Coarse-to-Fine Syntactic MT using Language Projections

Slav Petrov Aria Haghighi Dan Klein

Why is MT so slow?

Why is MT so slow?

quiero salir

Why is MT so slow?

quiero

- ➡ i want
- ➡ i like
- ➡ i love
- ➡ i want to
- ➡ i like to
- ➡ i love to

salir

- ➡ leave
- ➡ to leave
- ➡ go
- ➡ to go
- ➡ exit
- ➡ to exit

Why is MT so slow?

quiero

- ➡ i want
- ➡ i like
- ➡ i love
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salir

- ➡ leave
- ➡ to leave
- ➡ go
- ➡ to go
- ➡ exit
- ➡ to exit

Translations:

Why is MT so slow?

quiero	salir
➡ i want	➡ leave
➡ i like	➡ to leave
➡ i love	➡ go
➡ i want to	➡ to go
➡ i like to	➡ exit
➡ i love to	➡ to exit

Translations:

Why is MT so slow?

quiero	salir
➡ i want	➡ leave
➡ i like	➡ to leave
➡ i love	➡ go
➡ i want to	➡ to go
➡ i like to	➡ exit
➡ i love to	➡ to exit

Translations:

Why is MT so slow?

quiero

- ➡ i want
- ➡ i like
- ➡ i love
- ➡ i want to
- ➡ i like to
- ➡ i love to

salir

- ➡ leave
- ➡ to leave
- ➡ go
- ➡ to go
- ➡ exit
- ➡ to exit

Translations:

- i want leave ✗

Why is MT so slow?

quiero

- ➡ i want
- ➡ i like
- ➡ i love
- ➡ i want to
- ➡ i like to
- ➡ i love to

salir

- ➡ leave
- ➡ to leave
- ➡ go
- ➡ to go
- ➡ exit
- ➡ to exit

Translations:

- i want leave ✗
- i like leave ✗

Why is MT so slow?

quiero

- ➡ i want
- ➡ i like
- ➡ i love
- ➡ i want to
- ➡ i like to
- ➡ i love to

salir

- ➡ leave
- ➡ to leave
- ➡ go
- ➡ to go
- ➡ exit
- ➡ to exit

Translations:

- i want leave ✗
- i like leave ✗
- i love leave ✗

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- ➡ i want
- ➡ i like
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salir

- ➡ leave
- ➡ to leave
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- ➡ to go
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- ➡ to exit

Translations:

- i want leave ✗
- i like leave ✗
- i love leave ✗
- i want to leave ✓

Why is MT so slow?

quiero

- ➡ i want
- ➡ i like
- ➡ i love
- ➡ i want to
- ➡ i like to
- ➡ i love to

salir

- ➡ leave
- ➡ to leave
- ➡ go
- ➡ to go
- ➡ exit
- ➡ to exit

Translations:

- i want leave ✗
- i like leave ✗
- i love leave ✗
- i want to leave ✓
- i like to leave ✗
- i love to leave ✗
- i want to leave ✗
- i like to leave ✗
- ...

Why is MT so slow?

There are too many words!

quiero

- ➡ i want
- ➡ i like
- ➡ i love
- ➡ i want to
- ➡ i like to
- ➡ i love to

salir

- ➡ leave
- ➡ to leave
- ➡ go
- ➡ to go
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Translations:

- i want leave ✗
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- ➡ to exit

Translations:

- i want leave ✗
- i like leave ✗
- i love leave ✗
- i want to leave ✓
- i like to leave ✗
- i love to leave ✗
- i want to leave ✗
- i like to leave ✗
- ...

Coarse-to-Fine Decoding

Spanish: reanudación del período de sesiones

Coarse-to-Fine Decoding

Spanish: reanudación del período de sesiones

English:

Coarse-to-Fine Decoding

Spanish: reanudación del período de sesiones

English:

Coarse-to-Fine Decoding

Spanish: reanudación del período de sesiones

English:

resumption	of	the	session

Coarse-to-Fine Decoding

Spanish: reanudación del período de sesiones

English:

resumption	of	the	session

Coarse-to-Fine Decoding

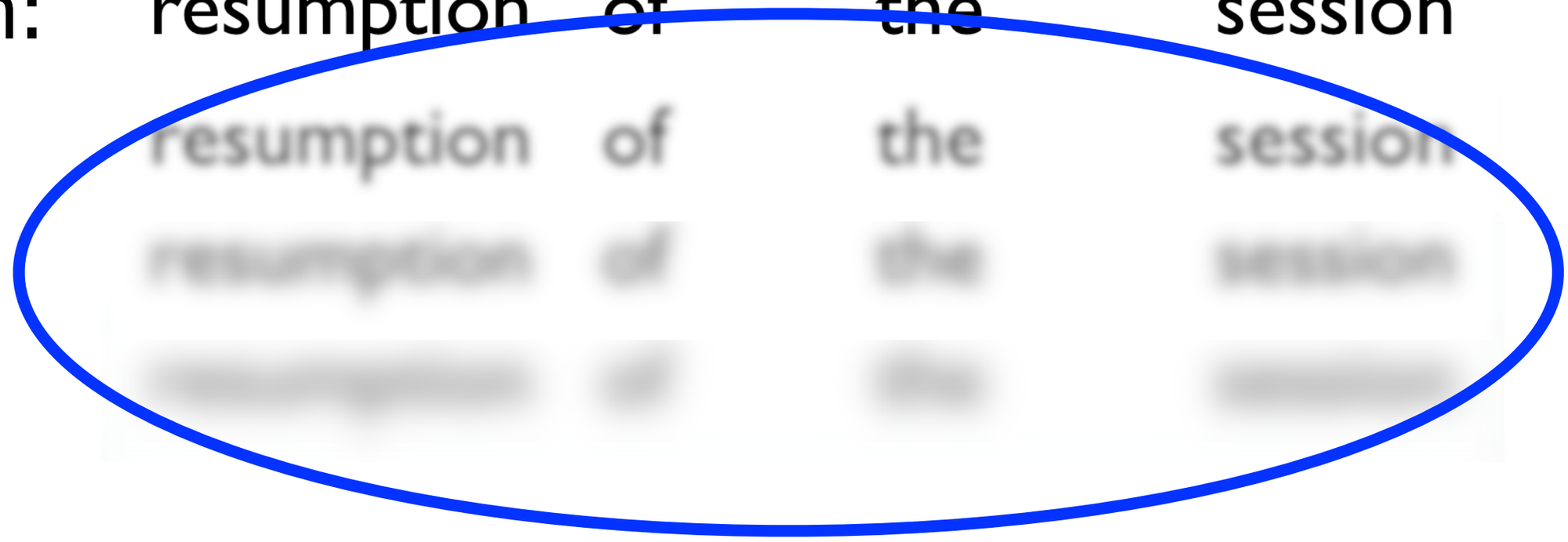
Spanish: reanudación del período de sesiones

English: resumption of the session

Coarse-to-Fine Decoding

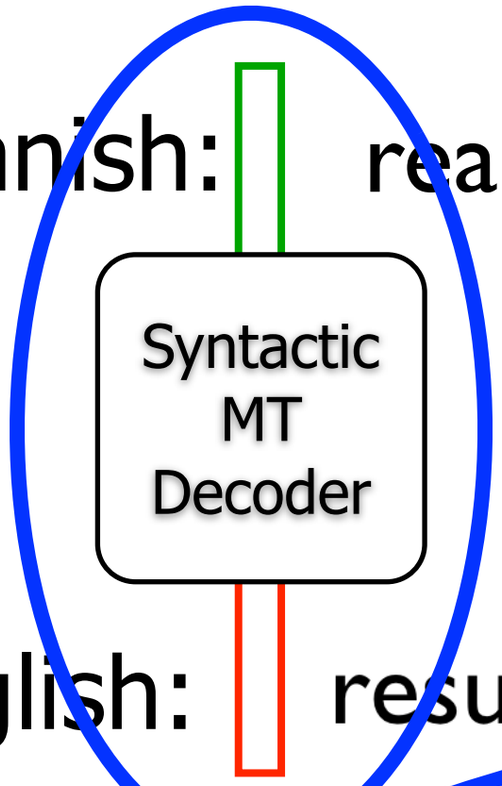
Spanish: reanudación del período de sesiones

English: resumption of the session



Coarse-to-Fine Decoding

Spanish: reanudación del período de sesiones



English: resumption of the session

resumption of the session

resumption of the session

resumption of the session

Coarse Pass

Coarse-to-Fine Syntactic MT using Language Projections

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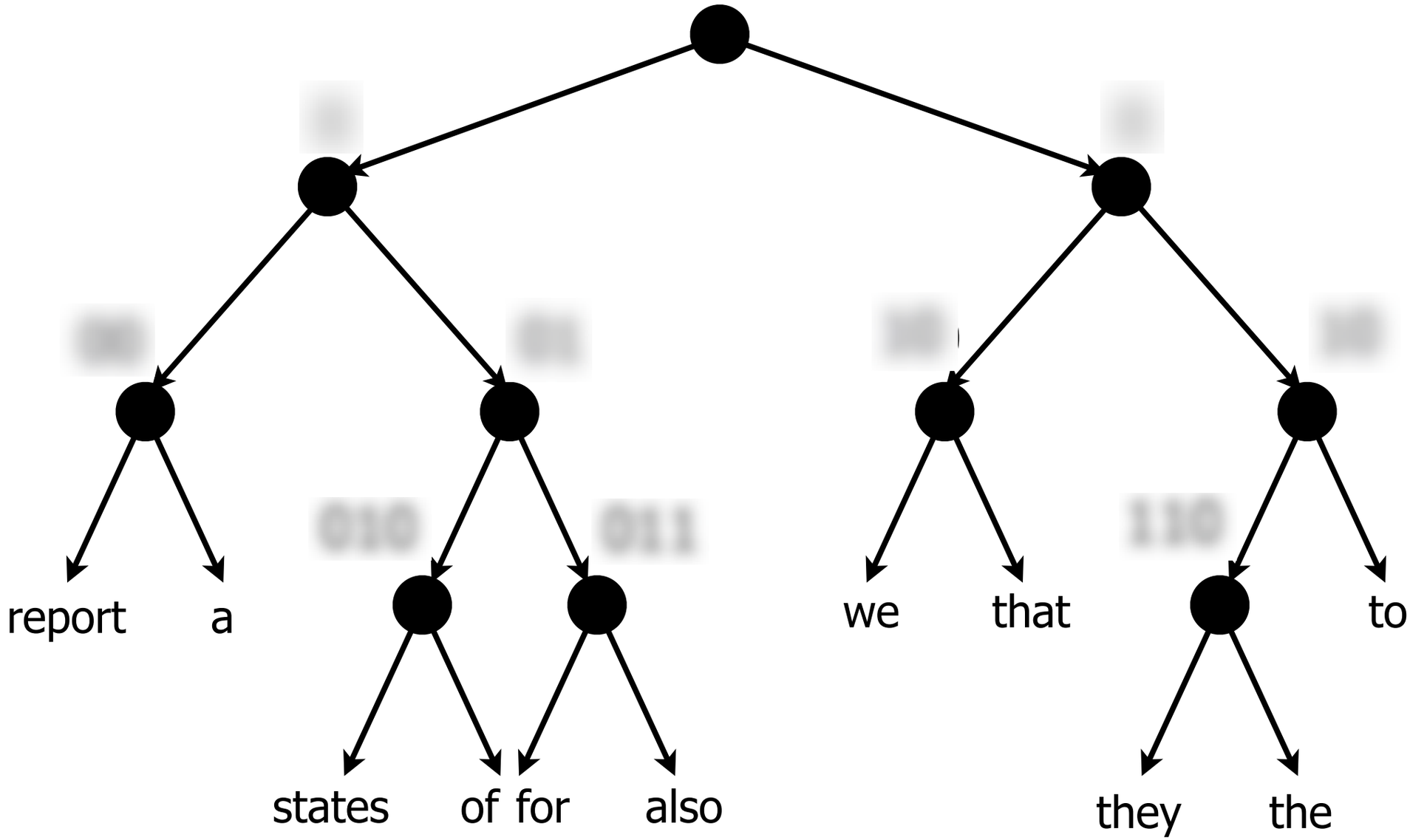
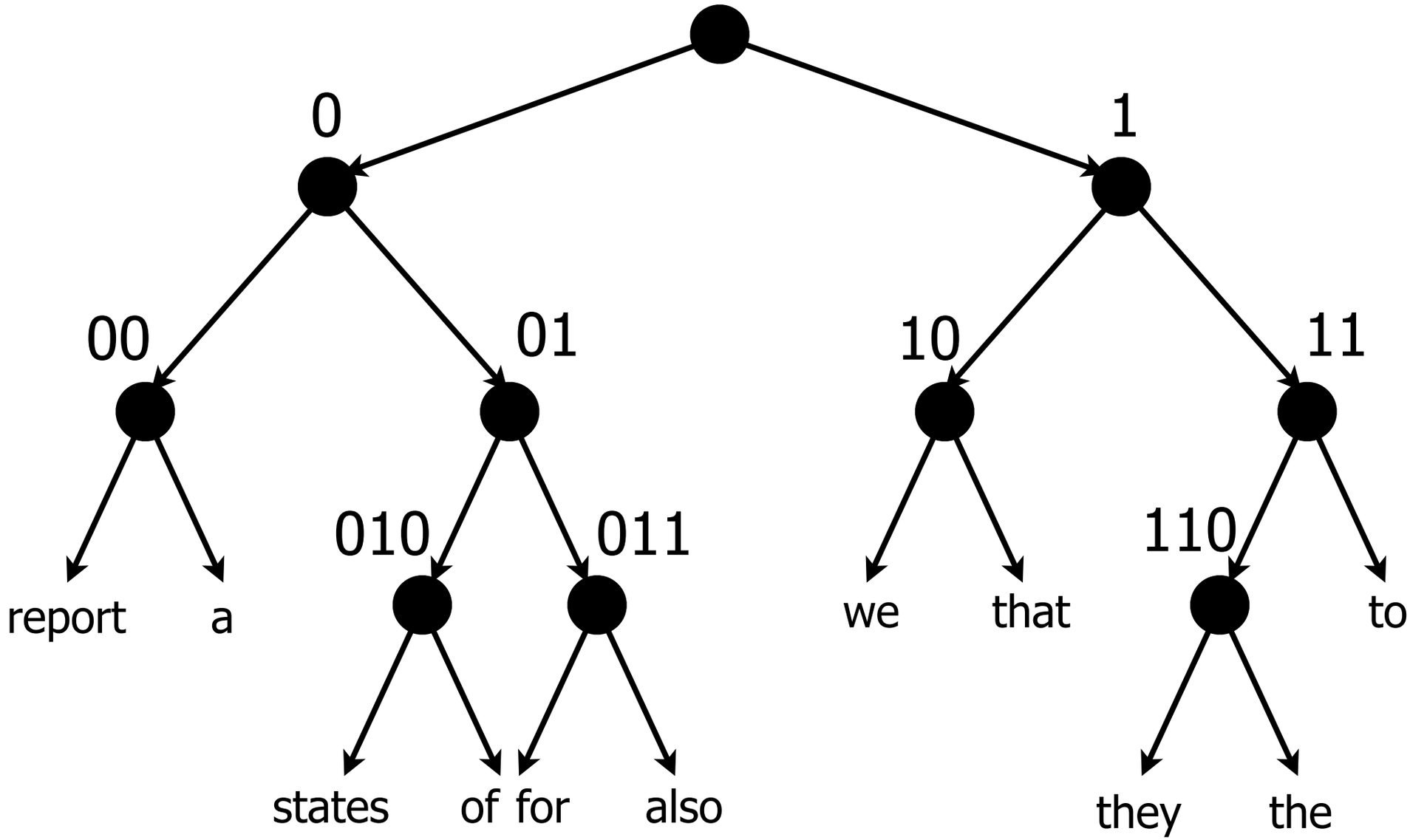
Second Pass

