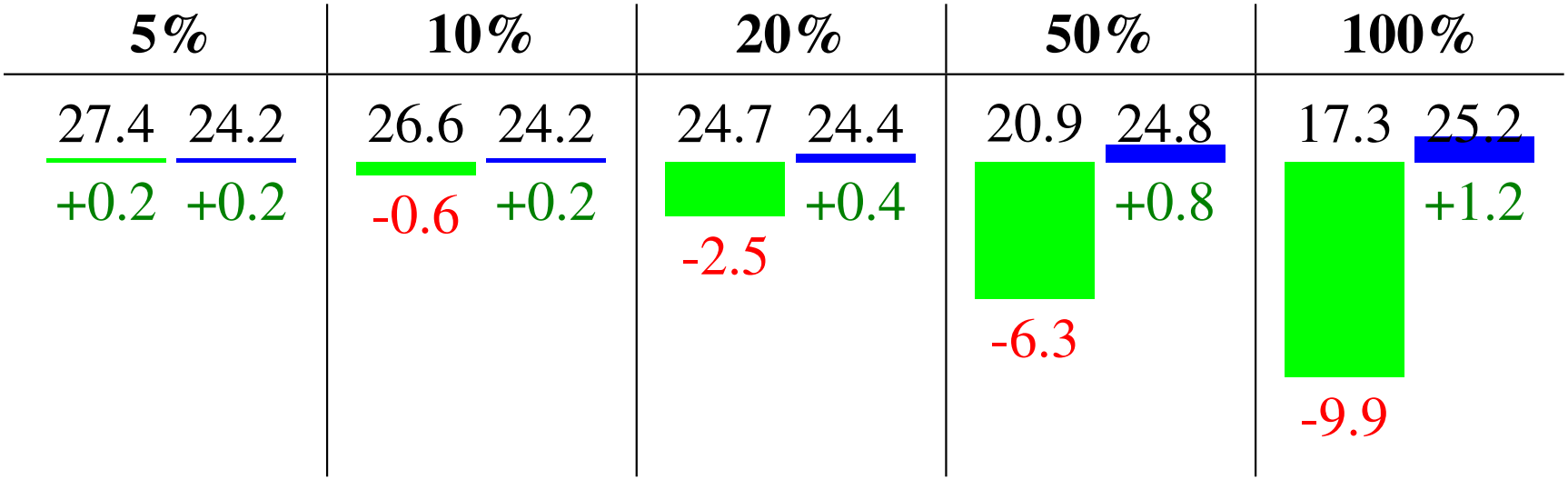


Let’s go get more data!