Fine Pass

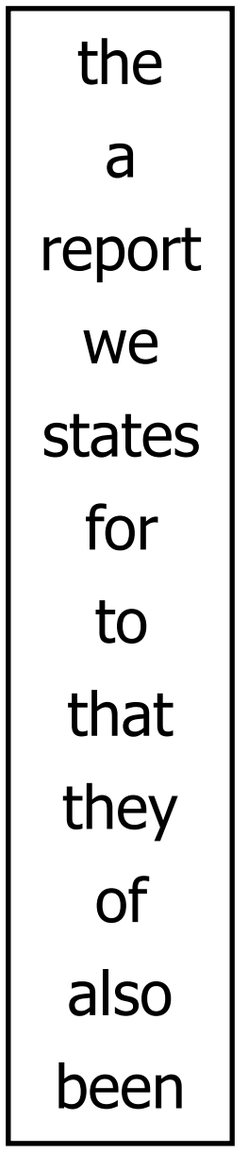
Hierarchical Clustering



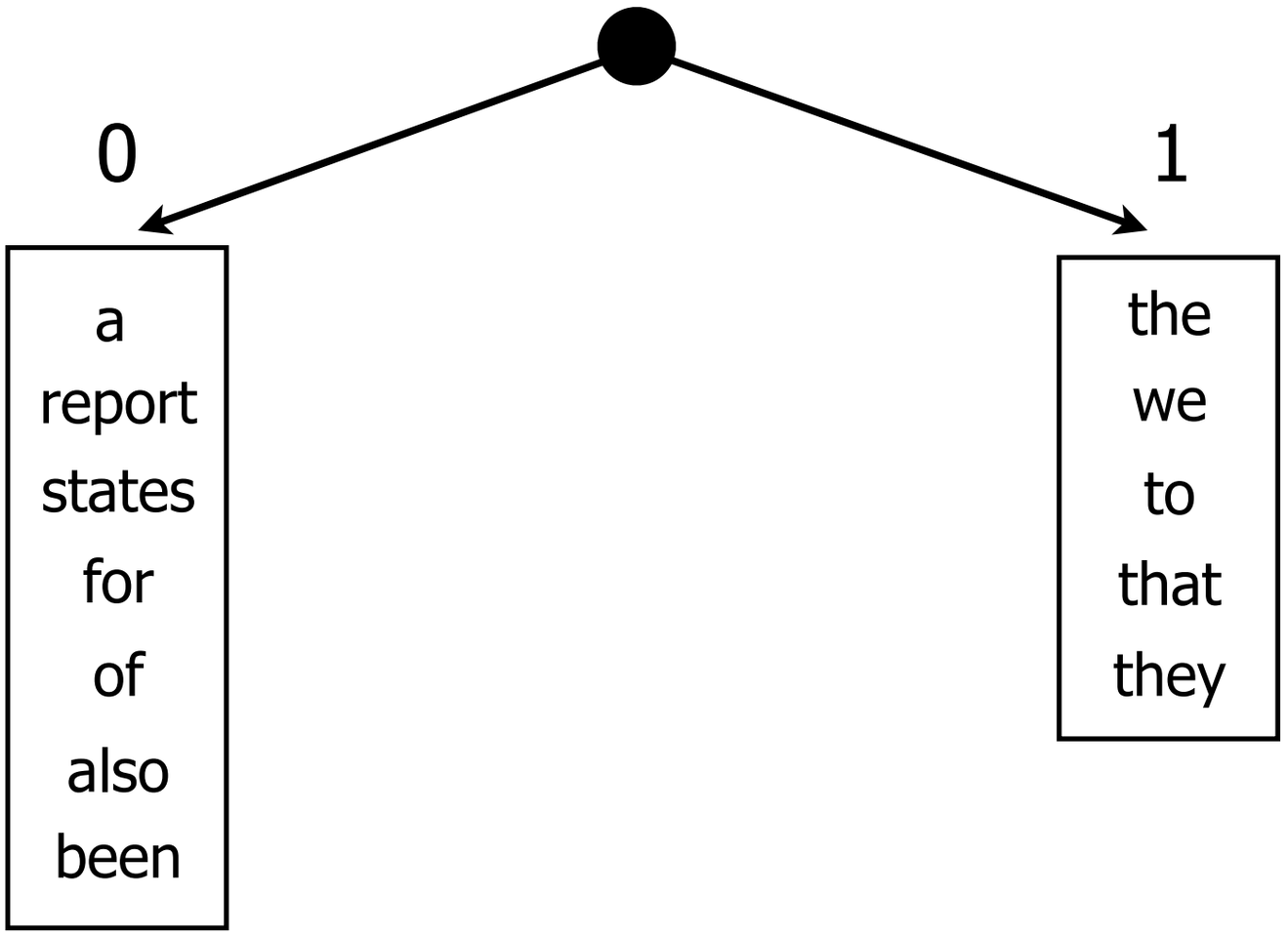
Hierarchical Clustering



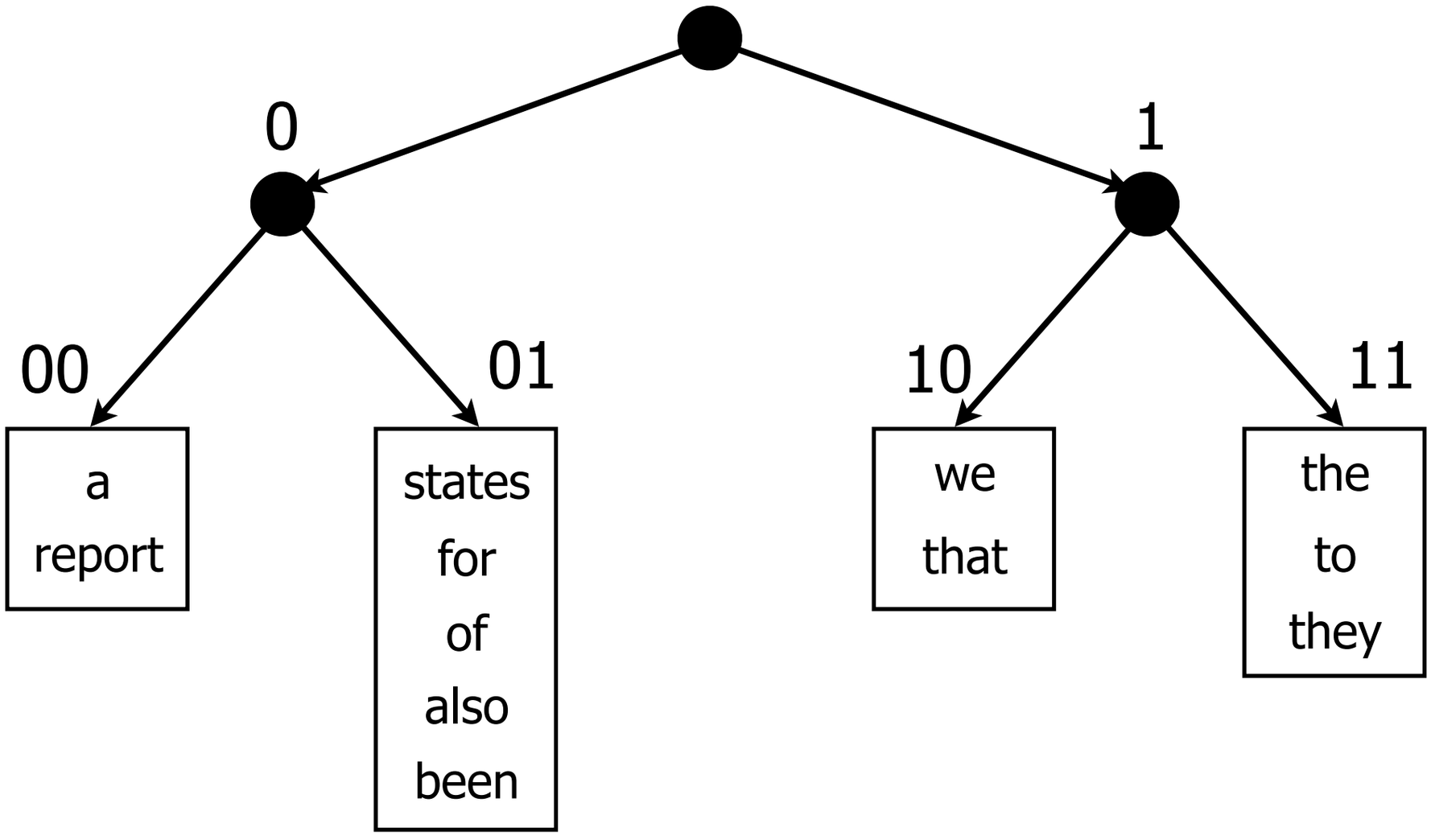
Random Clustering



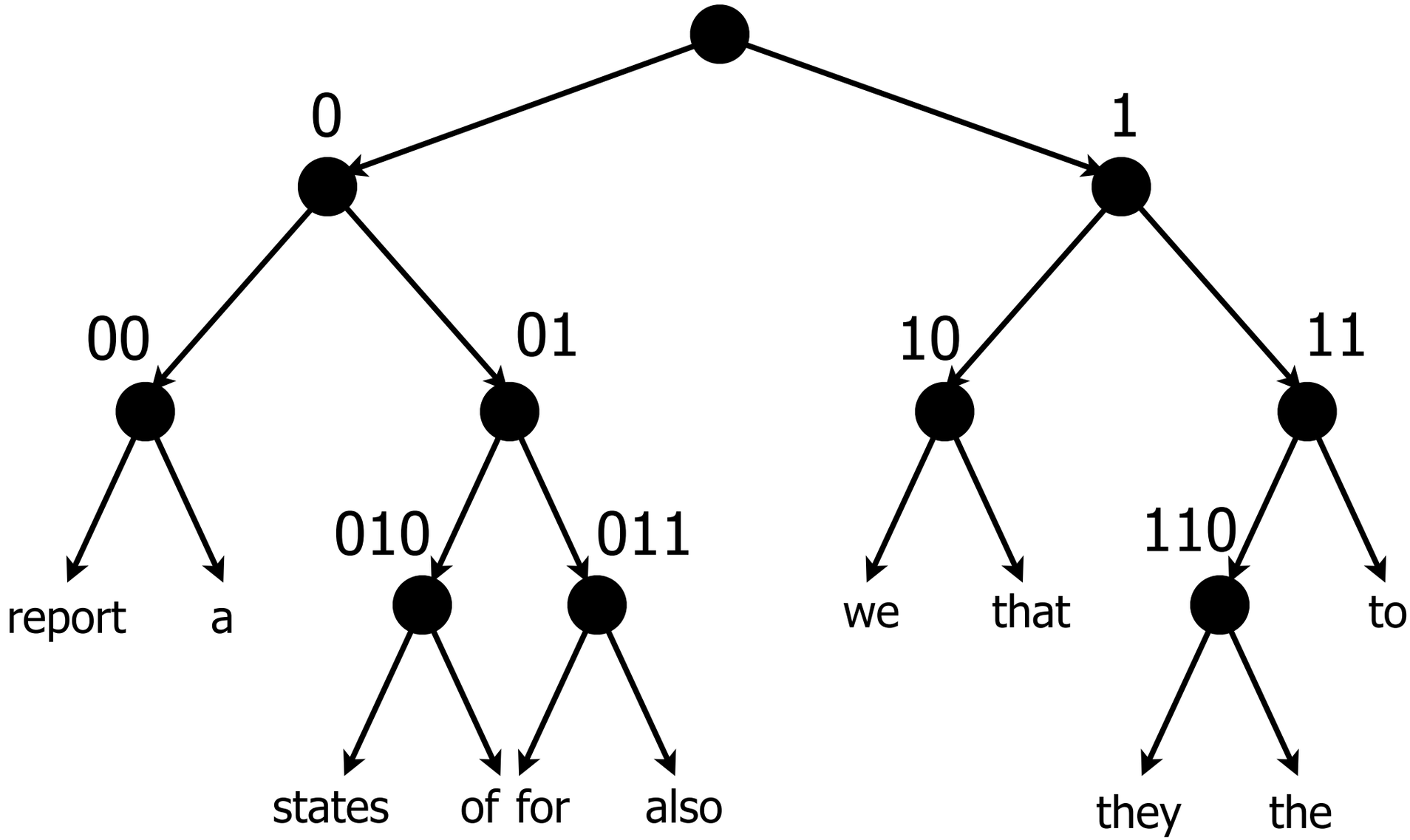
Random Clustering



Random Clustering

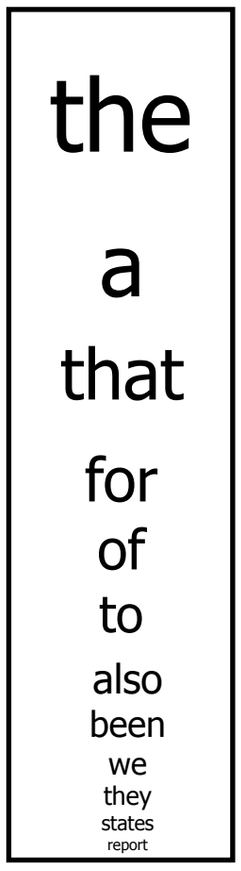


Random Clustering

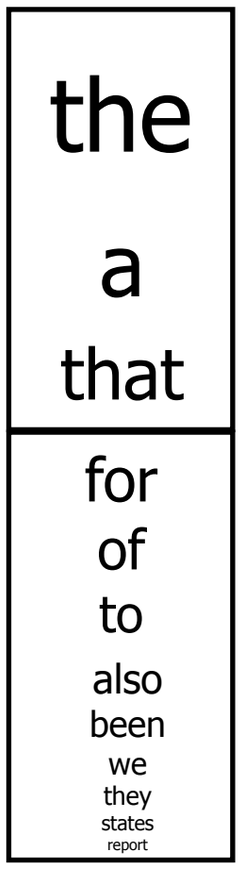


Frequency Clustering

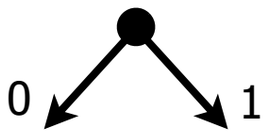
Frequency Clustering



Frequency Clustering



Frequency Clustering



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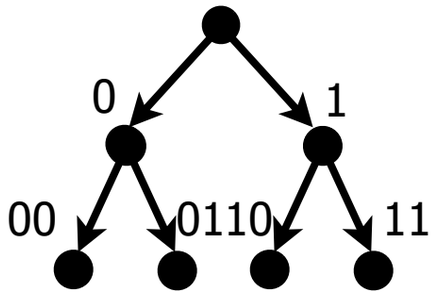
Frequency Clustering



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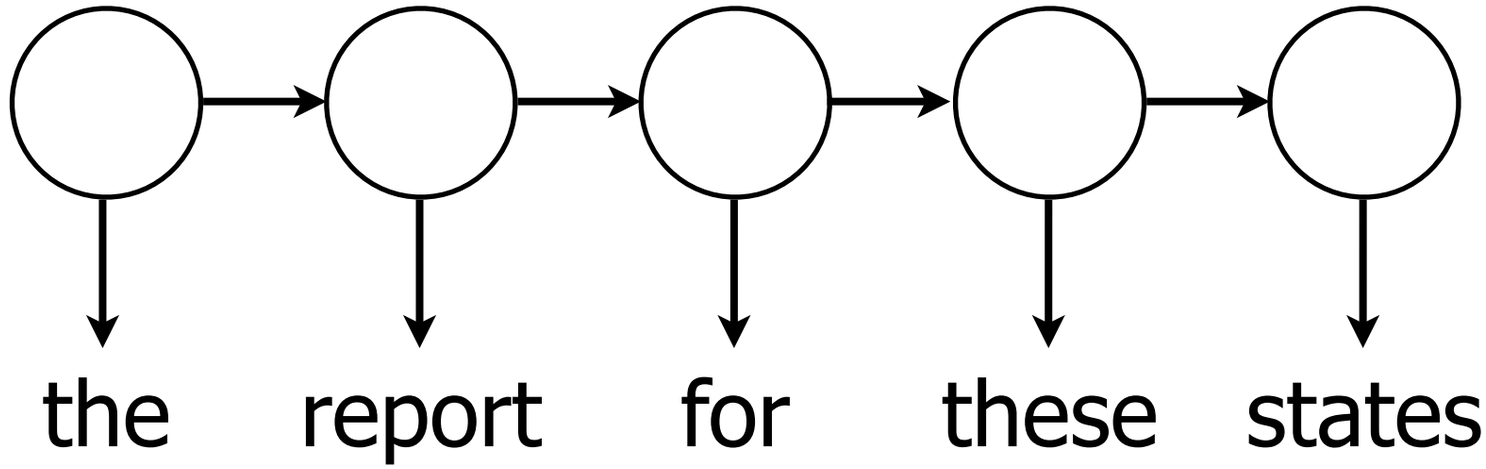
HMM Clustering

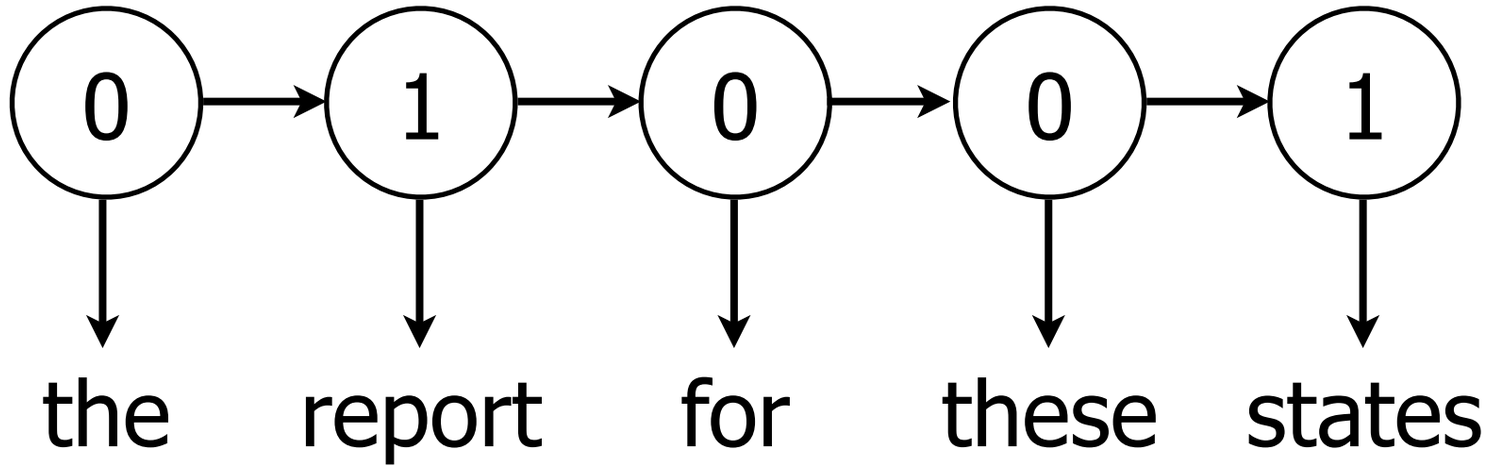
HMM Clustering

the report for these states

HMM Clustering



HMM Clustering



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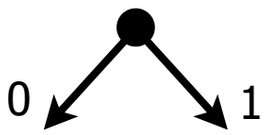

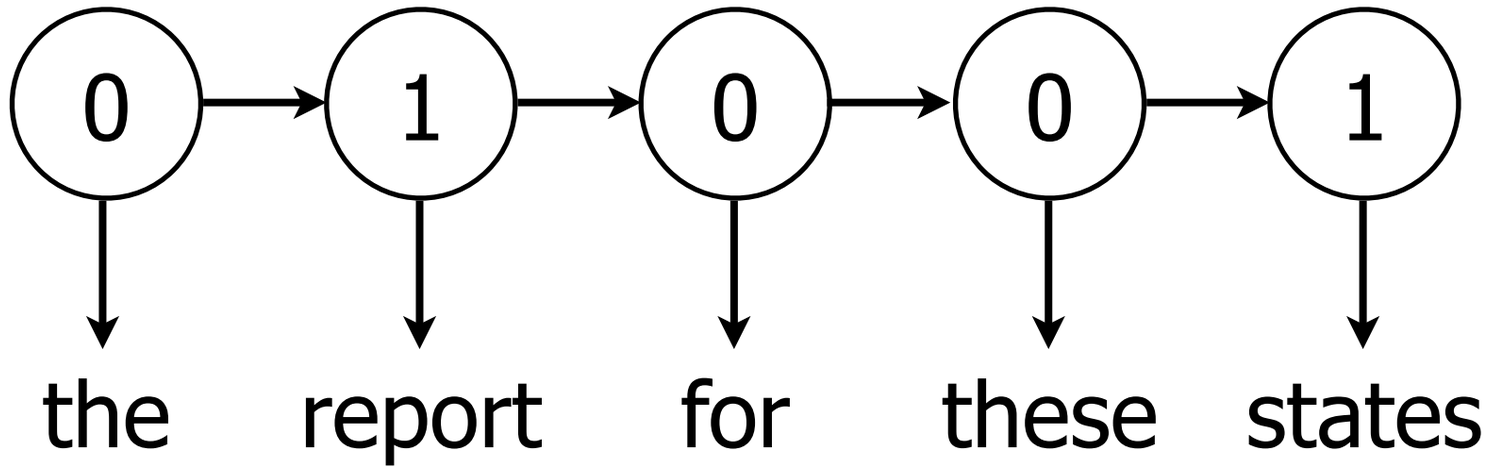

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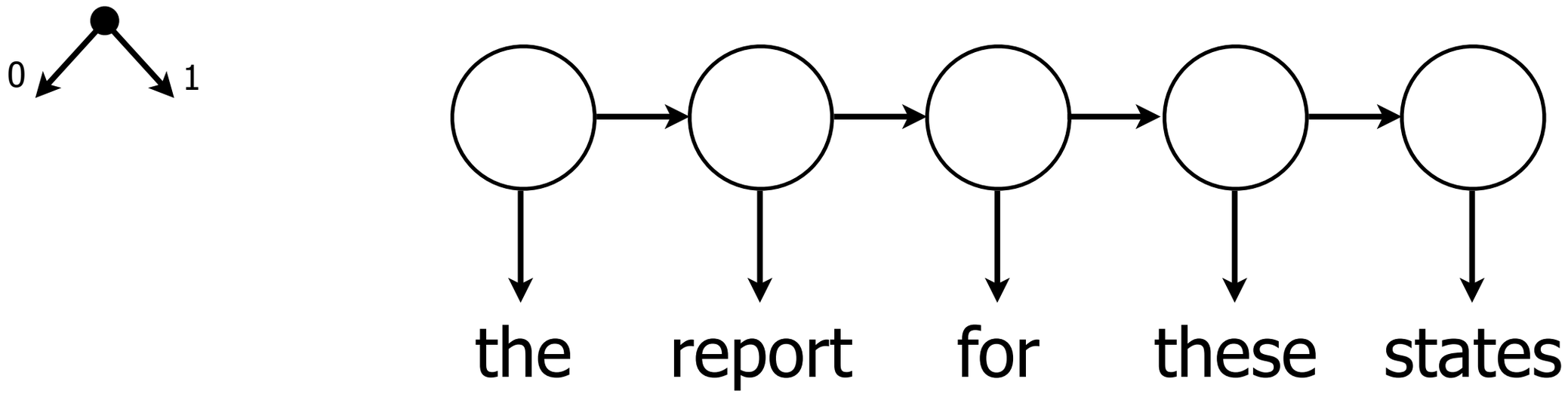

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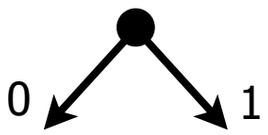

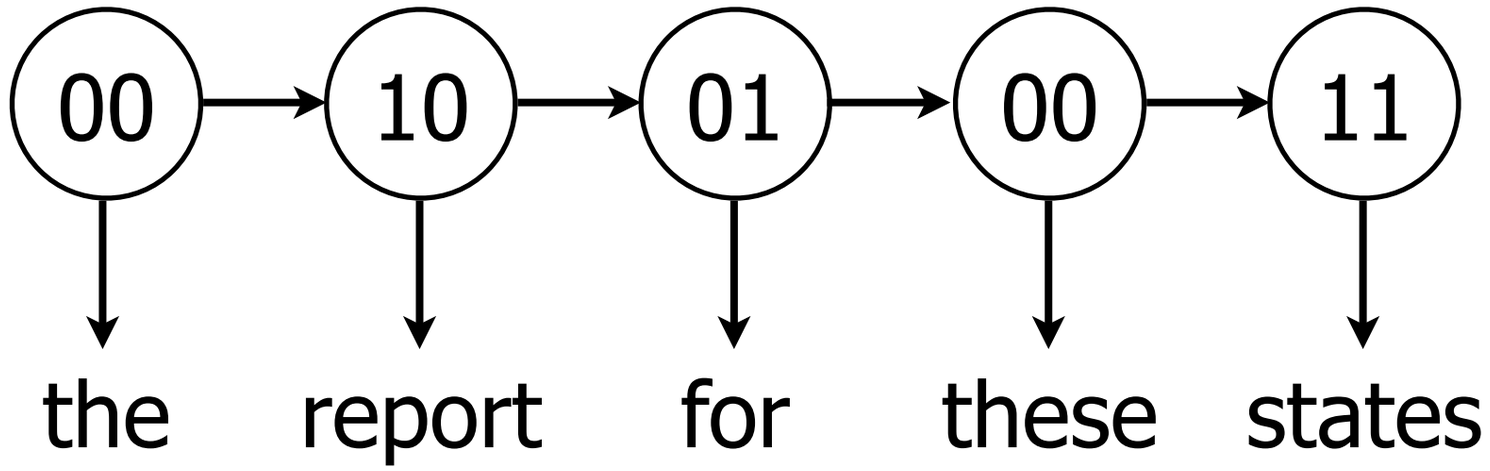

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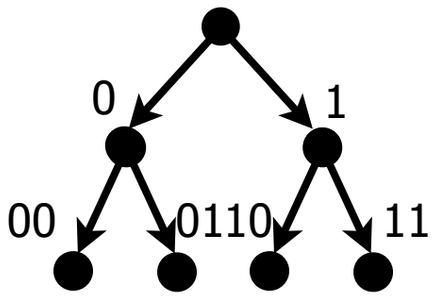
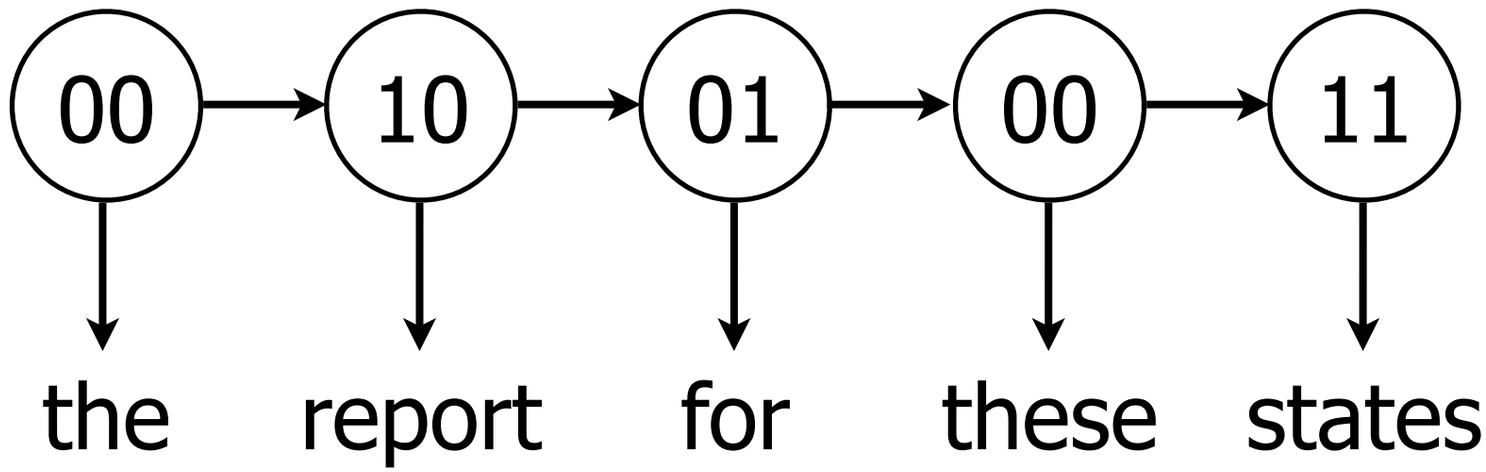
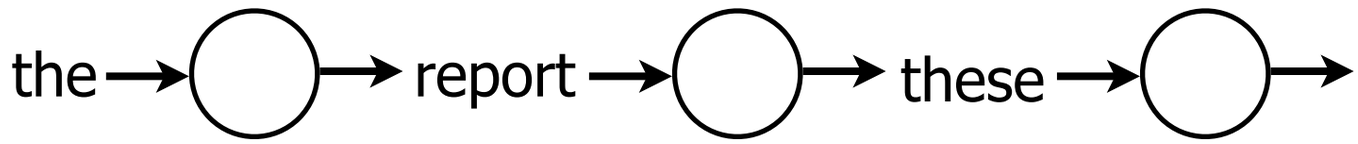




JCluster

[Goodman ’01]

JCluster



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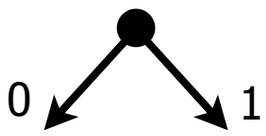
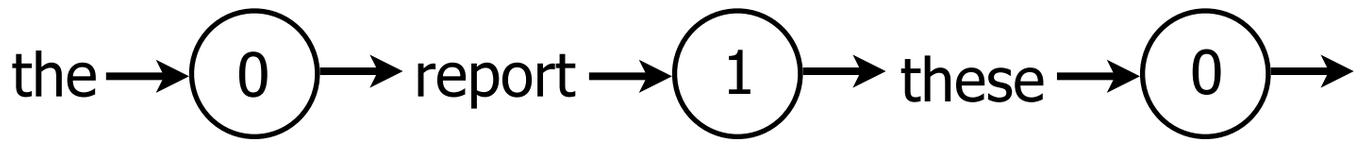
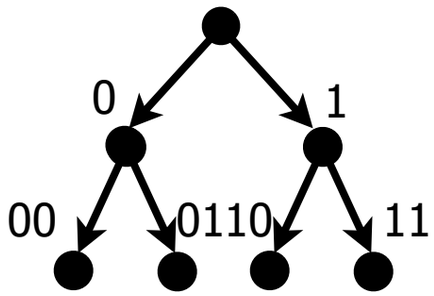
JCluster

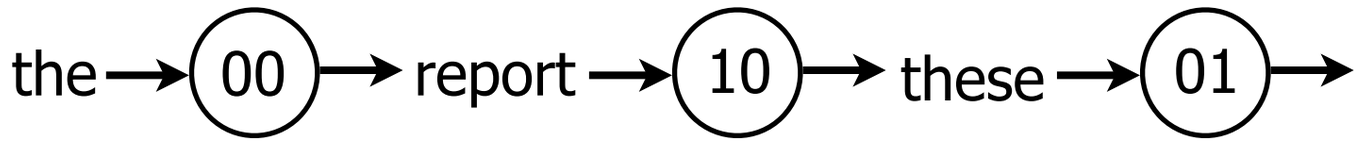




[Goodman ’01]

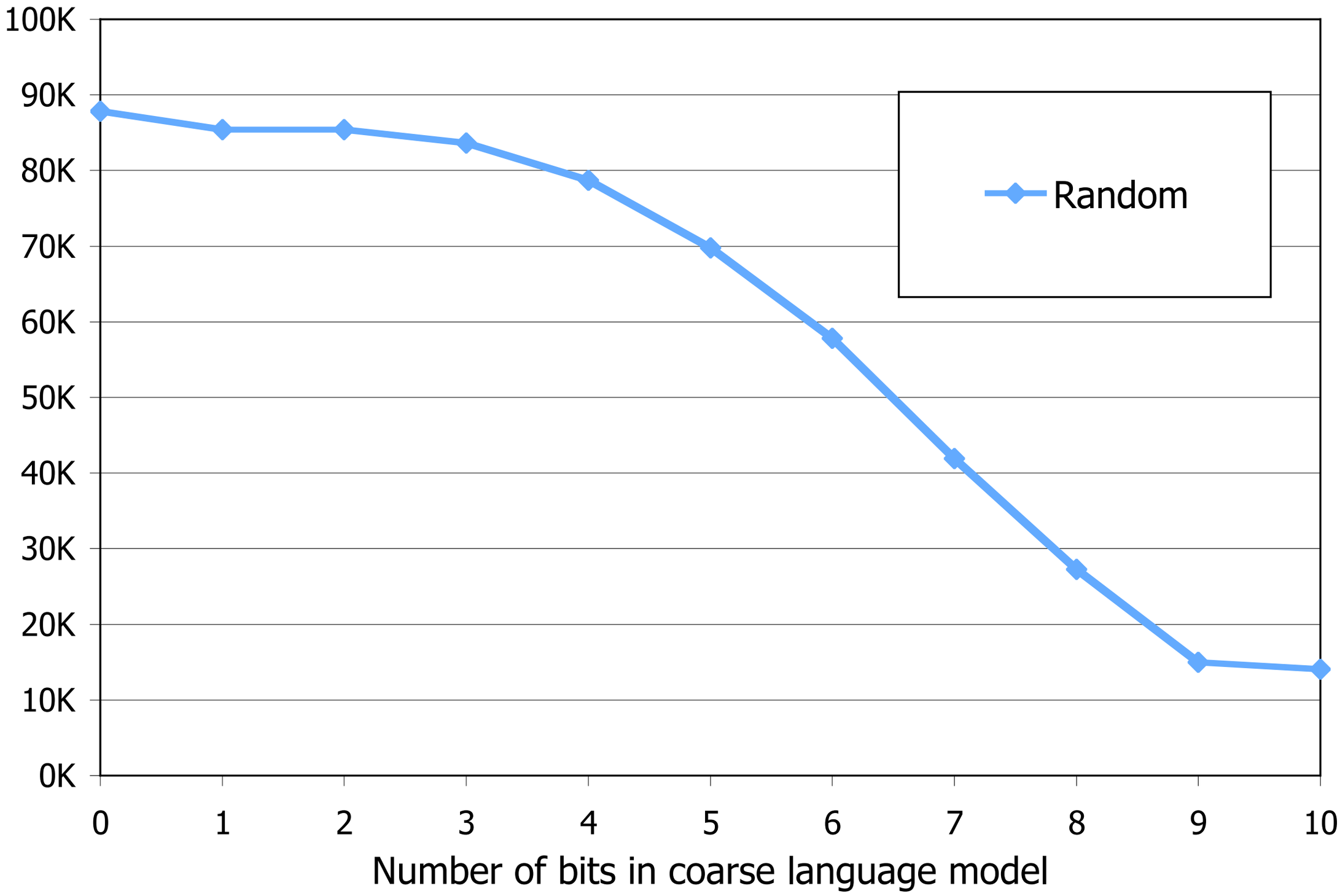
JCluster





[Goodman ’01]

Cluster Quality (Perplexity)



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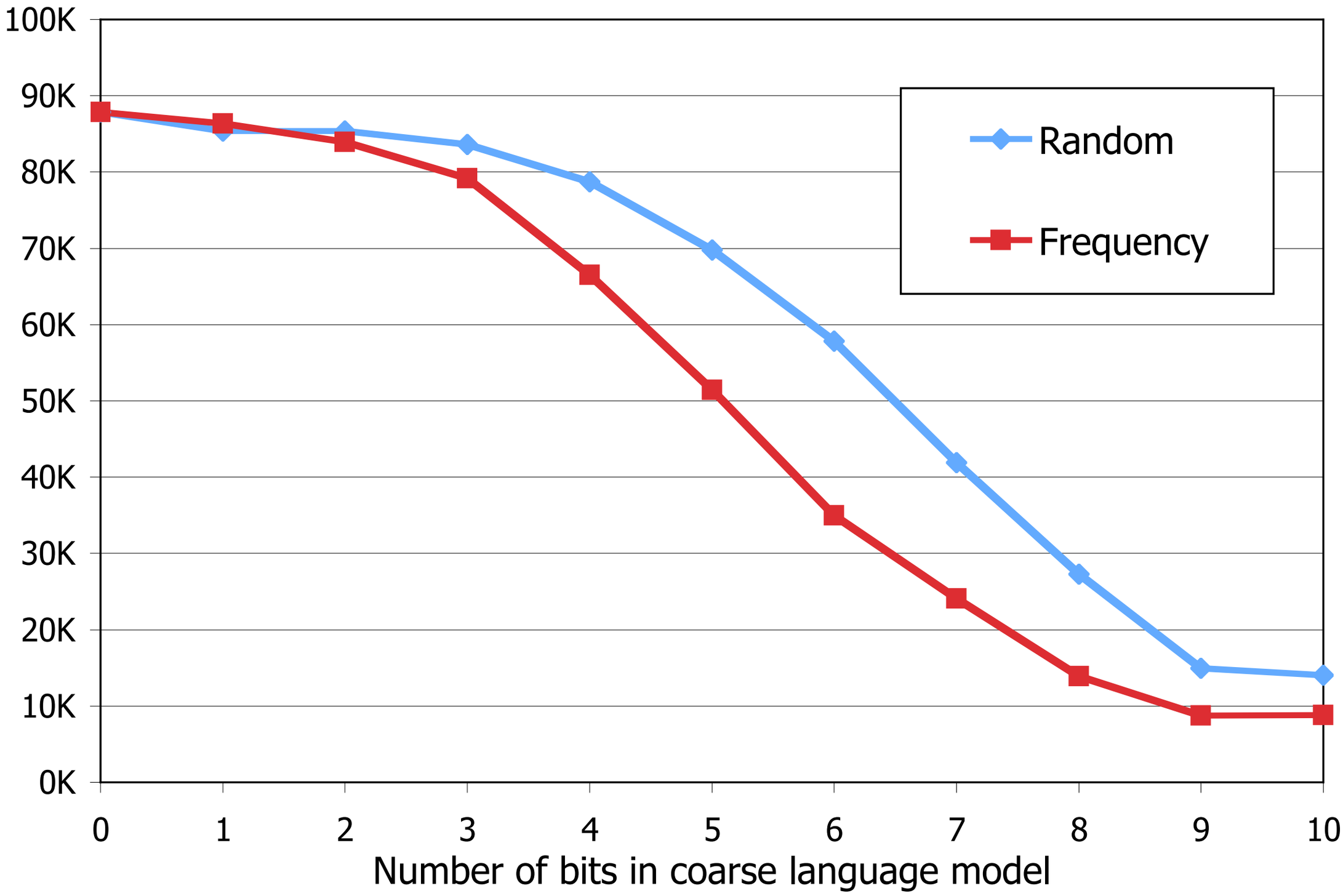

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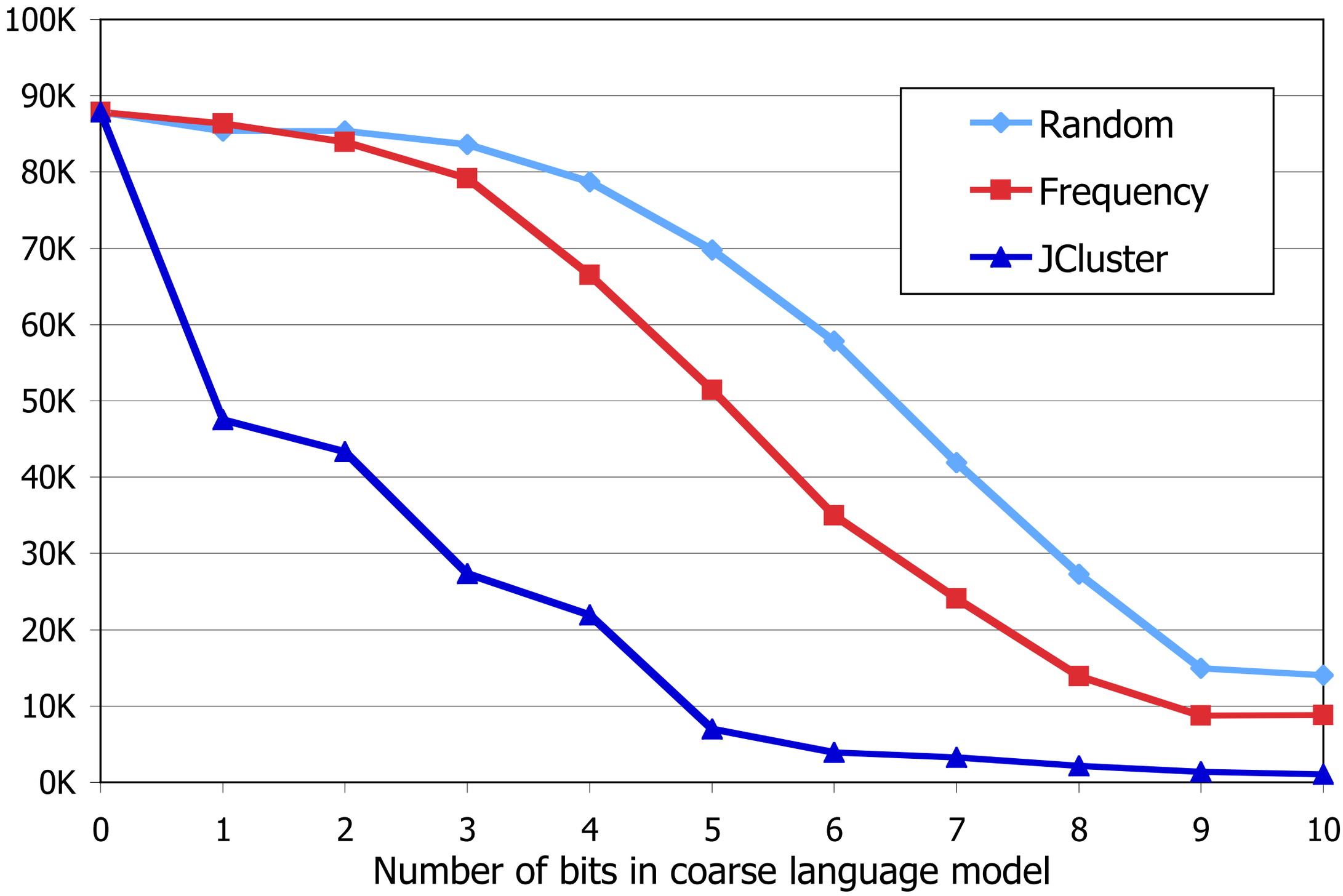

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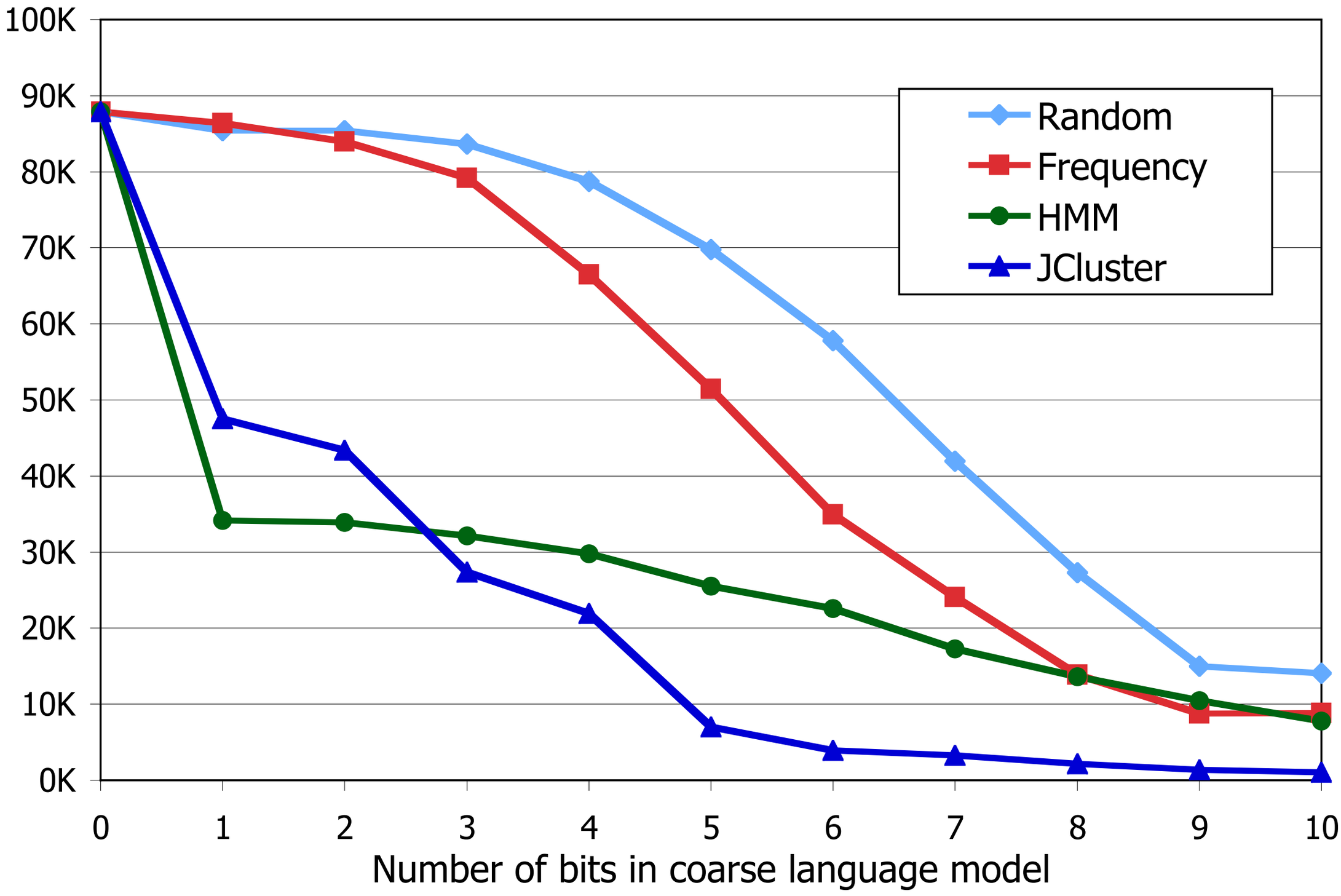


Hierarchical Clustering

Hierarchical Clustering

fine
the
a
they
we
states
report
also
in

Hierarchical Clustering

fine	1-bit
the	0
a	0
they	0
we	0
states	1
report	1
also	1
in	1

Hierarchical Clustering

fine	1-bit	2-bit
the	0	00
a	0	00
they	0	01
we	0	01
states	1	10
report	1	10
also	1	11
in	1	11

Hierarchical Clustering

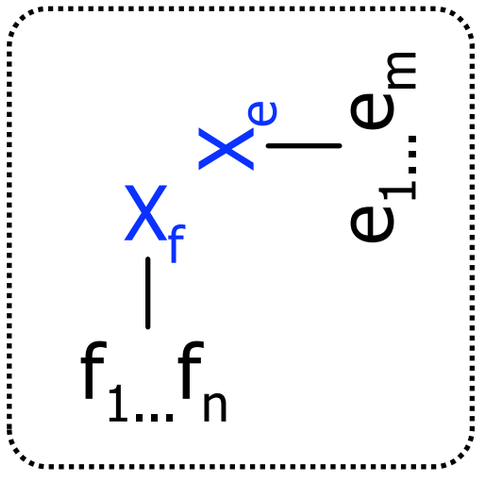
fine	1-bit	2-bit	3-bit
the	0	00	000
a	0	00	001
they	0	01	010
we	0	01	011
states	1	10	100
report	1	10	101
also	1	11	110
in	1	11	111

Inversion Transduction Grammars

[Wu ’97]

Inversion Transduction Grammars

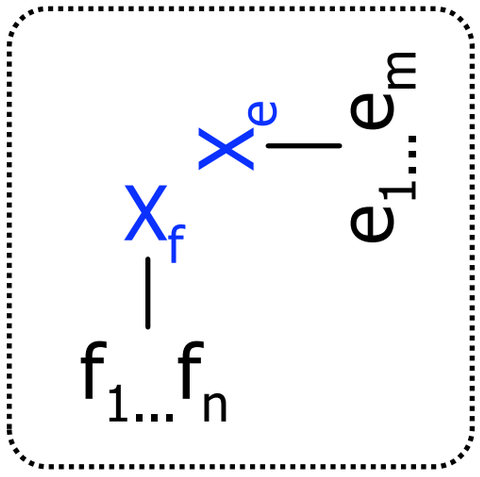
Generation



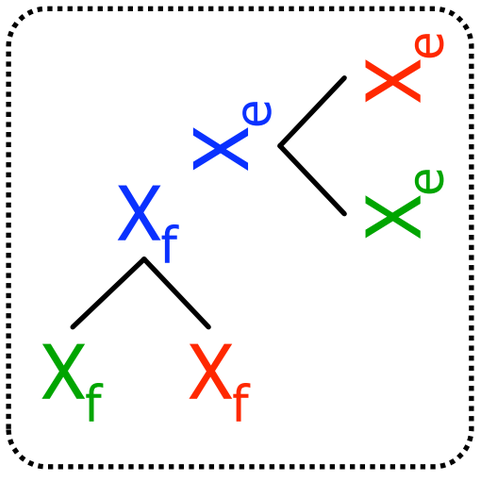
[Wu ’97]

Inversion Transduction Grammars

Generation

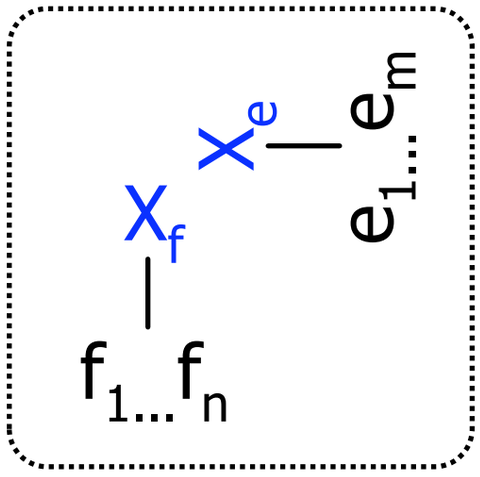
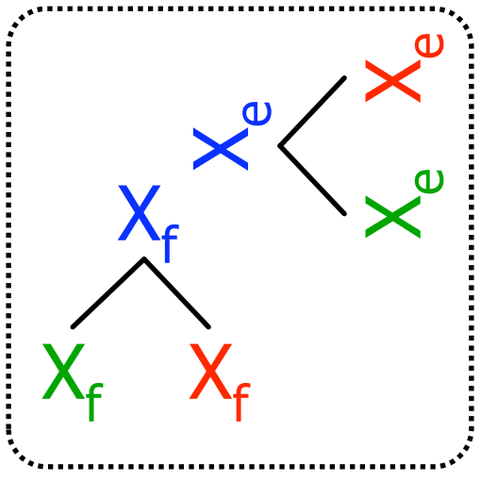
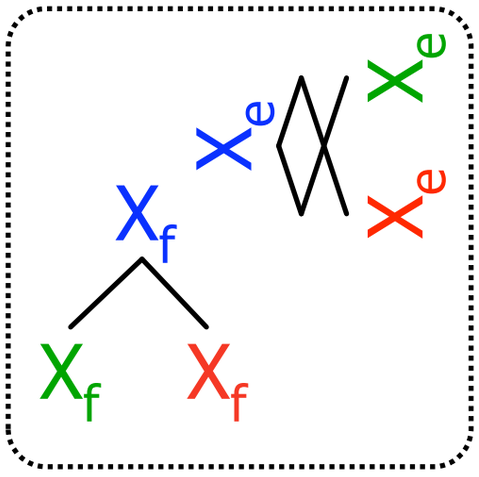


Monotonic Combination



[Wu ’97]

Inversion Transduction Grammars

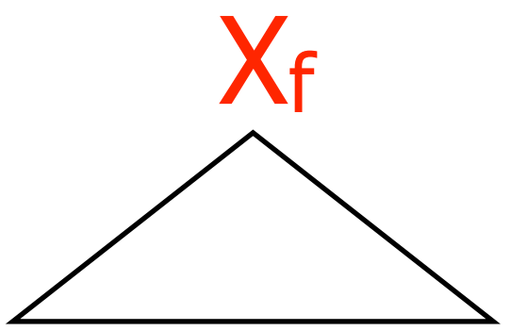
Generation	Monotonic Combination	Inverted Combination
		

[Wu ’97]

Translating with ITG (w/o LM)

reanudación del período de sesiones

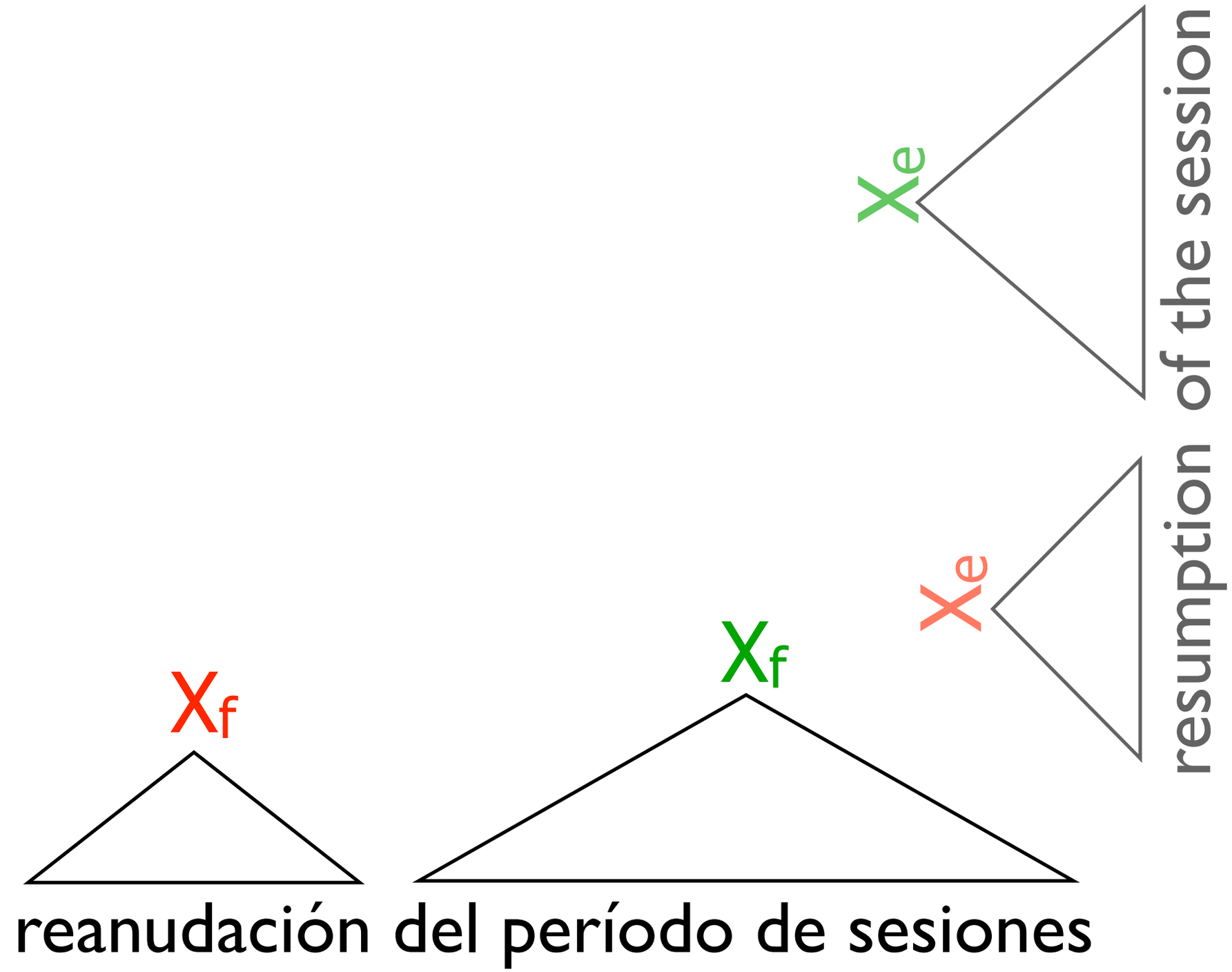
Translating with ITG (w/o LM)



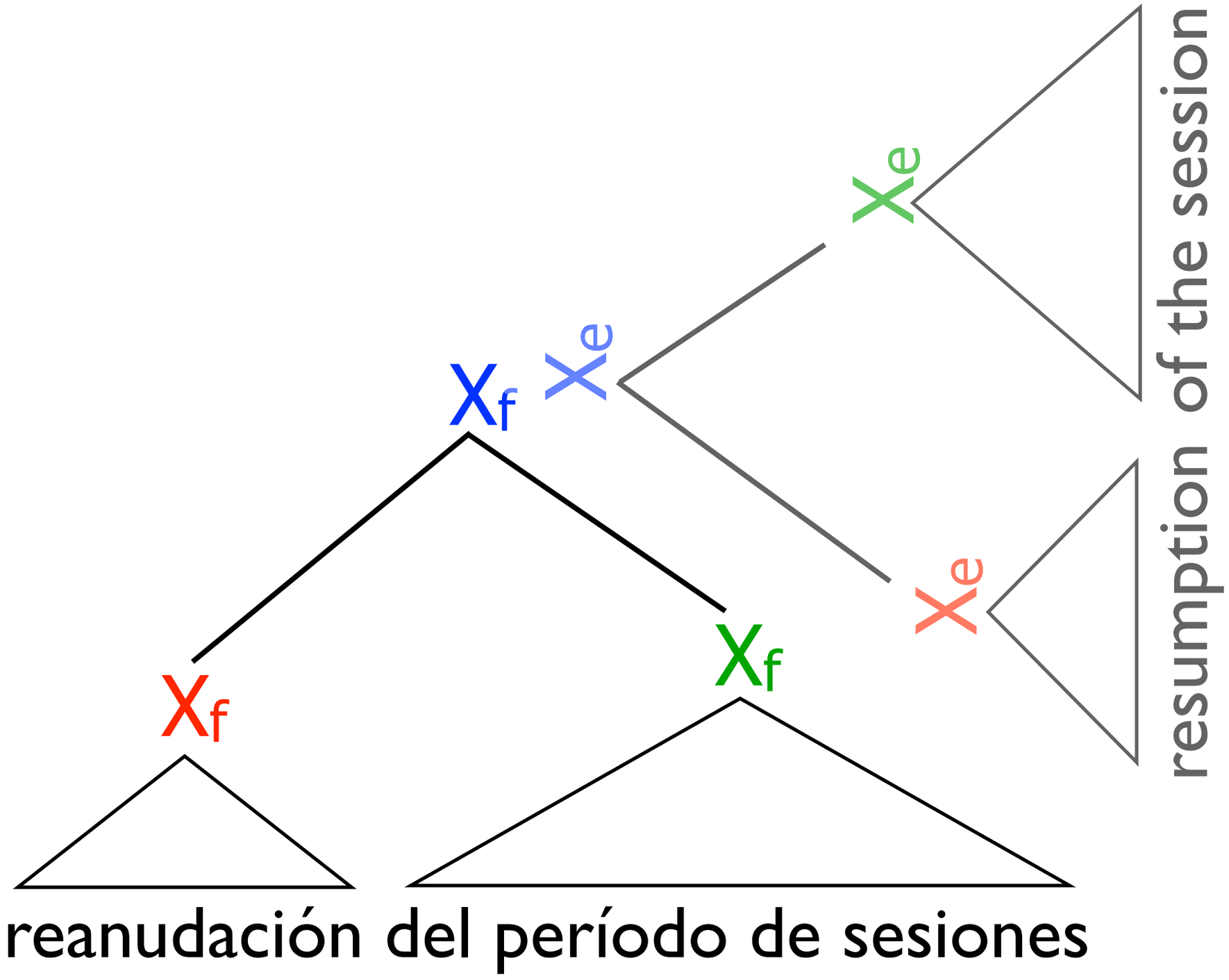
reanudación del período de sesiones

Translating with ITG (w/o LM)