De→En translation

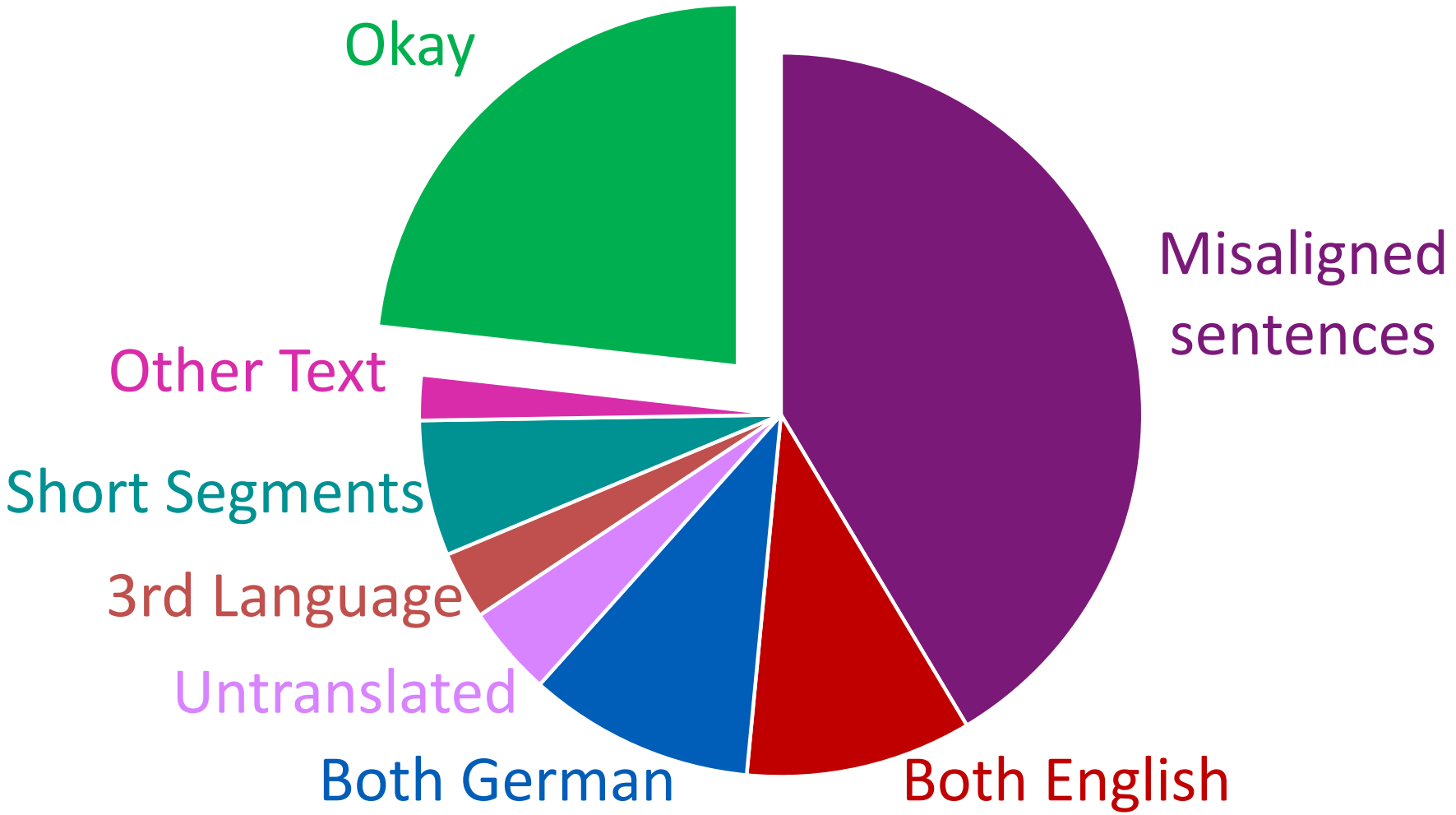
	NMT	SMT
WMT17	27.2	24.0
+ raw paracrawl	17.3 (-9.9)	25.2 (+1.2)

Raw Paracrawl



NMT SMT

Manual Analysis



Noise Types

- Misaligned Sentences
- Misordered words
- Wrong Language
- Untranslated Sentences
- Short Segments

Misaligned Sentences

Misaligned Sentences

Die Koalas sind süß	The koalas are cute
Die Kängurus springen	The kangaroos jump
Der Koala ist weich	The koala is soft
Das Känguru ist schnell	The kangaroo is fast

Misaligned Sentences

Die Koalas sind süß

Die Kängurus springen

Der Koala ist weich

Das Känguru ist schnell

The kangaroos jump

The koala is soft

The kangaroo is fast

The koalas are cute

Misaligned Sentences

5%		10%		20%		50%		100%	
26.5	24.0	26.5	24.0	26.3	23.9	26.1	23.9	25.3	23.4
-0.7	-0.0	-0.7	-0.0	-0.9	-0.1	-1.1	-0.1	-1.9	-0.6

NMT SMT

Misordered Words

Misordered Words (source)

Die Koalas sind süß	The koalas are cute
Die Kängurus springen	The kangaroos jump
Der Koala ist weich	The koala is soft
Das Känguru ist schnell	The kangaroo is fast

Misordered Words (source)

Koalas Die sind süß	The koalas are cute
Kängurus springen Die	The kangaroos jump
ist Der weich Koala	The koala is soft
schnell Känguru ist Das	The kangaroo is fast

Misordered Words (source)

5%		10%		20%		50%		100%	
26.9	24.0	26.6	23.6	26.4	23.9	26.6	23.6	25.5	23.7
-0.3	-0.0	-0.6	-0.4	-0.8	-0.1	-0.6	-0.4	-1.7	-0.3

NMT SMT

Misordered Words (target)

Die Koalas sind süß	The koalas are cute
Die Kängurus springen	The kangaroos jump
Der Koala ist weich	The koala is soft
Das Känguru ist schnell	The kangaroo is fast

Misordered Words (target)

Die Koalas sind süß	koalas cute are The
Die Kängurus springen	kangaroos The jump
Der Koala ist weich	is The soft koala
Das Känguru ist schnell	fast The is kangaroo

Misordered Words (target)

5%		10%		20%		50%		100%	
27.0	24.0	26.8	24.0	26.4	23.4	26.7	23.2	26.1	22.9
-0.2	-0.0	-0.4	-0.0	-0.8	-0.6	-0.5	-0.8	-1.1	-1.1

NMT SMT

Wrong Language

Wrong Language (French source)

Die Koalas sind süß	The koalas are cute
Die Kängurus springen	The kangaroos jump
Der Koala ist weich	The koala is soft
Das Känguru ist schnell	The kangaroo is fast

Wrong Language (French source)

Les koalas sont mignons	The koalas are cute
Les kangourous sautent	The kangaroos jump
Le koala est doux	The koala is soft
Le kangourou est rapide	The kangaroo is fast

Wrong Language (French source)

5%		10%		20%		50%		100%	
26.9	24.0	26.8	23.9	26.8	23.9	26.8	23.9	26.8	23.8
-0.3	-0.0	-0.4	-0.1	-0.4	-0.1	-0.4	-0.1	-0.4	-0.2

NMT SMT

Wrong Language (French target)

Die Koalas sind süß	The koalas are cute
Die Kängurus springen	The kangaroos jump
Der Koala ist weich	The koala is soft
Das Känguru ist schnell	The kangaroo is fast

Wrong Language (French target)

Die Koalas sind süß	Les koalas sont mignons
Die Kängurus springen	Les kangourous sautent
Der Koala ist weich	Le koala est doux
Das Känguru ist schnell	Le kangourou est rapide

Wrong Language (French target)

5%		10%		20%		50%		100%	
26.7	24.0	26.6	23.9	26.7	23.8	26.2	23.5	25.0	23.4
-0.5	-0.0	-0.6	-0.1	-0.5	-0.2	-1.0	-0.5	-2.2	-0.6

NMT SMT

Untranslated

Untranslated (English Source)

Die Koalas sind süß	The koalas are cute
Die Kängurus springen	The kangaroos jump
Der Koala ist weich	The koala is soft
Das Känguru ist schnell	The kangaroo is fast

Untranslated (English source)

The koalas are cute
The kangaroos jump
The koala is soft
The kangaroo is fast

The koalas are cute
The kangaroos jump
The koala is soft
The kangaroo is fast

Untranslated (English source)

5%		10%		20%		50%		100%	
27.2	23.9	27.0	23.9	26.7	23.6	26.8	23.7	26.9	23.5
-0.0	-0.1	-0.2	-0.1	-0.5	-0.4	-0.4	-0.3	-0.3	-0.5

NMT SMT

Untranslated (German target)

Die Koalas sind süß	The koalas are cute
Die Kängurus springen	The kangaroos jump
Der Koala ist weich	The koala is soft
Das Känguru ist schnell	The kangaroo is fast

Untranslated (German target)