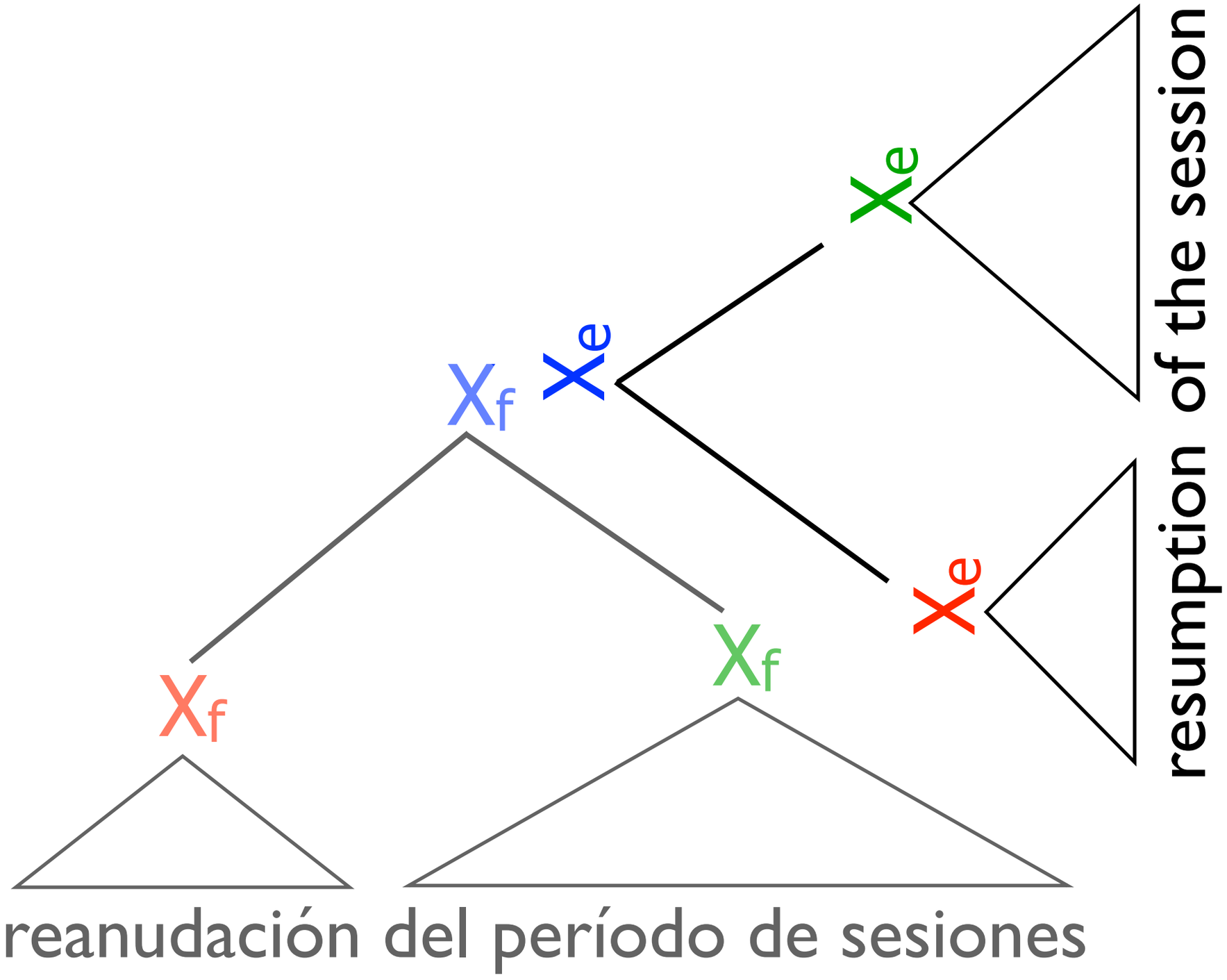
Translating with ITG (w/o LM)



Translating with ITG (w/o LM)



Translating with ITG (w/o LM)

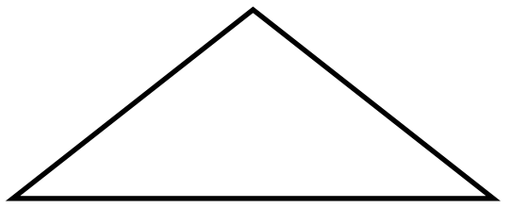


Syntactic MT w/ Language Model

reanudación del período de sesiones

Syntactic MT w/ Language Model

resumption-X_f-resumption



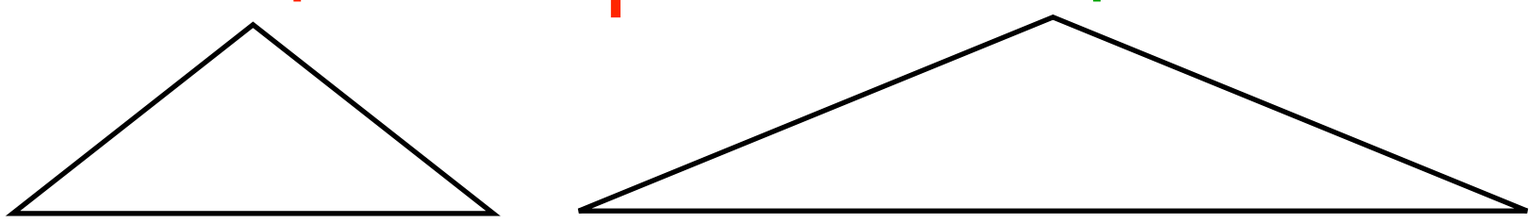
reanudación del período de sesiones

resumption

Syntactic MT w/ Language Model

resumption of the session

resumption-X_f-resumption of-X_f-session

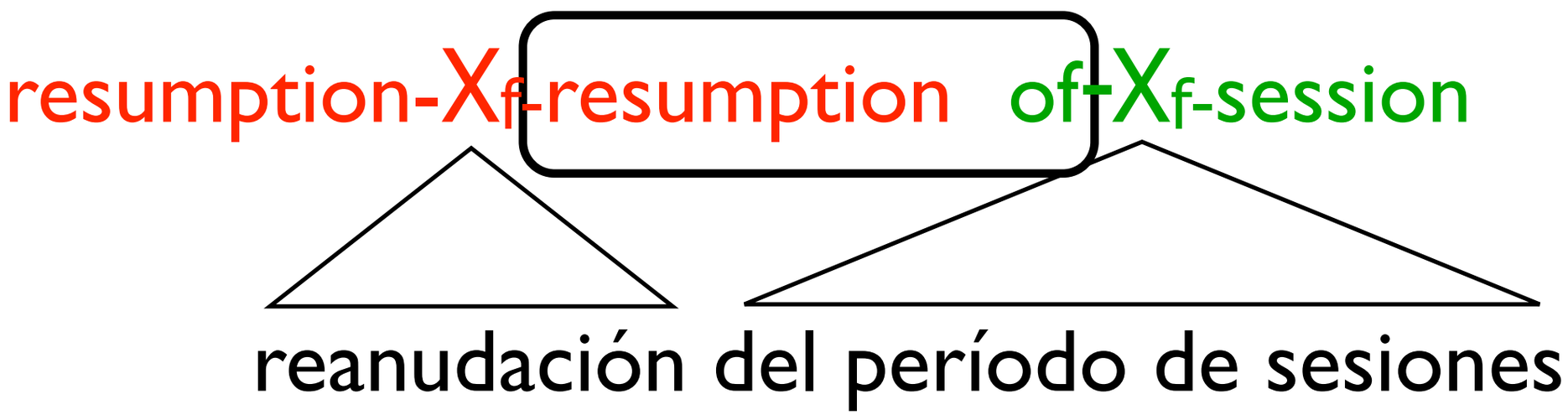


reanudación del período de sesiones

Syntactic MT w/ Language Model

Score with Language Model

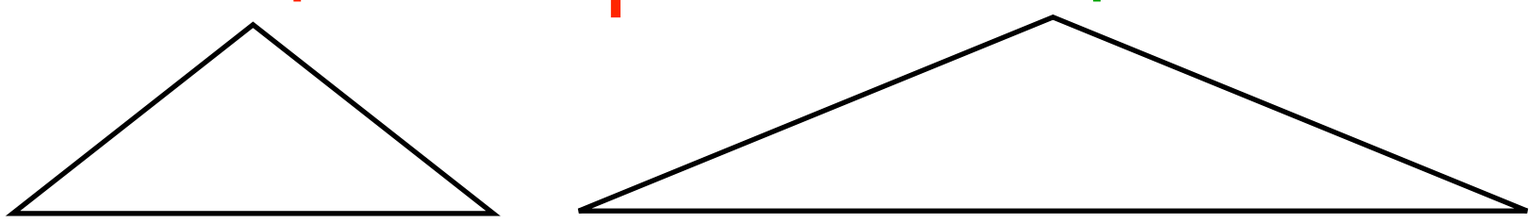
resumption of the session



Syntactic MT w/ Language Model

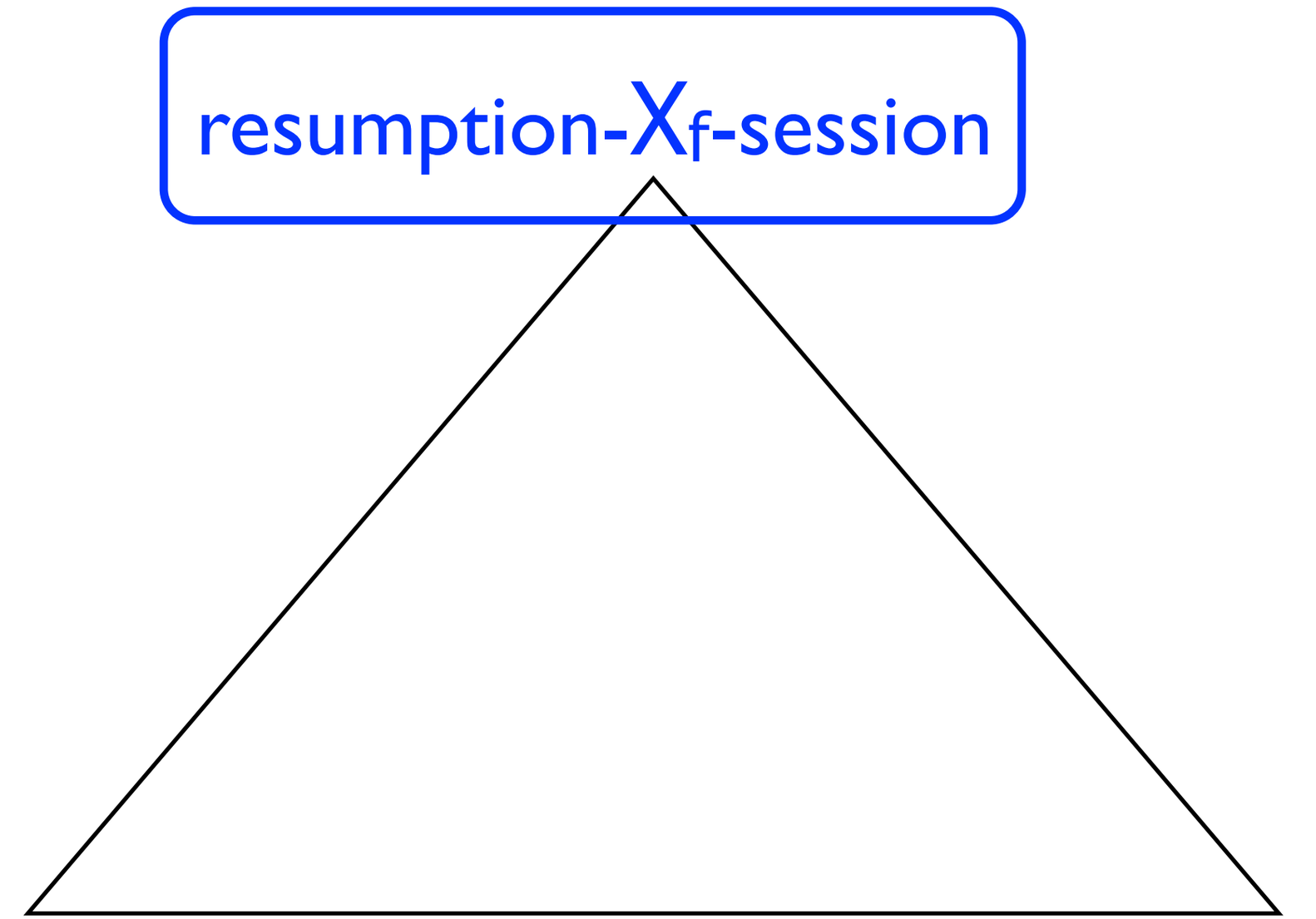
resumption of the session

resumption-X_f-resumption of-X_f-session



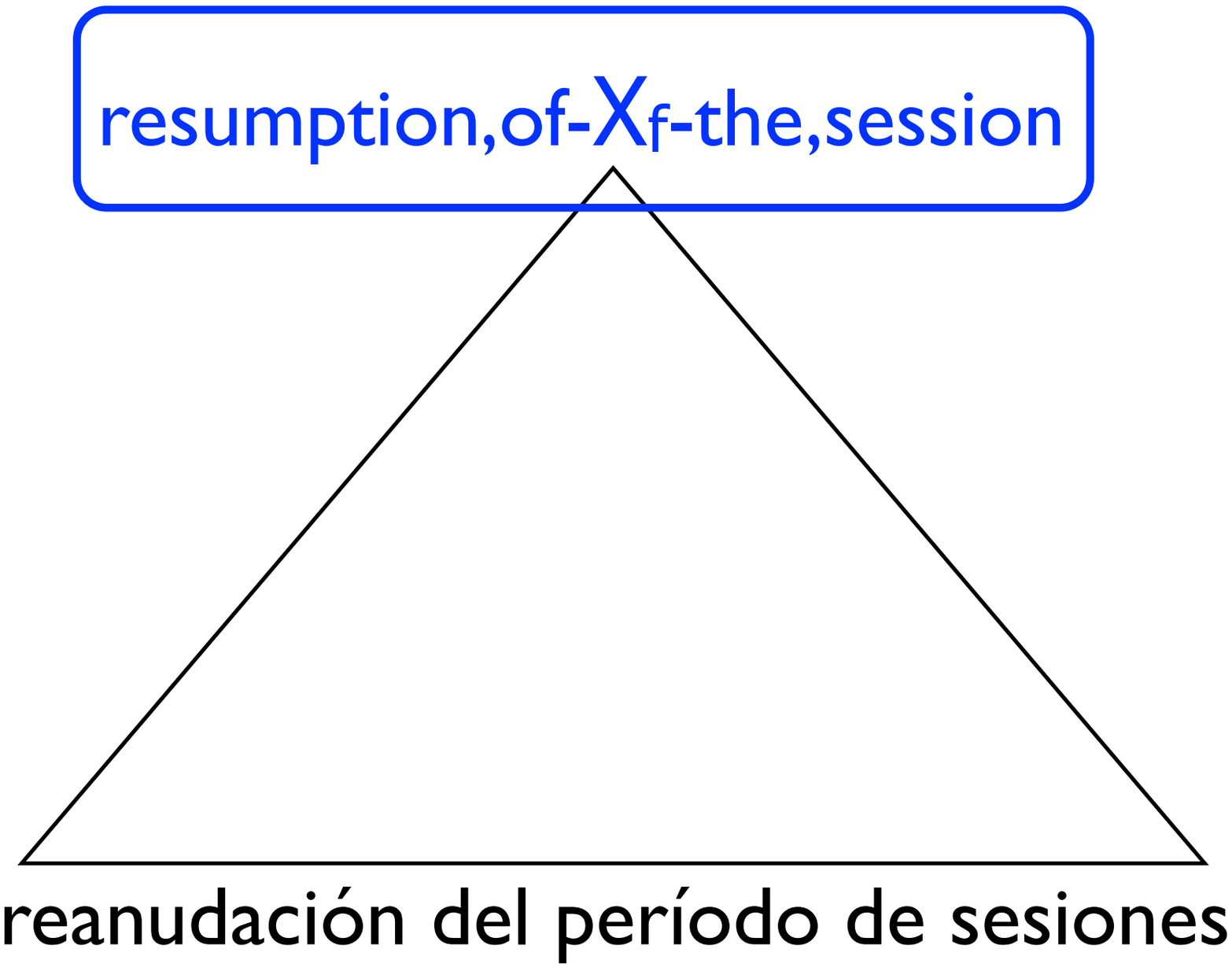
reanudación del período de sesiones

Syntactic MT w/ Language Model

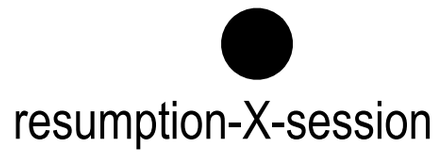


Syntactic MT w/ Language Model

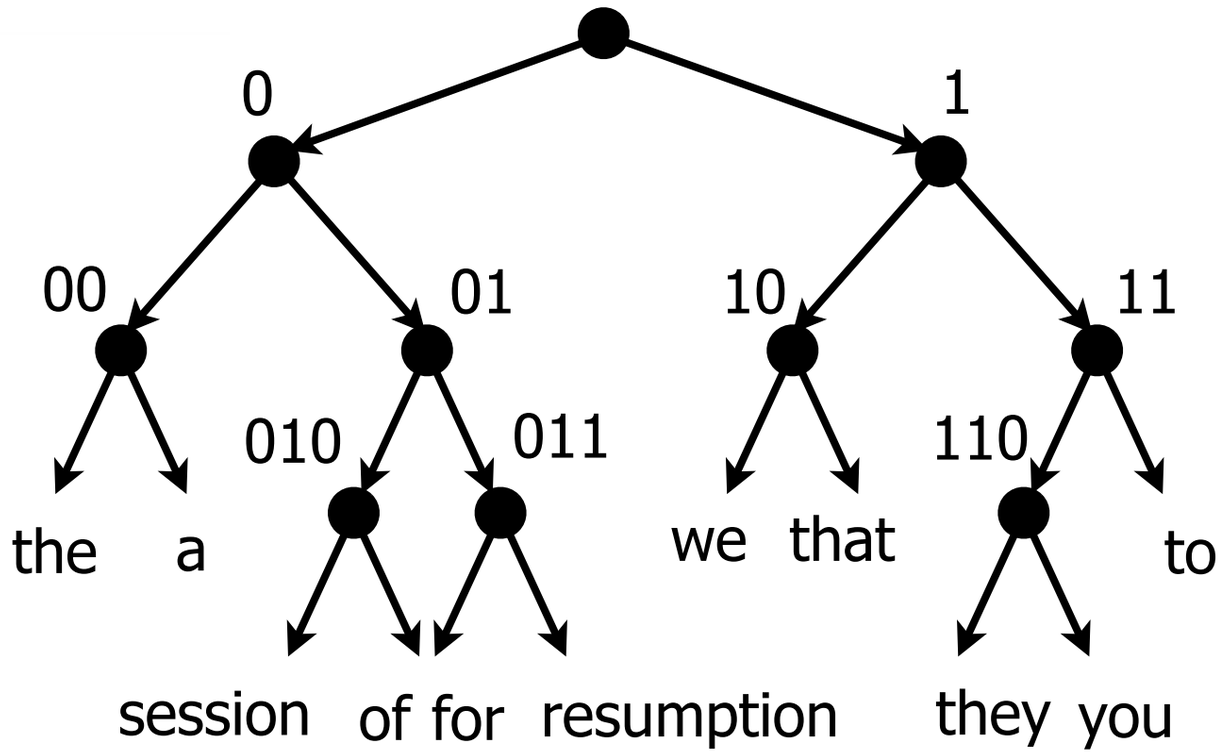
Lexical Explosion

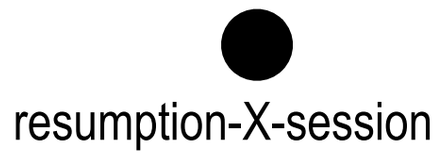


State Space Projections

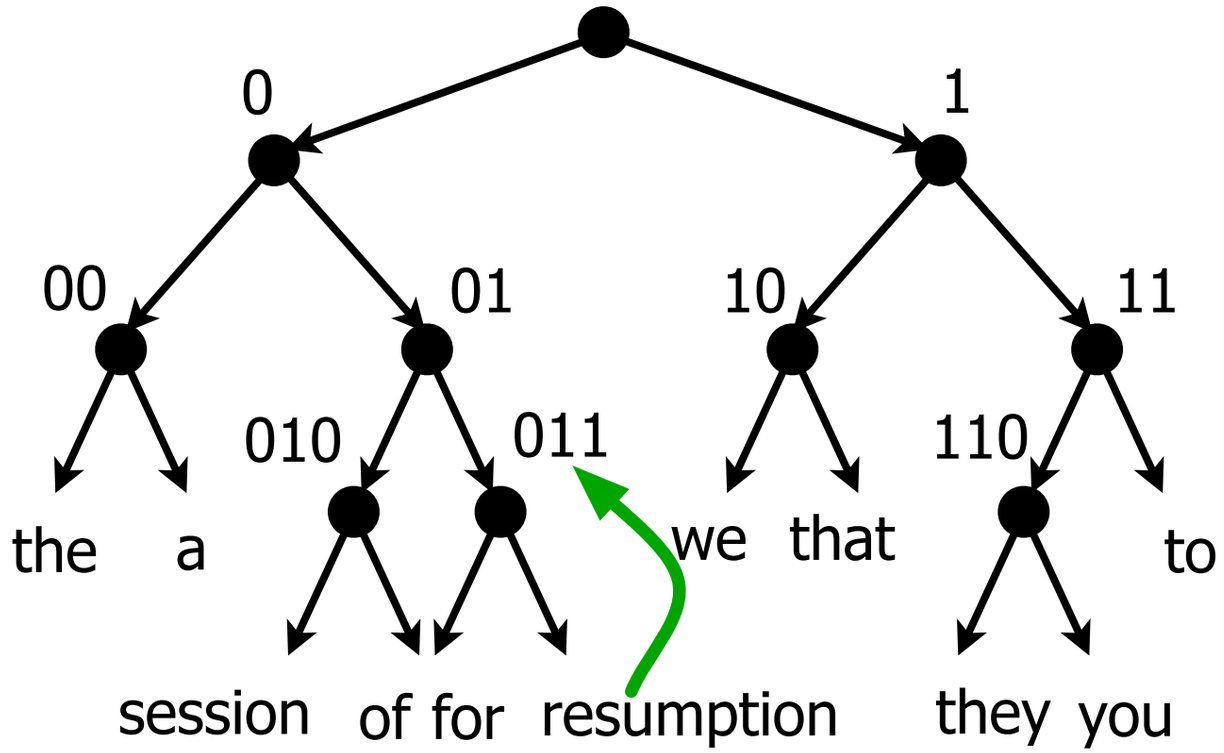


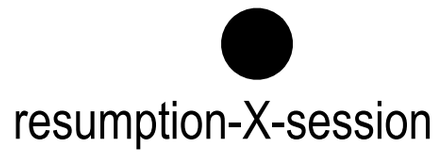
State Space Projections



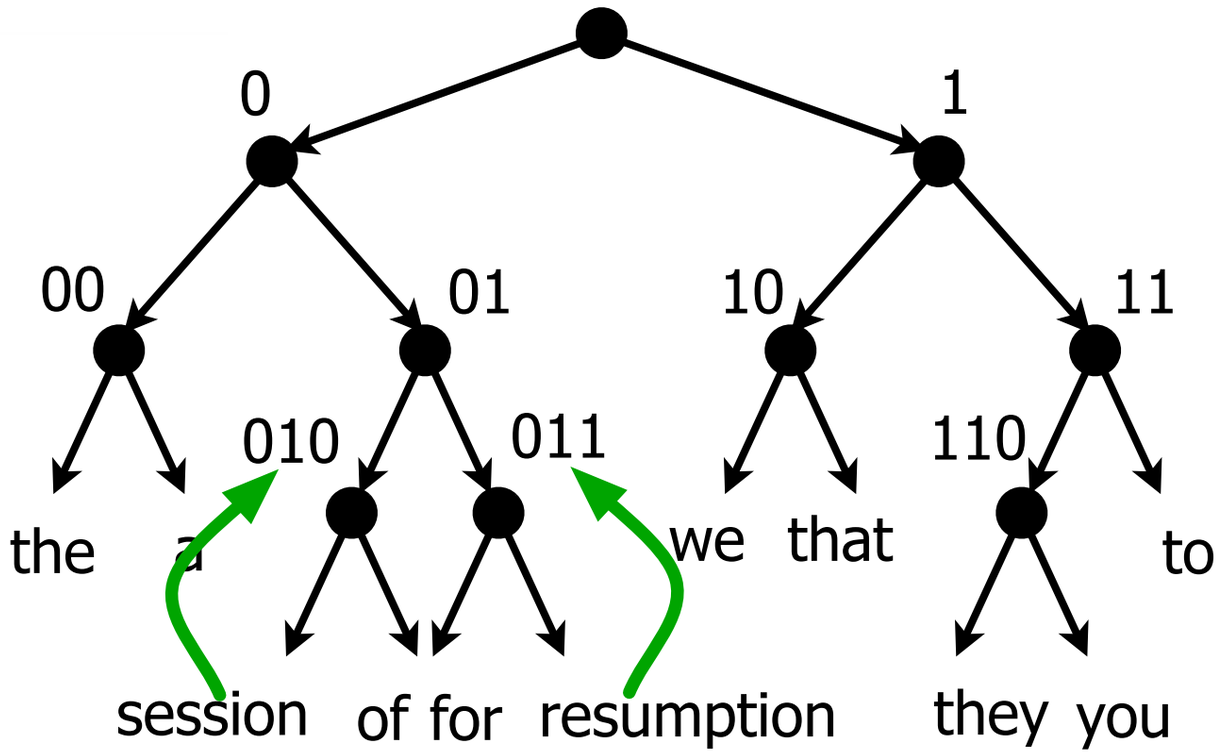


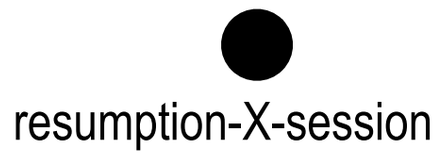
State Space Projections



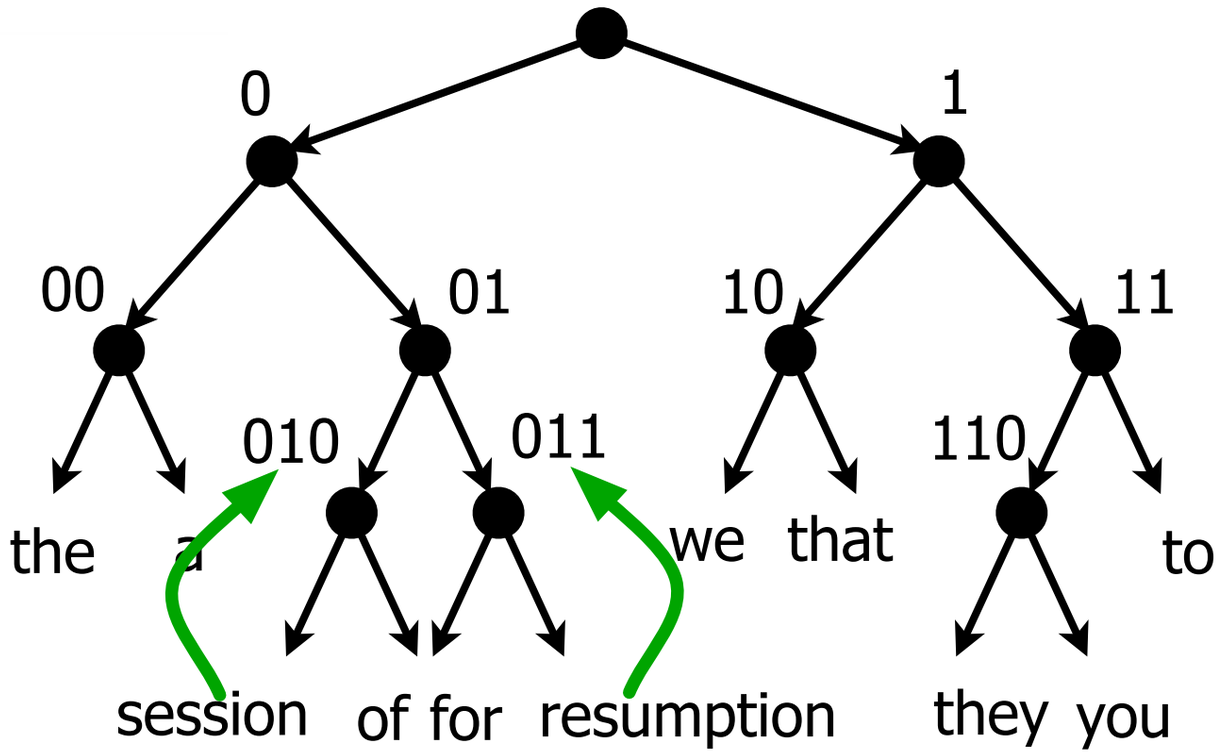


State Space Projections





State Space Projections

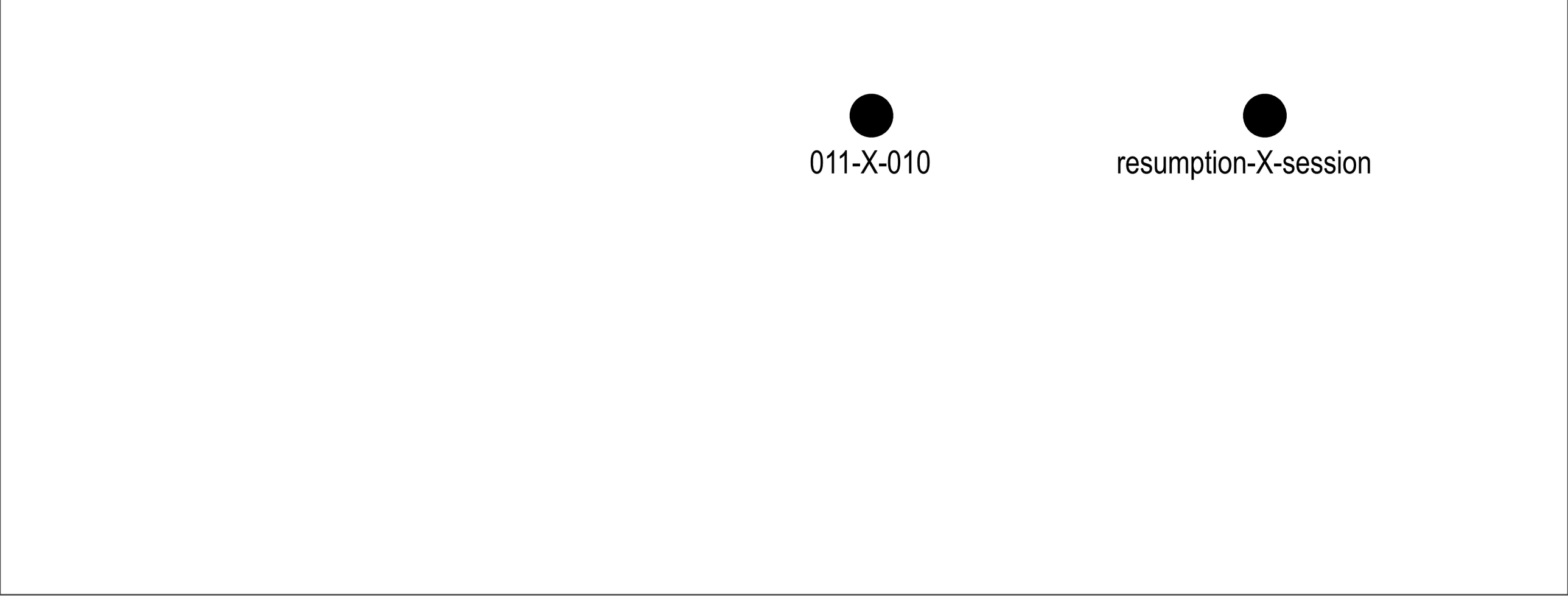


-X-

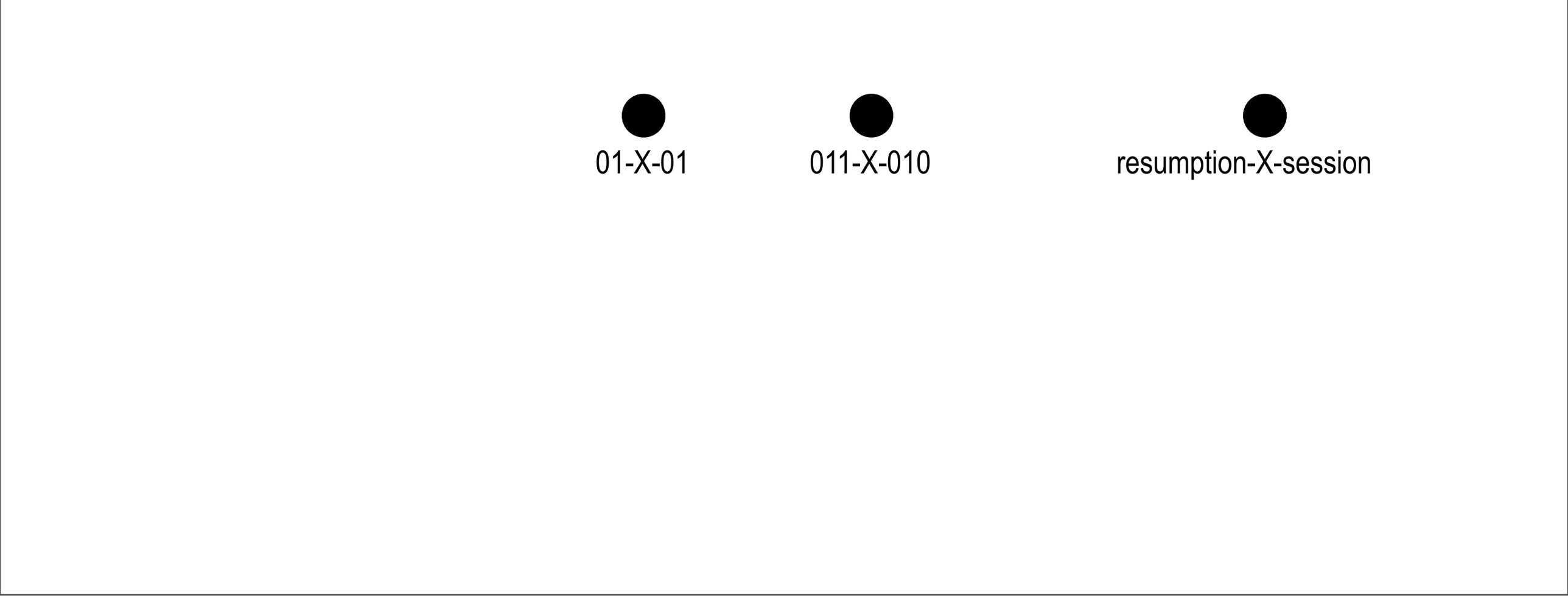
resumption-X-session

State Space Projections

State Space Projections



State Space Projections



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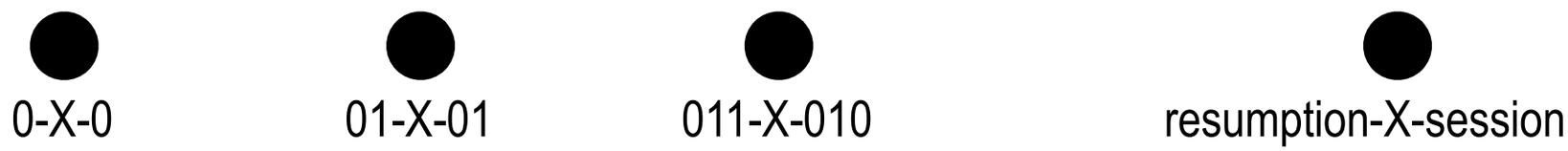
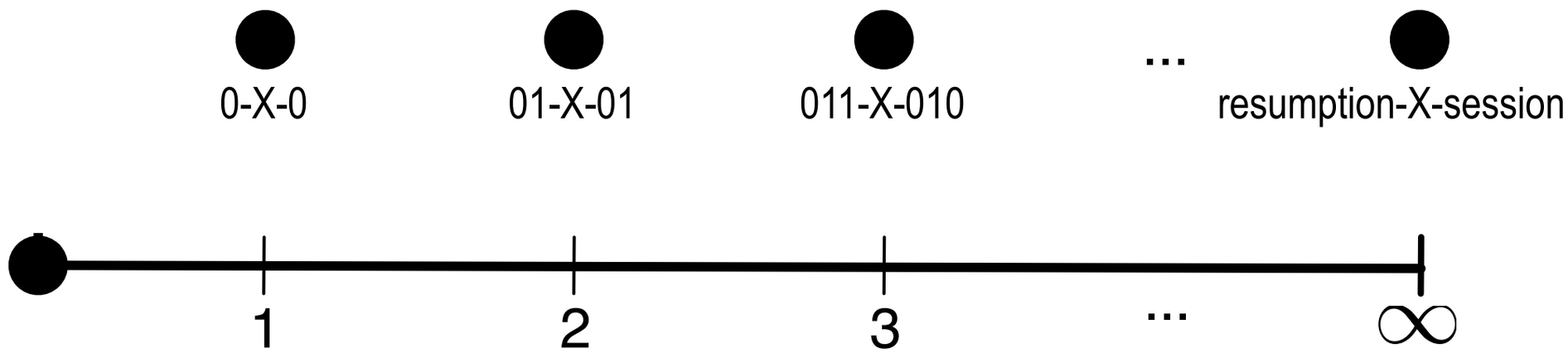
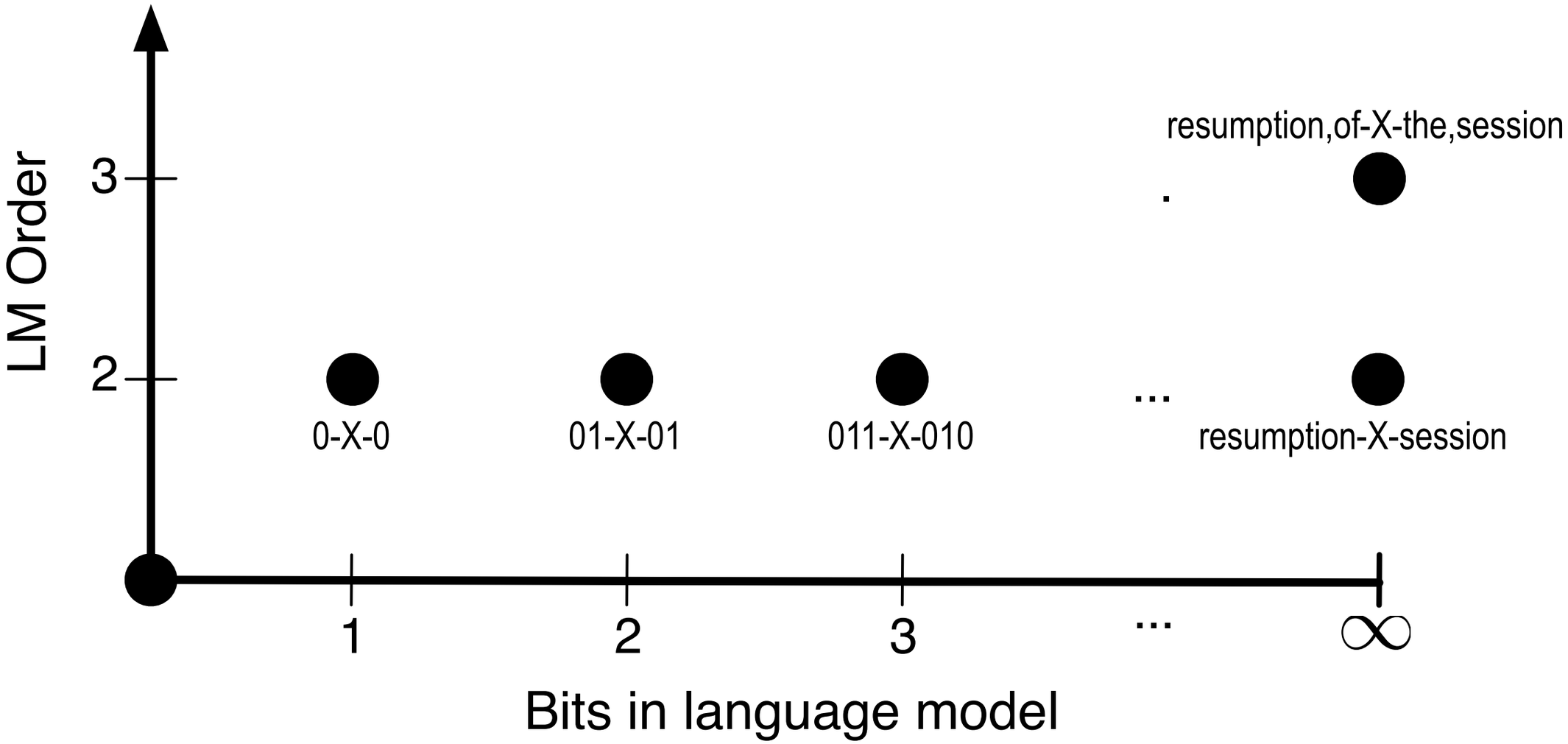