Die Koalas sind süß

Die Kängurus springen

Der Koala ist weich

Das Känguru ist schnell

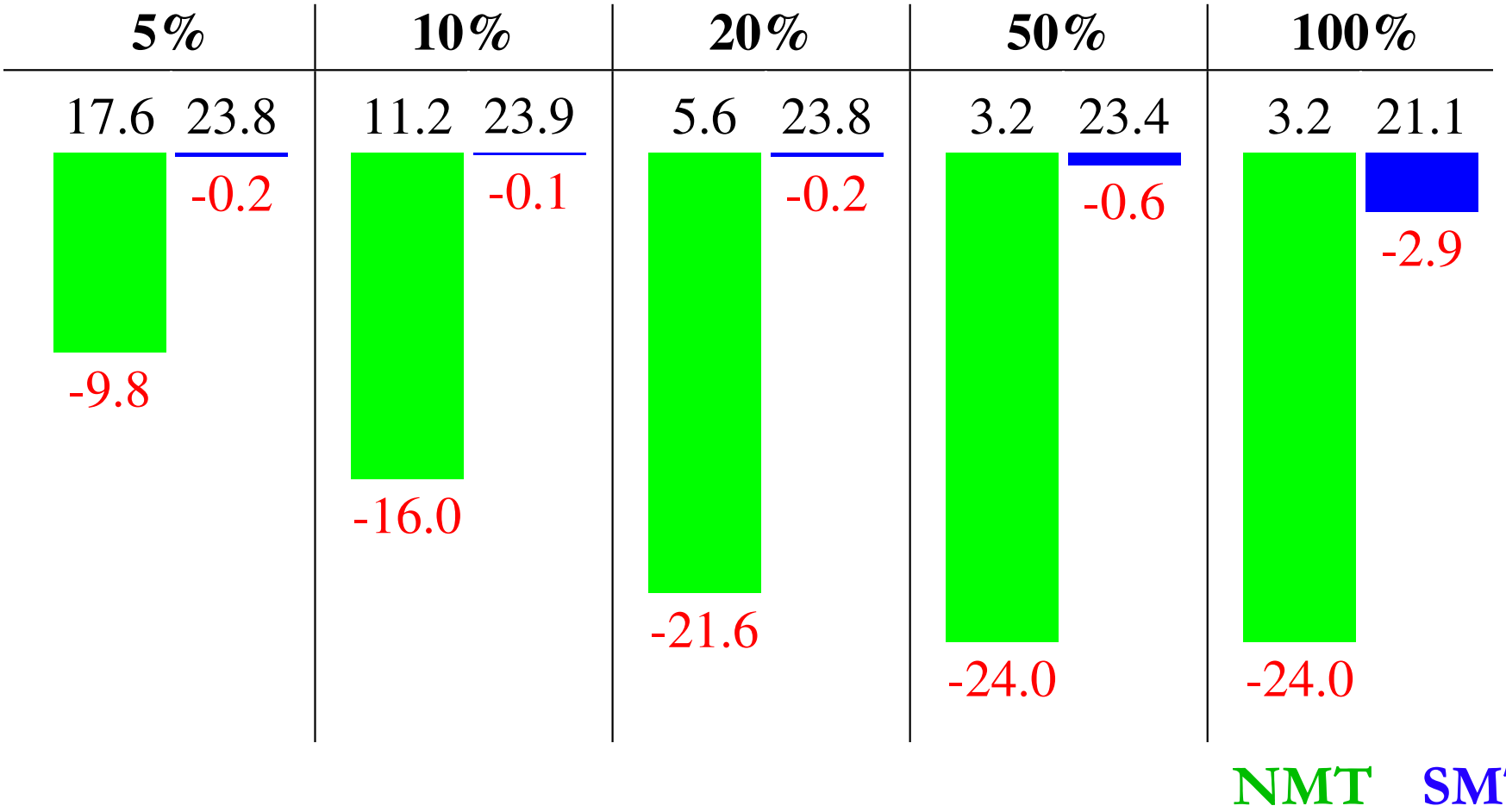
Die Koalas sind süß

Die Kängurus springen

Der Koala ist weich

Das Känguru ist schnell

Untranslated (German target)