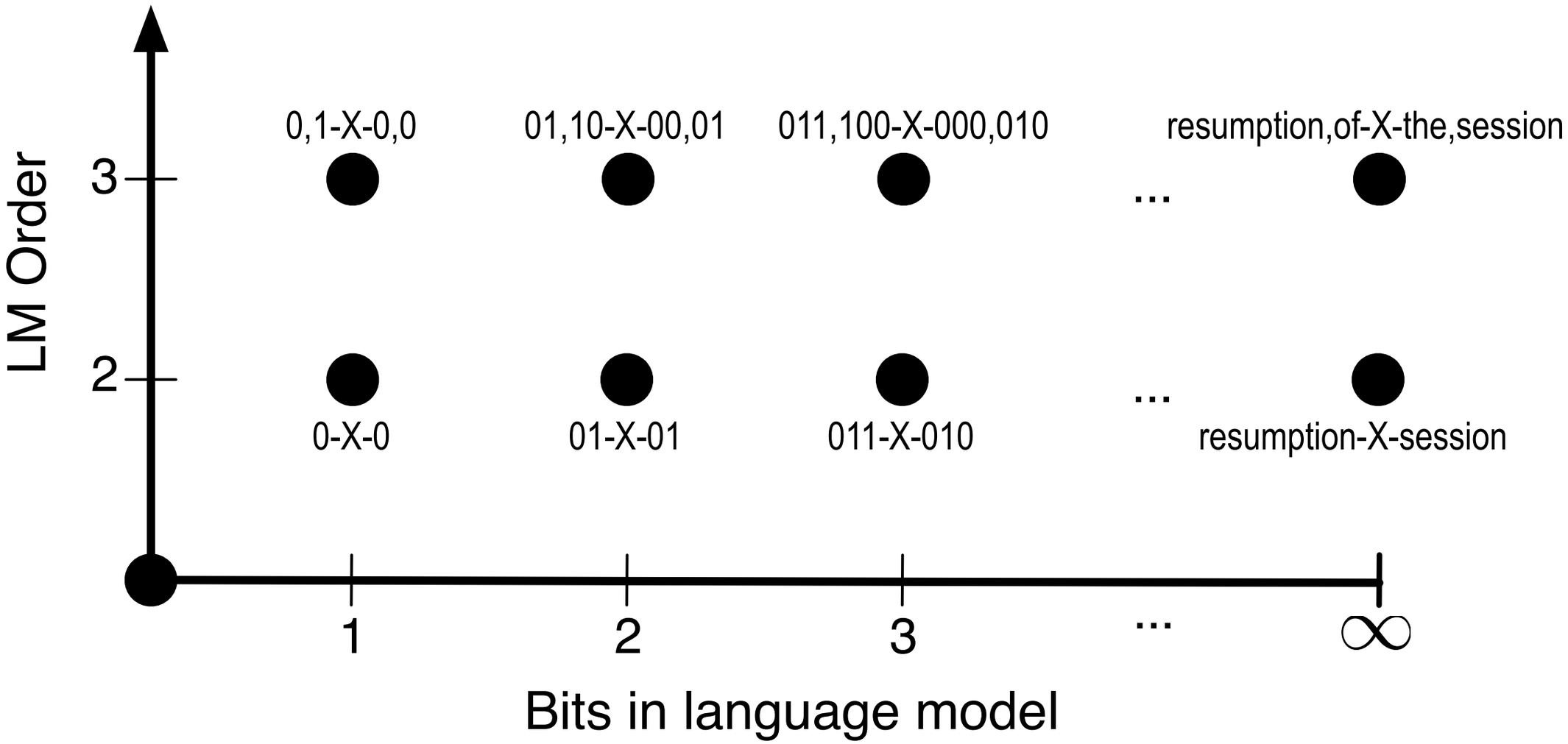
State Space Projections



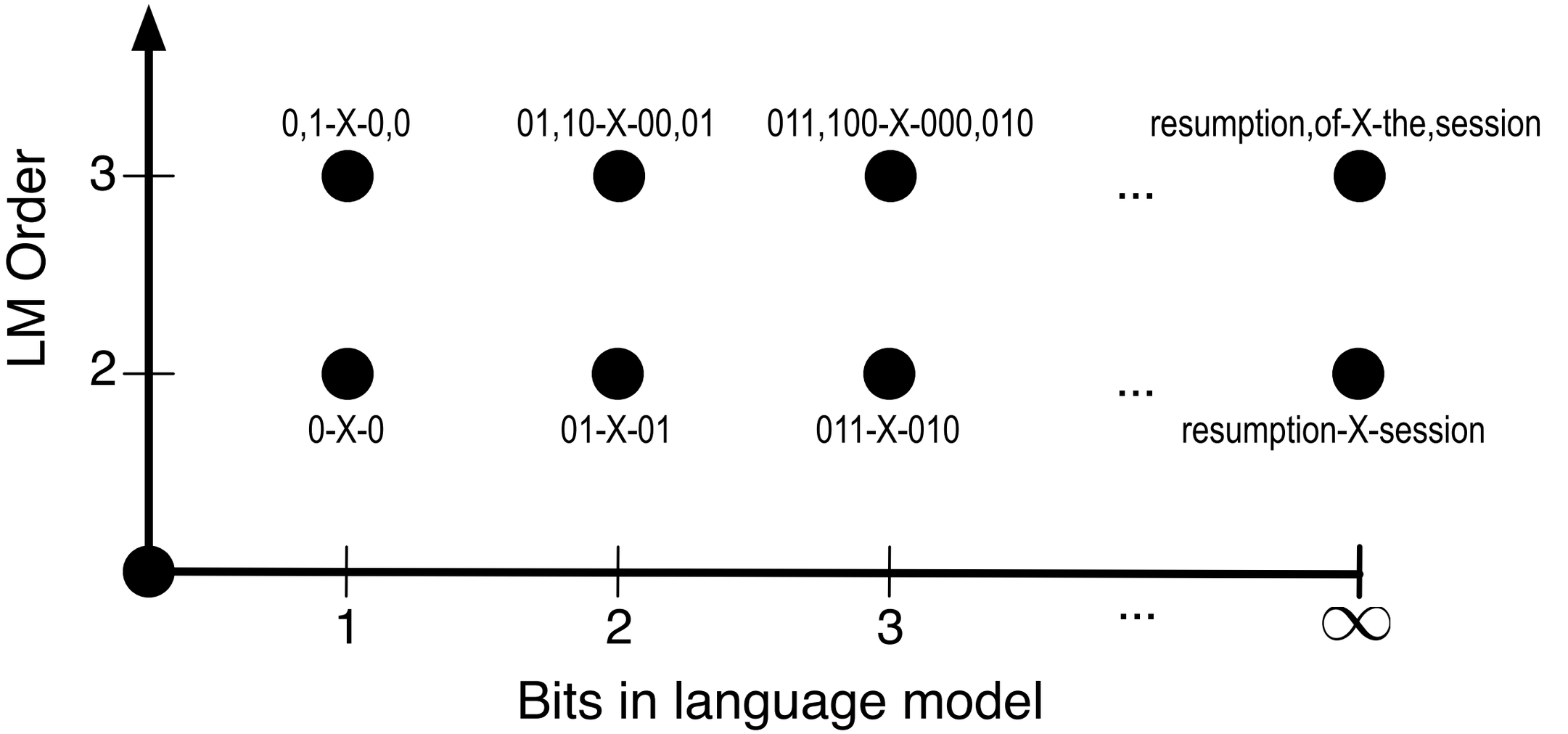
State Space Projections



State Space Projections

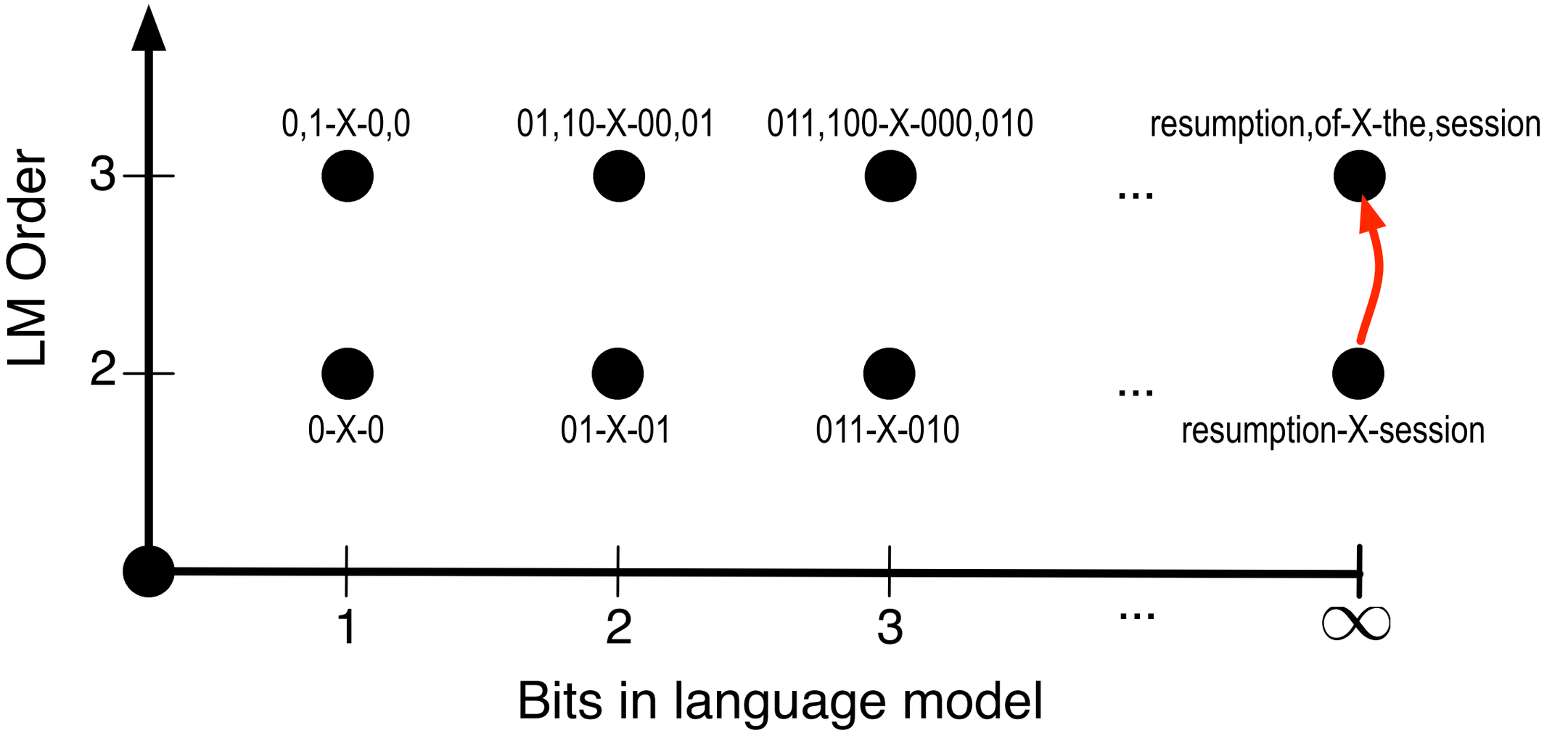


Coarse-to-Fine Inference

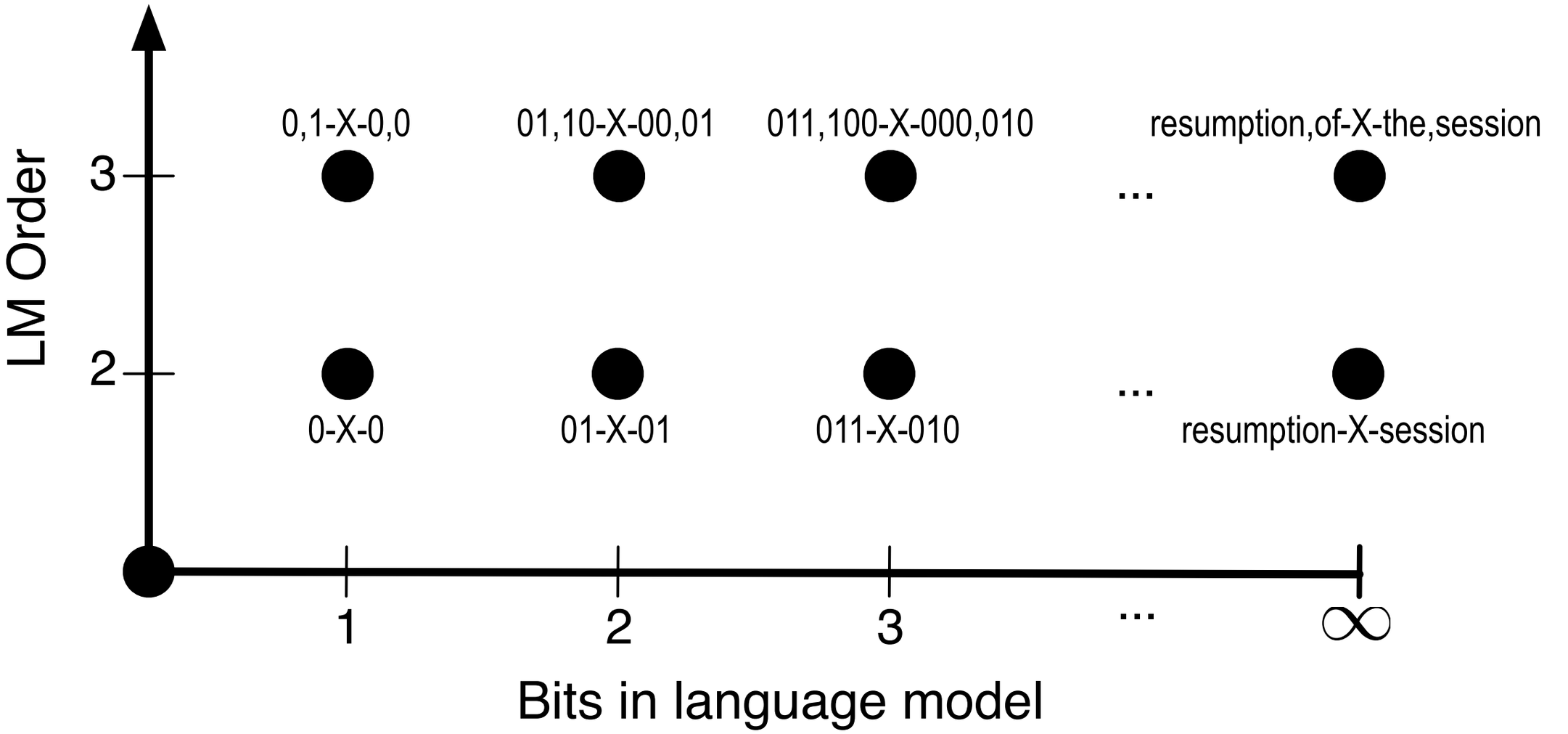


Coarse-to-Fine Inference

Order based [Zhang & Gildea '08]

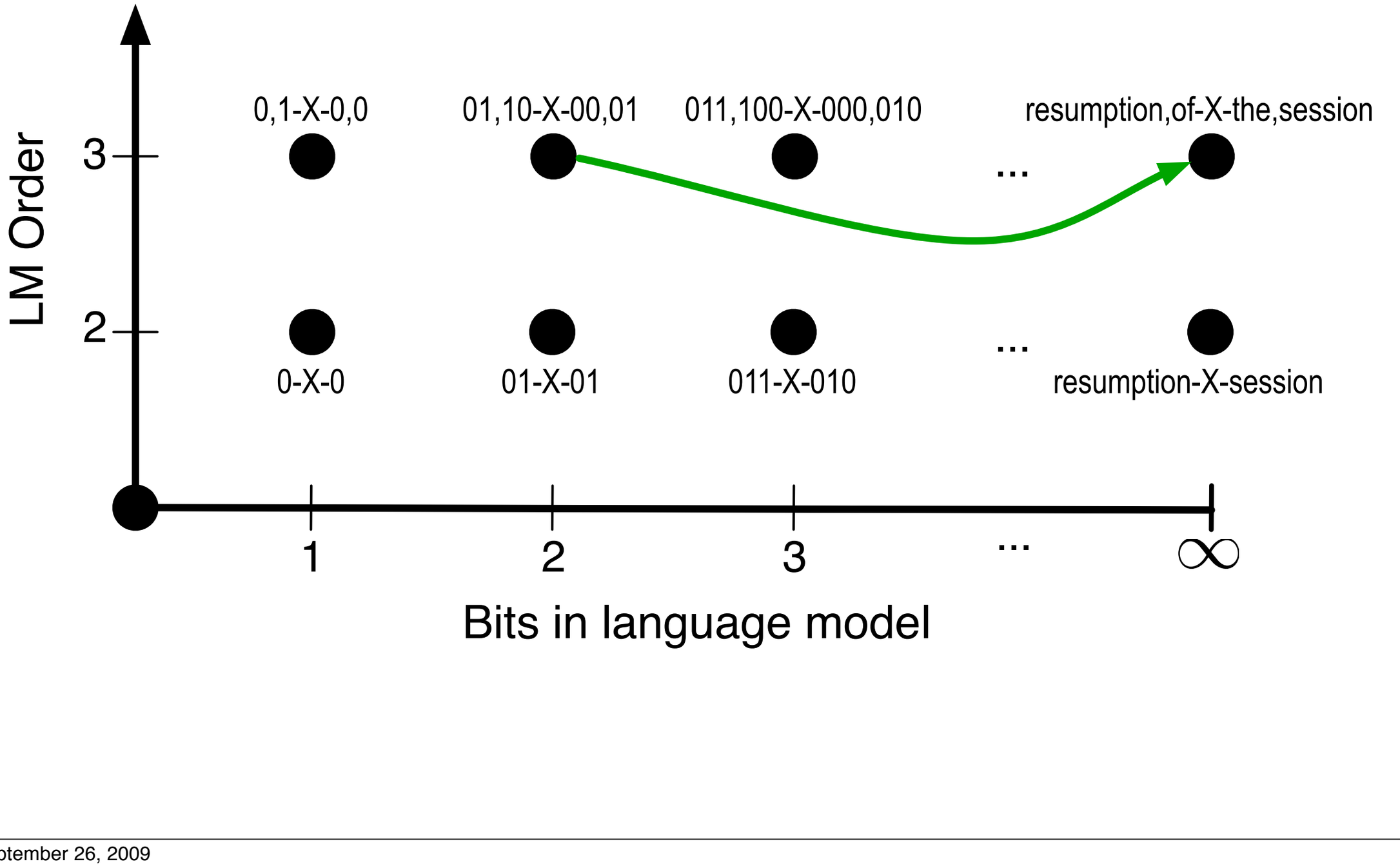


Coarse-to-Fine Inference

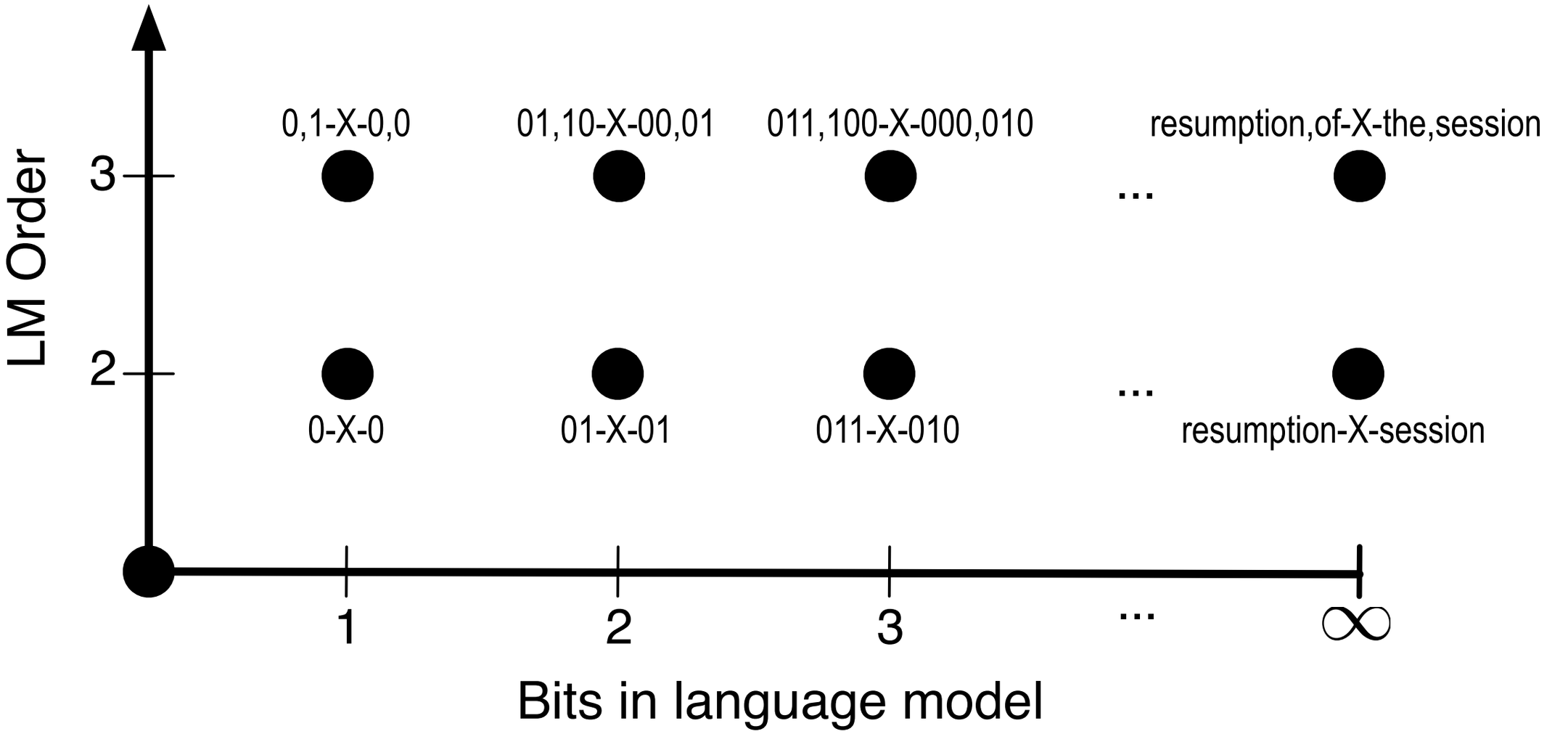


Coarse-to-Fine Inference

Encoding based

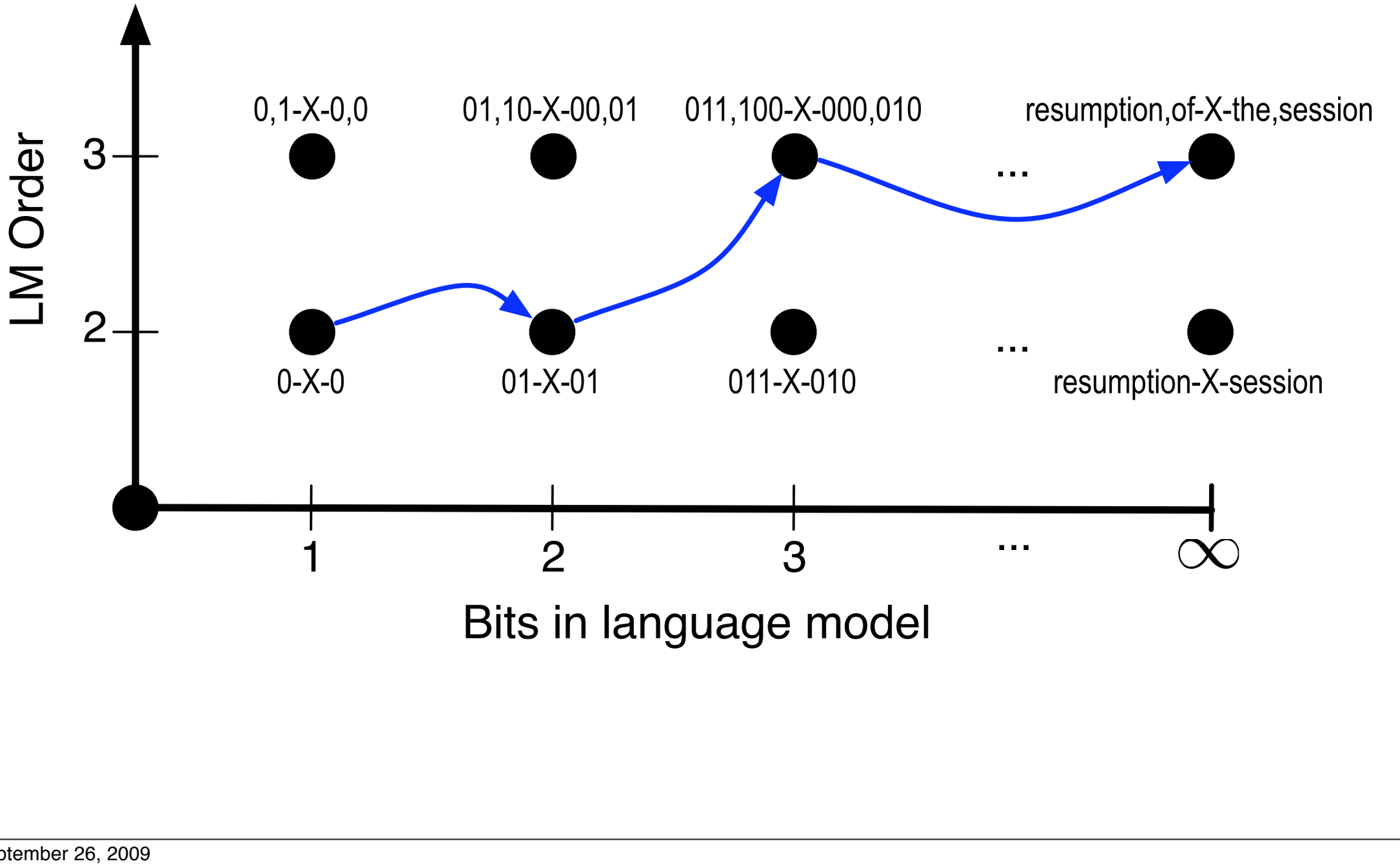


Coarse-to-Fine Inference



Coarse-to-Fine Inference

Combine both?



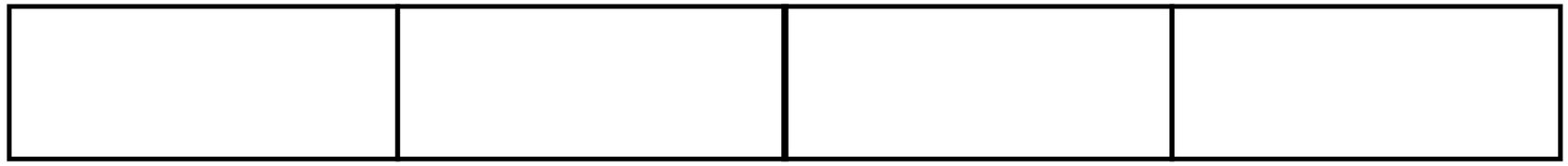
Experimental Setup

- Europarl corpus:
  - Spanish, German, French → English
  - About 8M words of parallel text
  - Average sentence length 30
  - 2K development sentences
- Pre-Processing
  - Standard GIZA++ word alignments and phrase extraction
  - SRILM trigram language model
- ITG translation model
  - Extracted phrases / scores used as ITG terminal productions
  - Simplistic distortion model: 1 monotonic and 1 inverted rule
  - Less than 1 BLEU point below Moses on same setup

Coarse-to-Fine Pruning

For each span:

Coarse Pass:



Coarse-to-Fine Pruning

For each span:

Coarse Pass:

0-X-0	0-X-1	1-X-0	1-X-1

Coarse-to-Fine Pruning

For each span:

Coarse Pass:

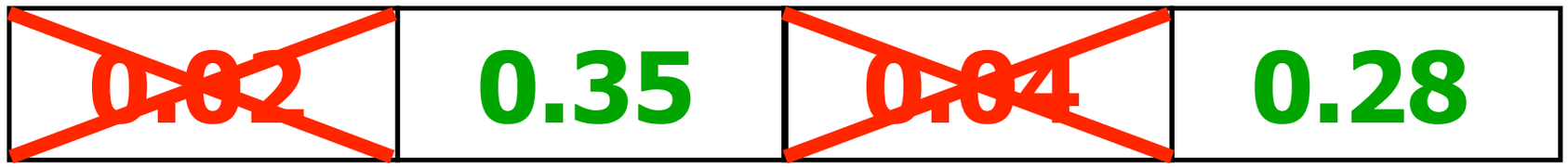
Posteriors	0.02	0.35	0.04	0.28

Coarse-to-Fine Pruning

For each span:

Coarse Pass:

Posteriors



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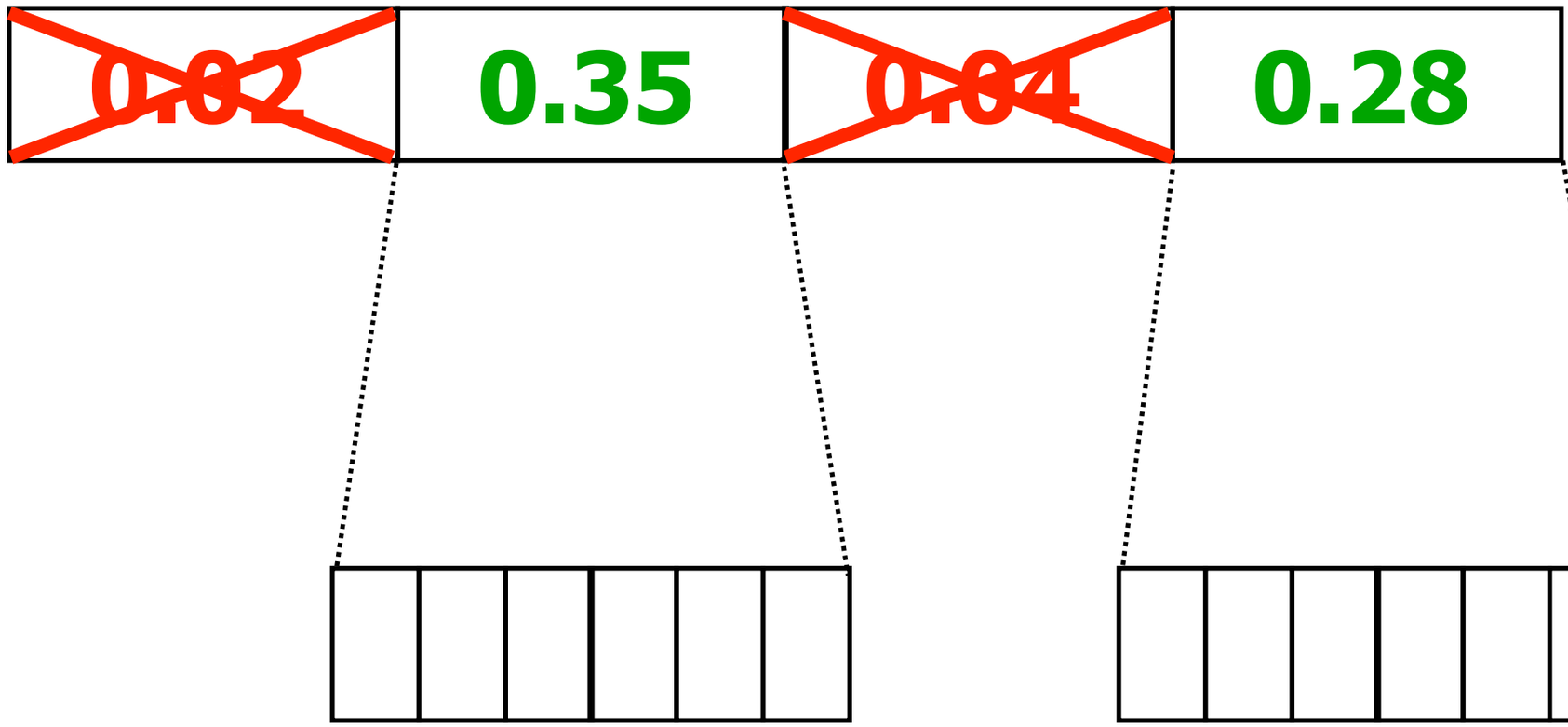
Coarse-to-Fine Pruning

For each span:

Coarse Pass:

Posteriors



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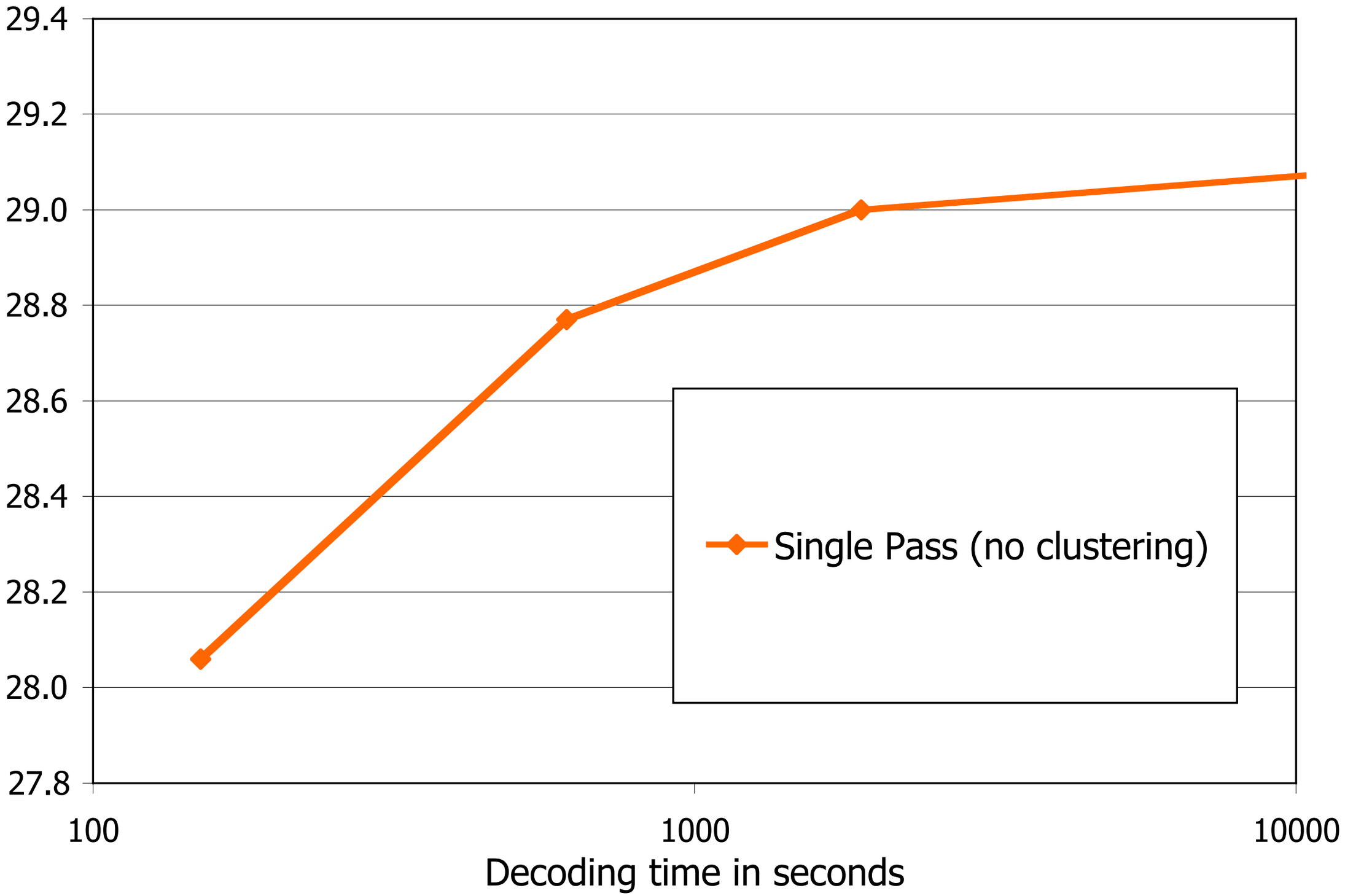
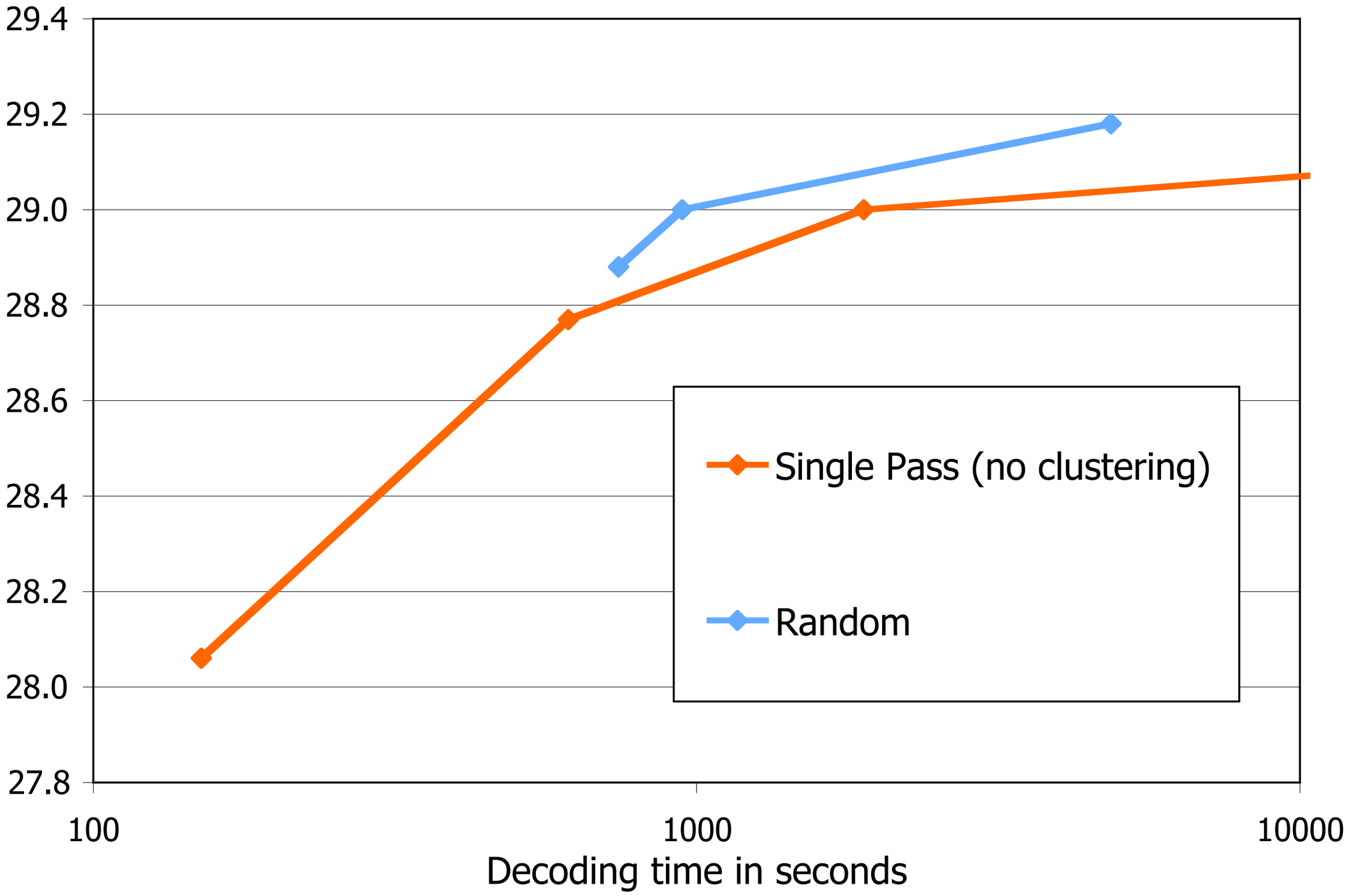
Finer Pass:

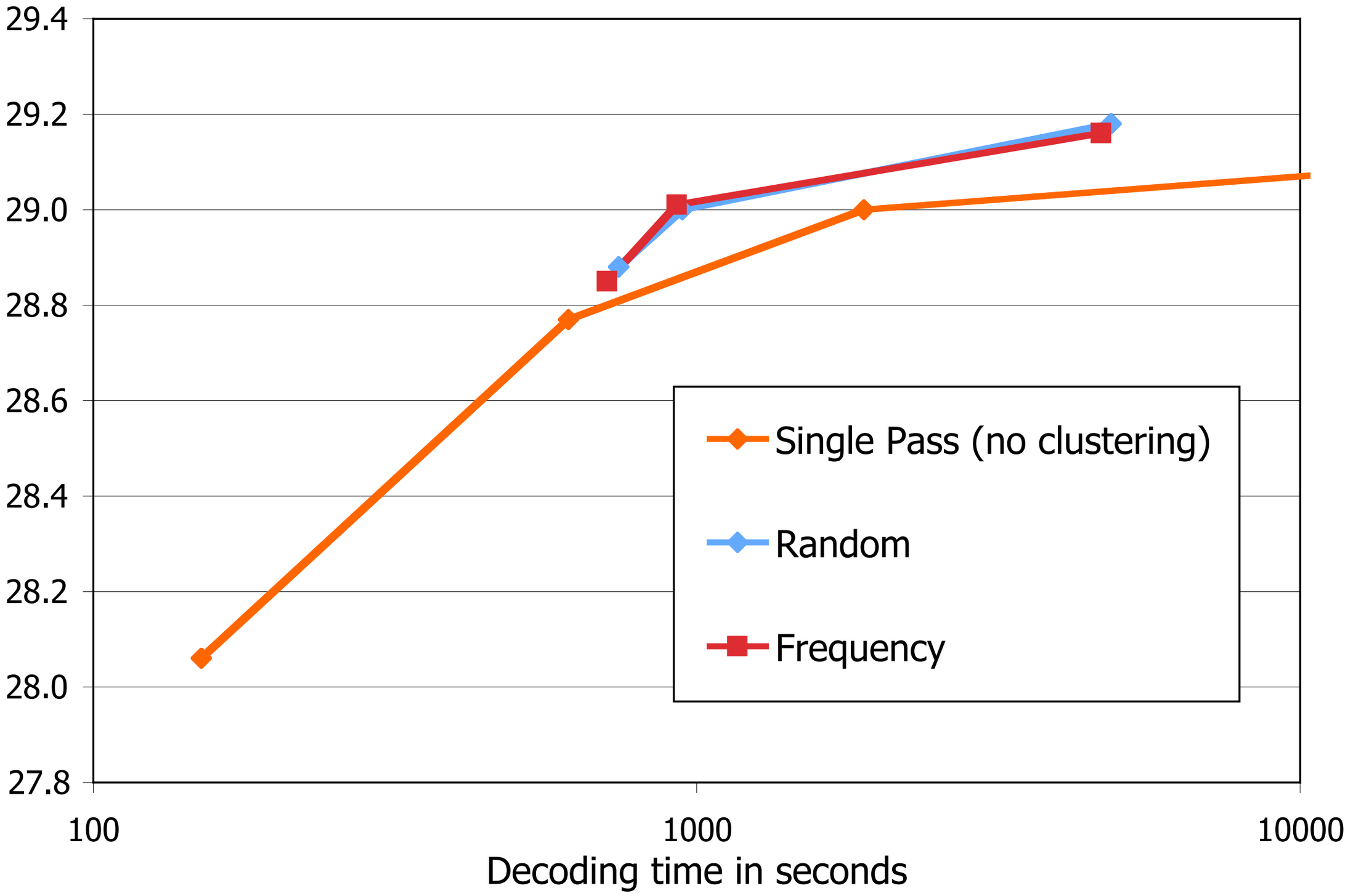
Cluster Quality (BLEU)



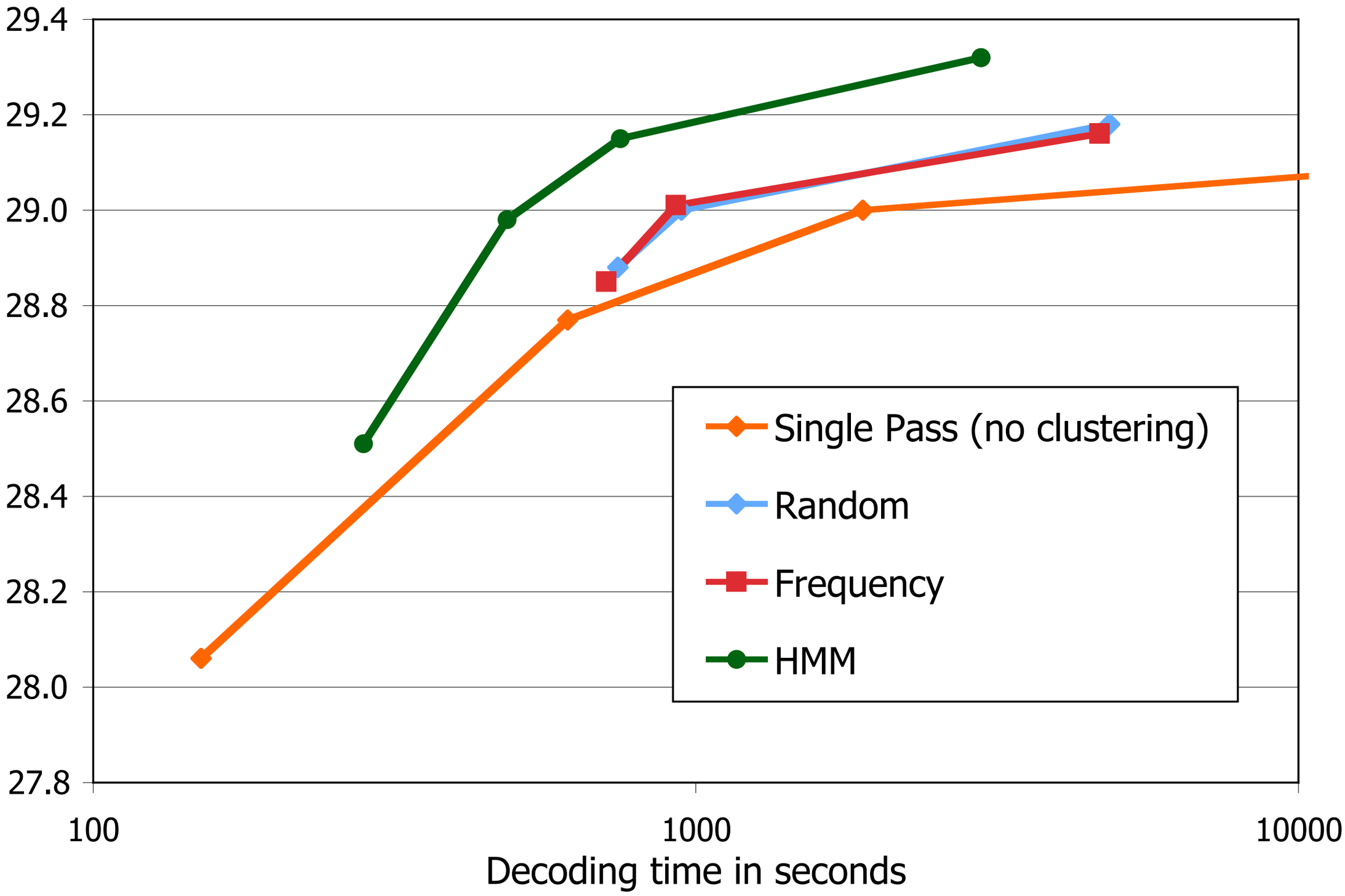
Cluster Quality (BLEU)



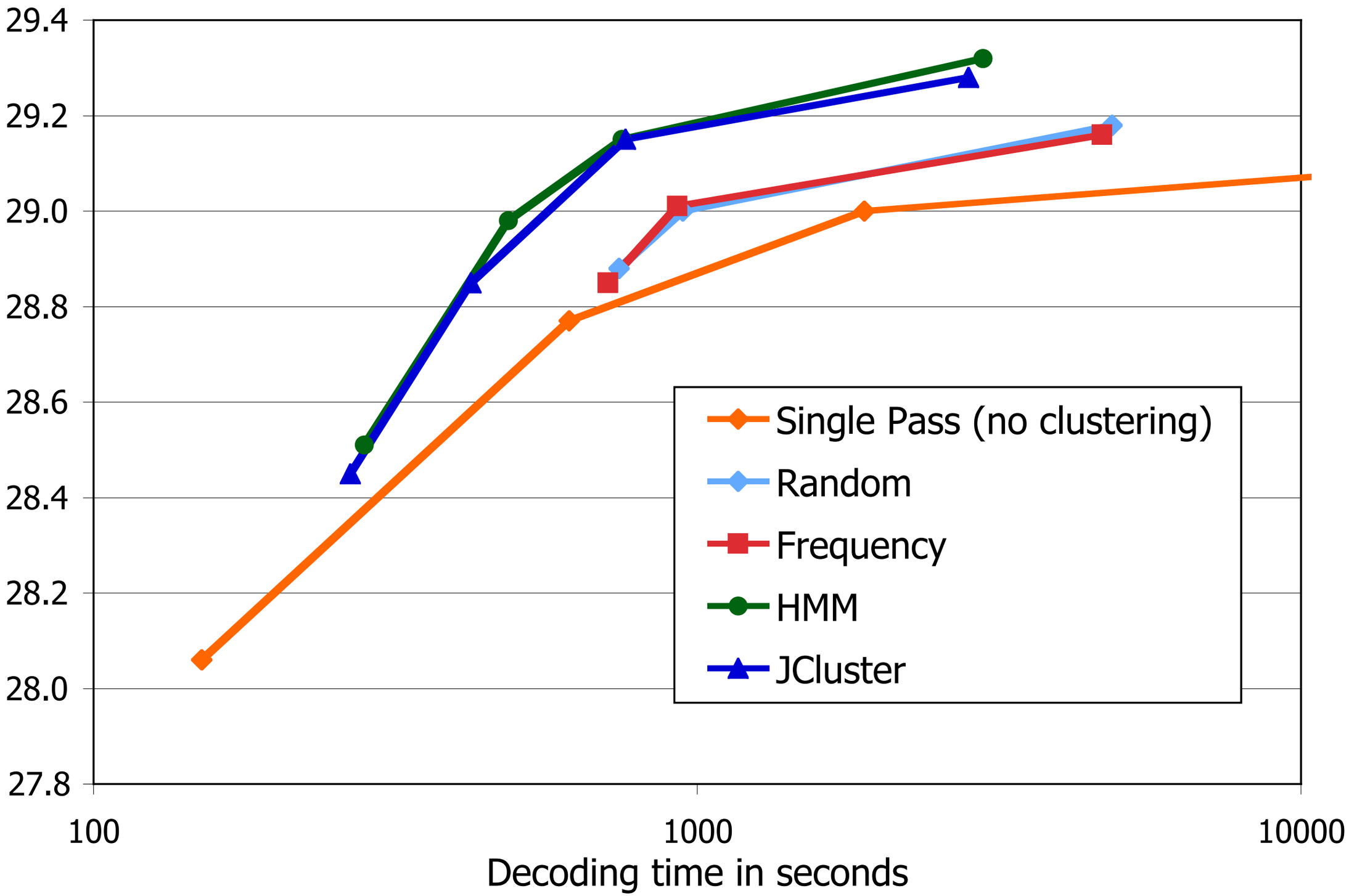
Cluster Quality (BLEU)



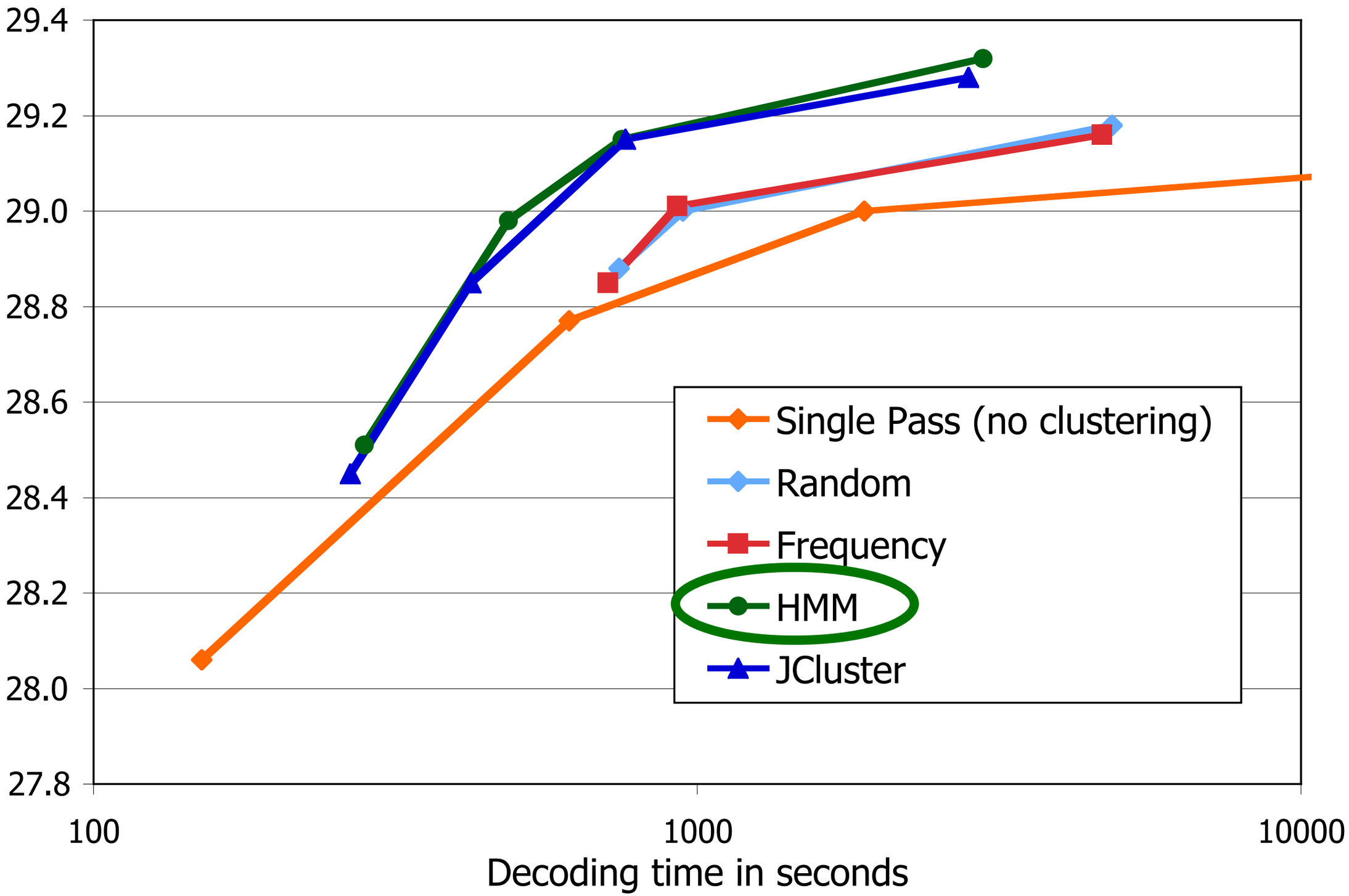
Cluster Quality (BLEU)



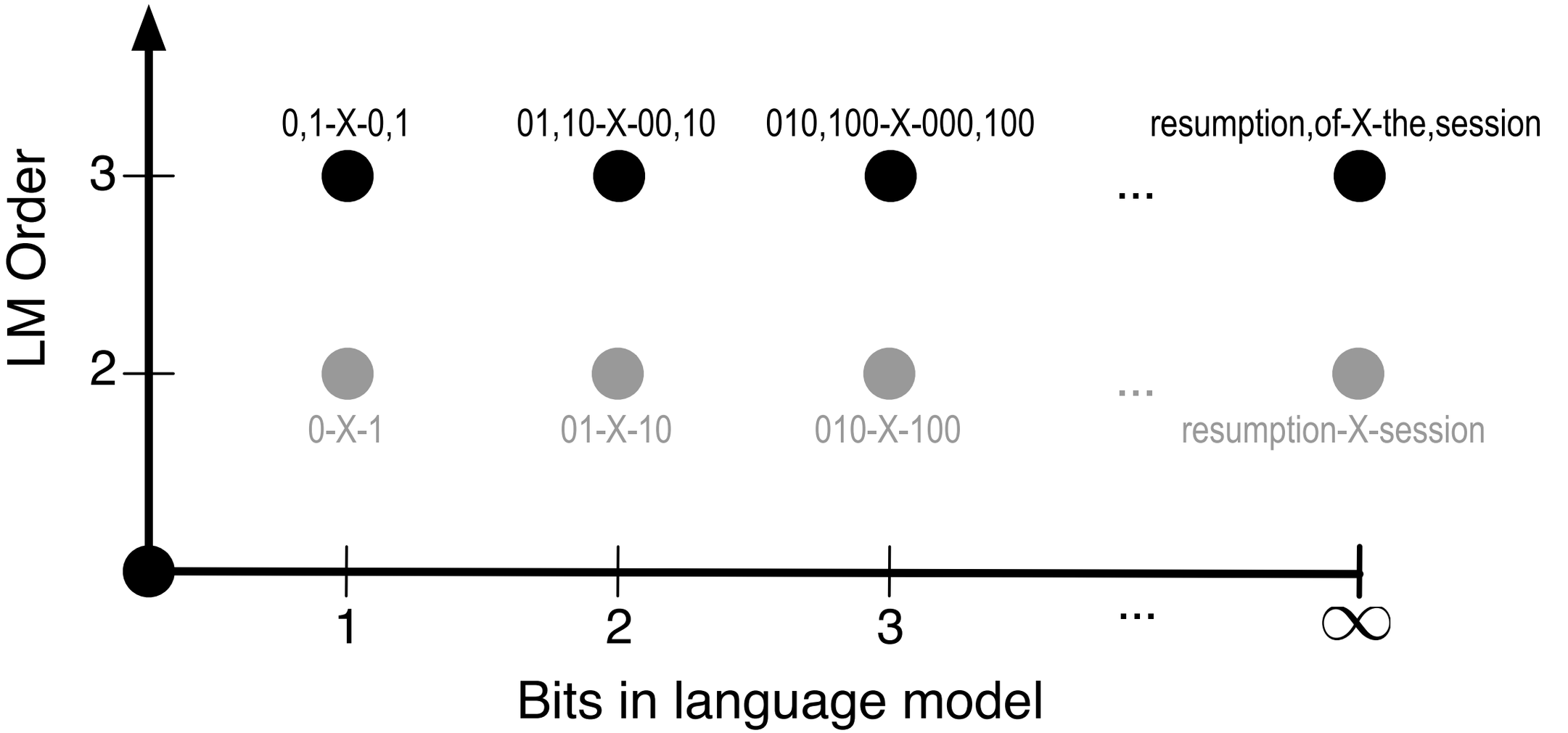
Cluster Quality (BLEU)



Cluster Quality (BLEU)



Where to start?