Short Segments

Short Segments

Die	The
süß	cute
Känguru	Kangaroo
schnell	fast

Short Segments

≤ 2 words

5%		10%		20%	
27.1	24.1	26.5	23.9	26.7	23.8
-0.1	+0.1	-0.7	-0.1	-0.5	-0.2

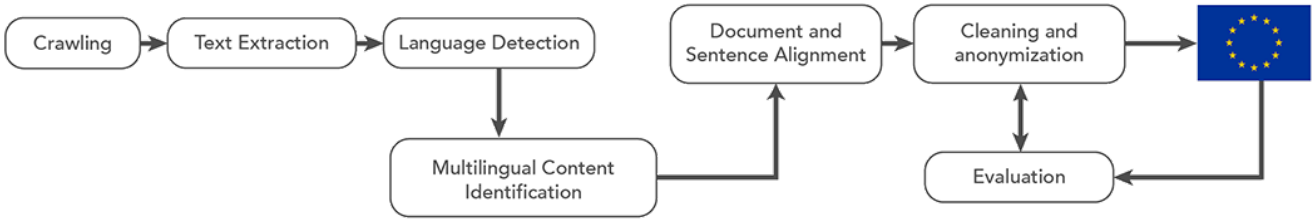
3-5 words

5%		10%		20%		50%	
27.8	24.2	27.6	24.5	28.0	24.5	26.6	24.2
+0.6	+0.2	+0.4	+0.5	+0.8	+0.5	-0.6	+0.2

	5%		10%		20%		50%		100%	
MISALIGNED SENTENCES	26.5	24.0	26.5	24.0	26.3	23.9	26.1	23.9	25.3	23.4
	-0.7	-0.0	-0.7	-0.0	-0.9	-0.1	-1.1	-0.1	-1.9	-0.6
MISORDERED WORDS (SOURCE)	26.9	24.0	26.6	23.6	26.4	23.9	26.6	23.6	25.5	23.7
	-0.3	-0.0	-0.6	-0.4	-0.8	-0.1	-0.6	-0.4	-1.7	-0.3
MISORDERED WORDS (TARGET)	27.0	24.0	26.8	24.0	26.4	23.4	26.7	23.2	26.1	22.9
	-0.2	-0.0	-0.4	-0.0	-0.8	-0.6	-0.5	-0.8	-1.1	-1.1
WRONG LANGUAGE (FRENCH SOURCE)	26.9	24.0	26.8	23.9	26.8	23.9	26.8	23.9	26.8	23.8
	-0.3	-0.0	-0.4	-0.1	-0.4	-0.1	-0.4	-0.1	-0.4	-0.2
WRONG LANGUAGE (FRENCH TARGET)	26.7	24.0	26.6	23.9	26.7	23.8	26.2	23.5	25.0	23.4
	-0.5	-0.0	-0.6	-0.1	-0.5	-0.2	-1.0	-0.5	-2.2	-0.6
UNTRANSLATED (ENGLISH SOURCE)	27.2	23.9	27.0	23.9	26.7	23.6	26.8	23.7	26.9	23.5
	-0.0	-0.1	-0.2	-0.1	-0.5	-0.4	-0.4	-0.3	-0.3	-0.5
UNTRANSLATED (GERMAN TARGET)	17.6	23.8	11.2	23.9	5.6	23.8	3.2	23.4	3.2	21.1
	-9.8	-0.2	-16.0	-0.1	-21.6	-0.2	-24.0	-0.6	-24.0	-2.9
SHORT SEGMENTS (max 2)	27.1	24.1	26.5	23.9	26.7	23.8				
	-0.1	+0.1	-0.7	-0.1	-0.5	-0.2				
SHORT SEGMENTS (max 5)	27.8	24.2	27.6	24.5	28.0	24.5	26.6	24.2		
	+0.6	+0.2	+0.4	+0.5	+0.8	+0.5	-0.6	+0.2		
RAW CRAWL DATA	27.4	24.2	26.6	24.2	24.7	24.4	20.9	24.8	17.3	25.2
	+0.2	+0.2	-0.6	+0.2	-2.5	+0.4	-6.3	+0.8	-9.9	+1.2

Filtering methods

ParaCrawl



- BiCleaner [Espla-Gomis & Forcada 2009]
- Zipporah [Xu & Koehn 2017]
- WMT shared task [Koehn, Khayrallah, Heafield & Forcada 2018]
  - Dual Conditional Cross-Entropy Filtering [Junczys-Dowmunt 2018]
  - Zipporah [Khayrallah, Xu & Koehn 2018]

Overview

- Review of Neural Machine Translation (NMT)
- Review of Domain Adaptation
- Improving Domain Adaptation
  - Regularized Training Objective for Continued Training for Domain Adaptation in Neural Machine Translation [Khayrallah, Thompson, Duh & Koehn 2018]
- Analysis of Noisy Corpora
  - On the Impact of Various Types of Noise on Neural Machine Translation [Khayrallah & Koehn 2018]

Questions?