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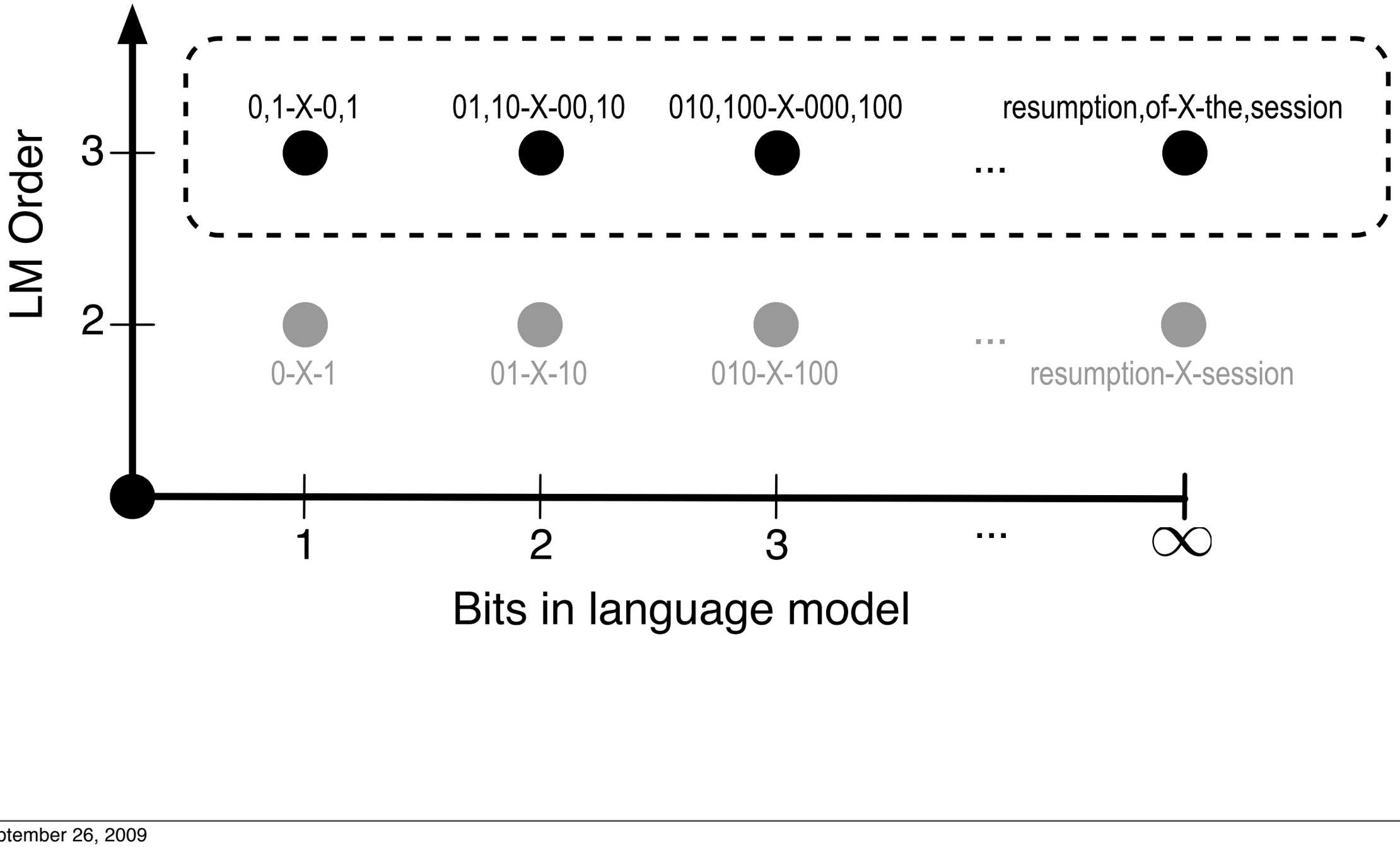

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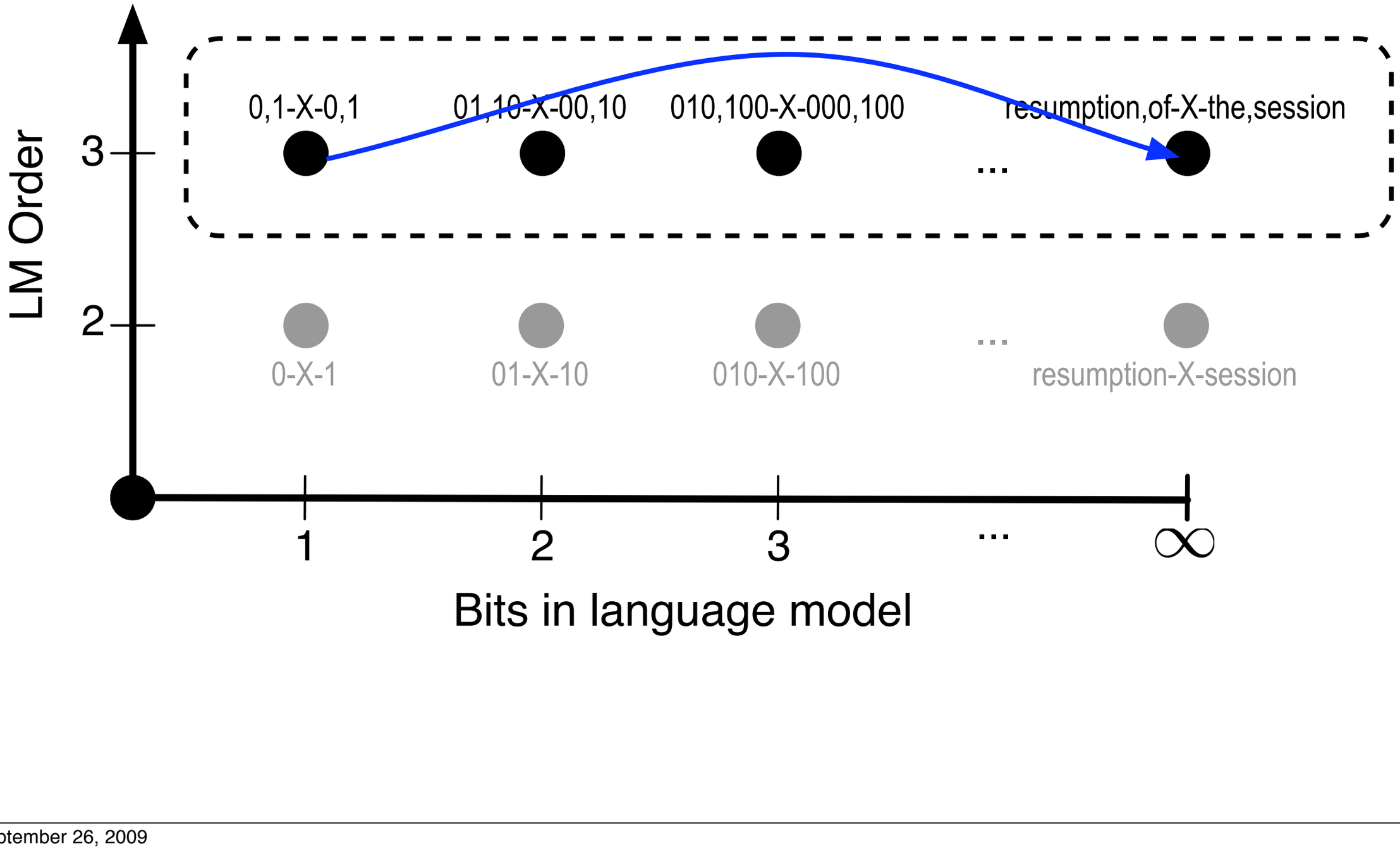

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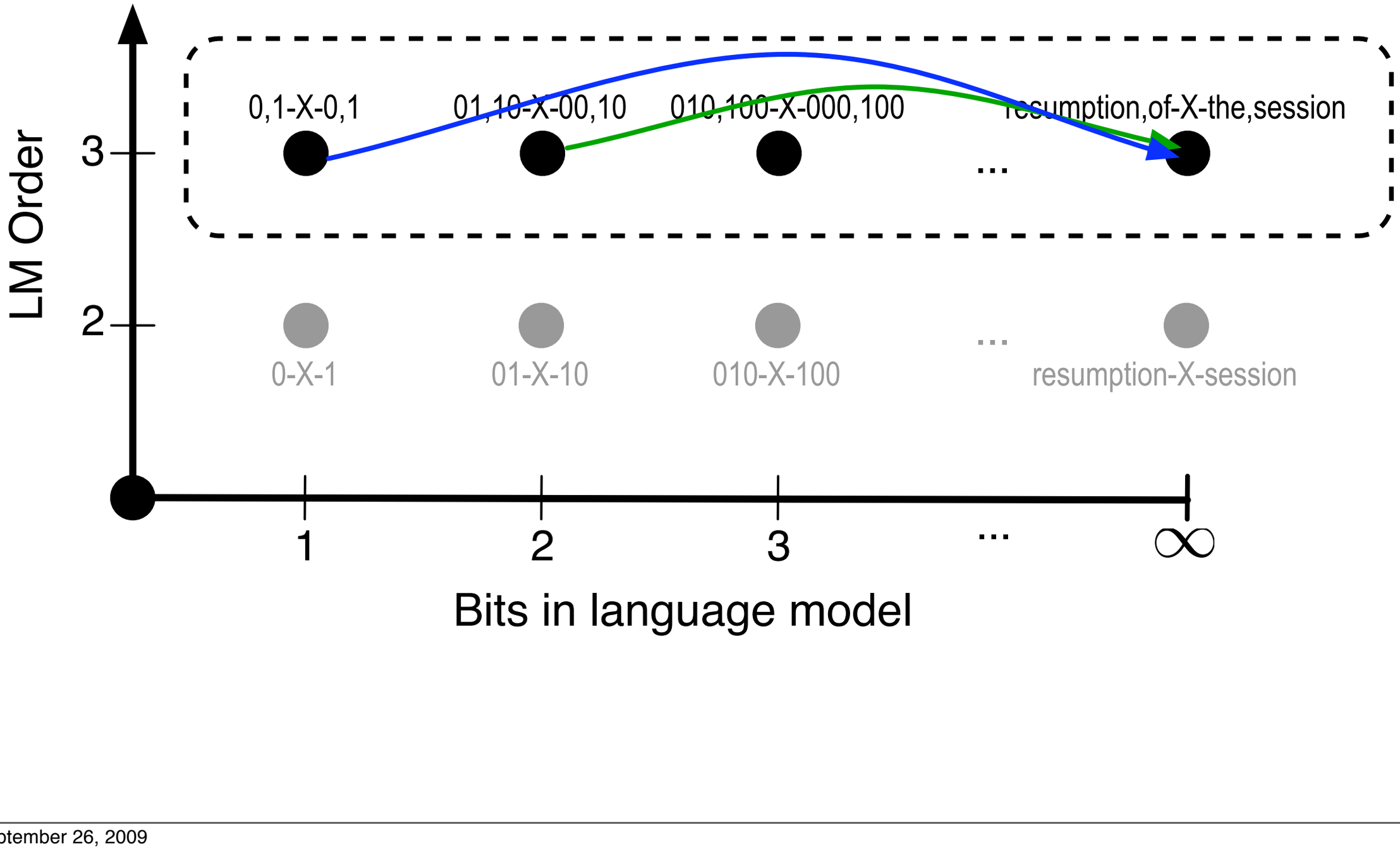

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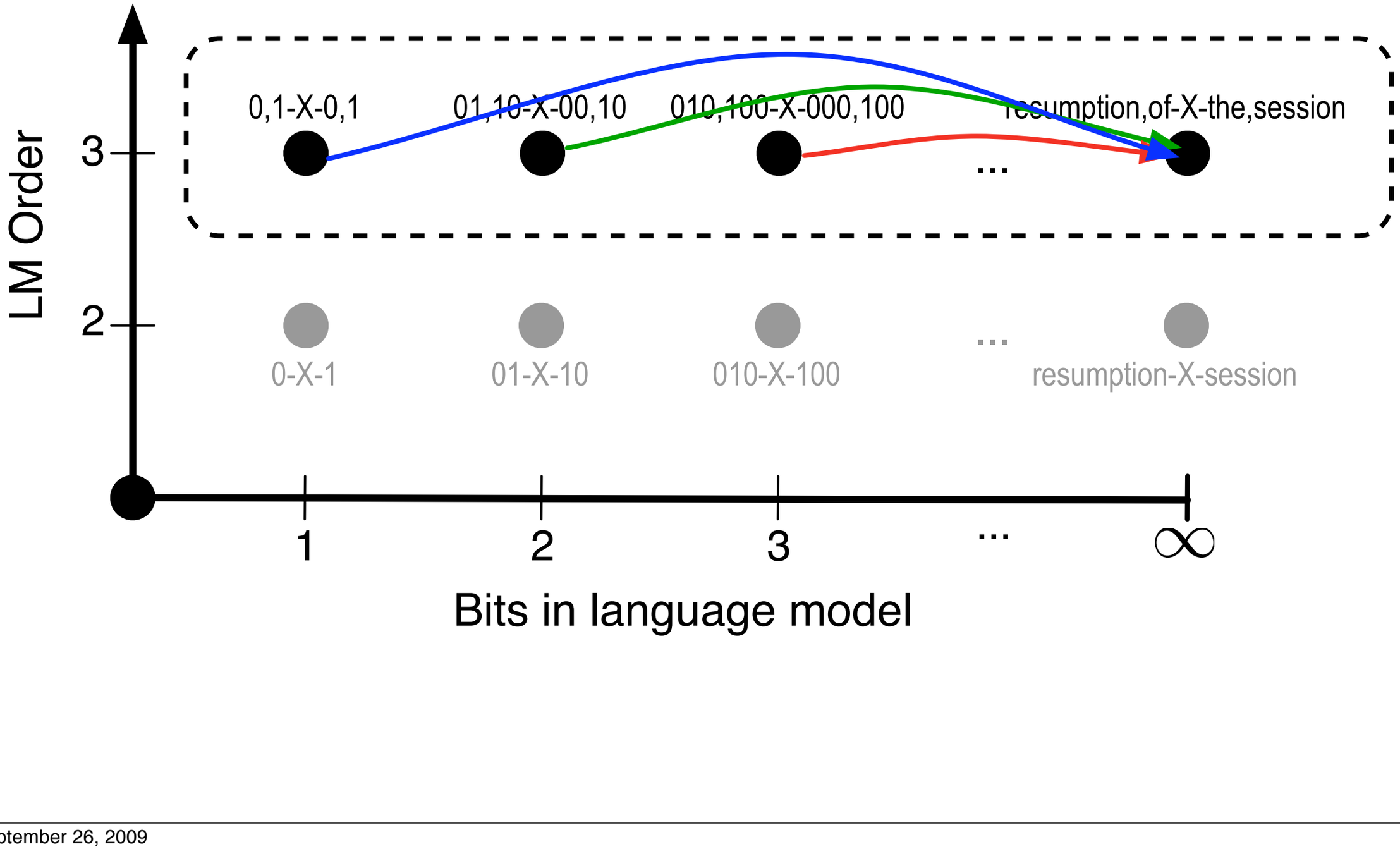

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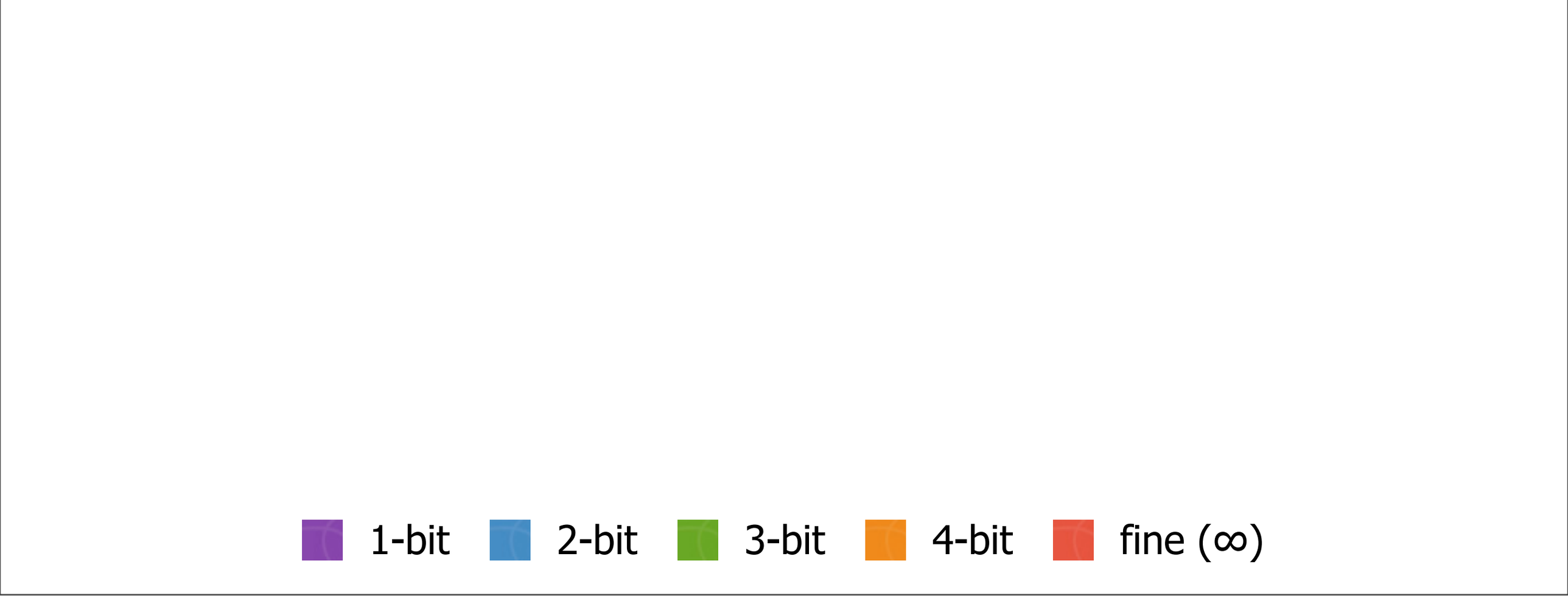

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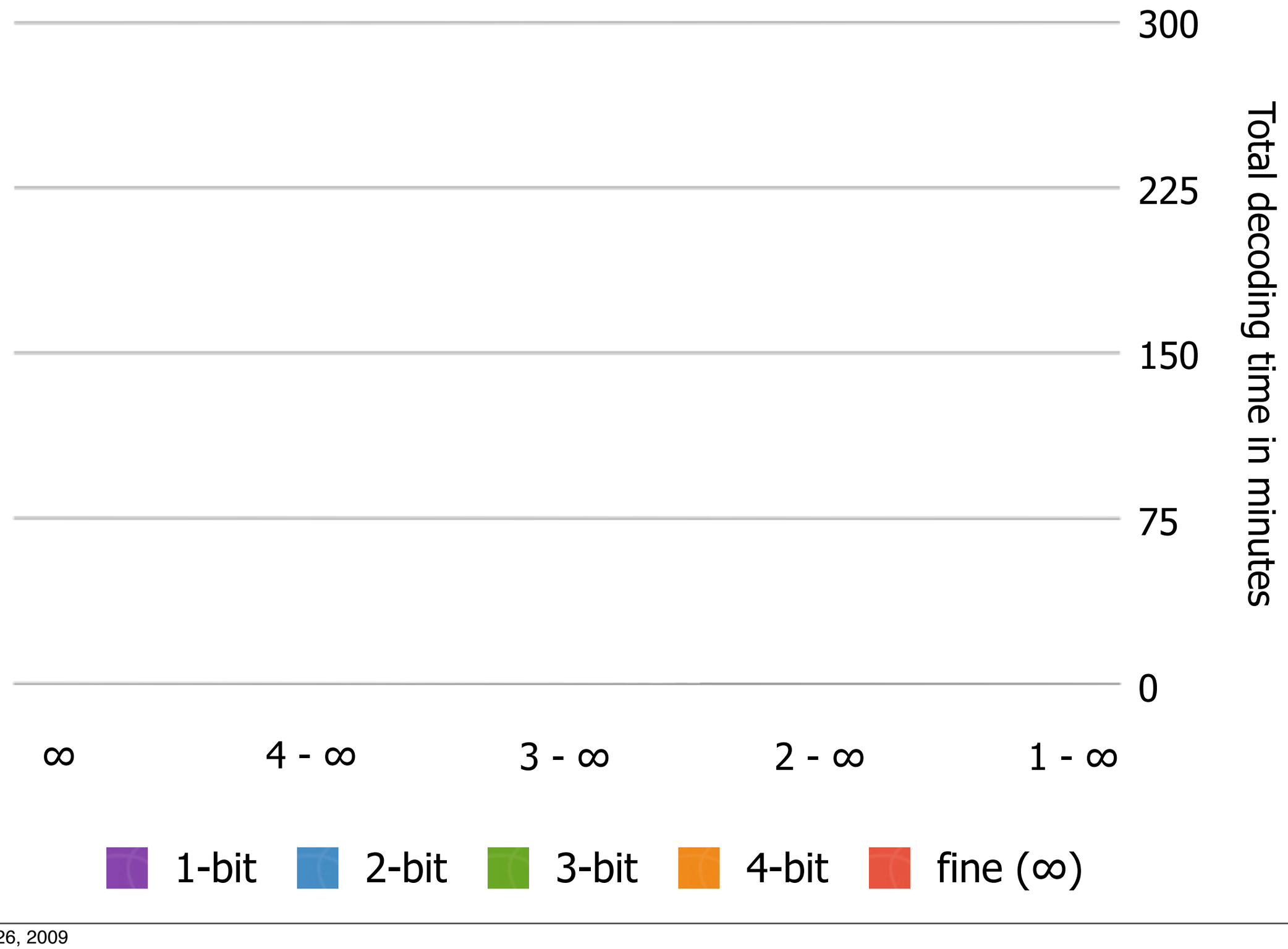

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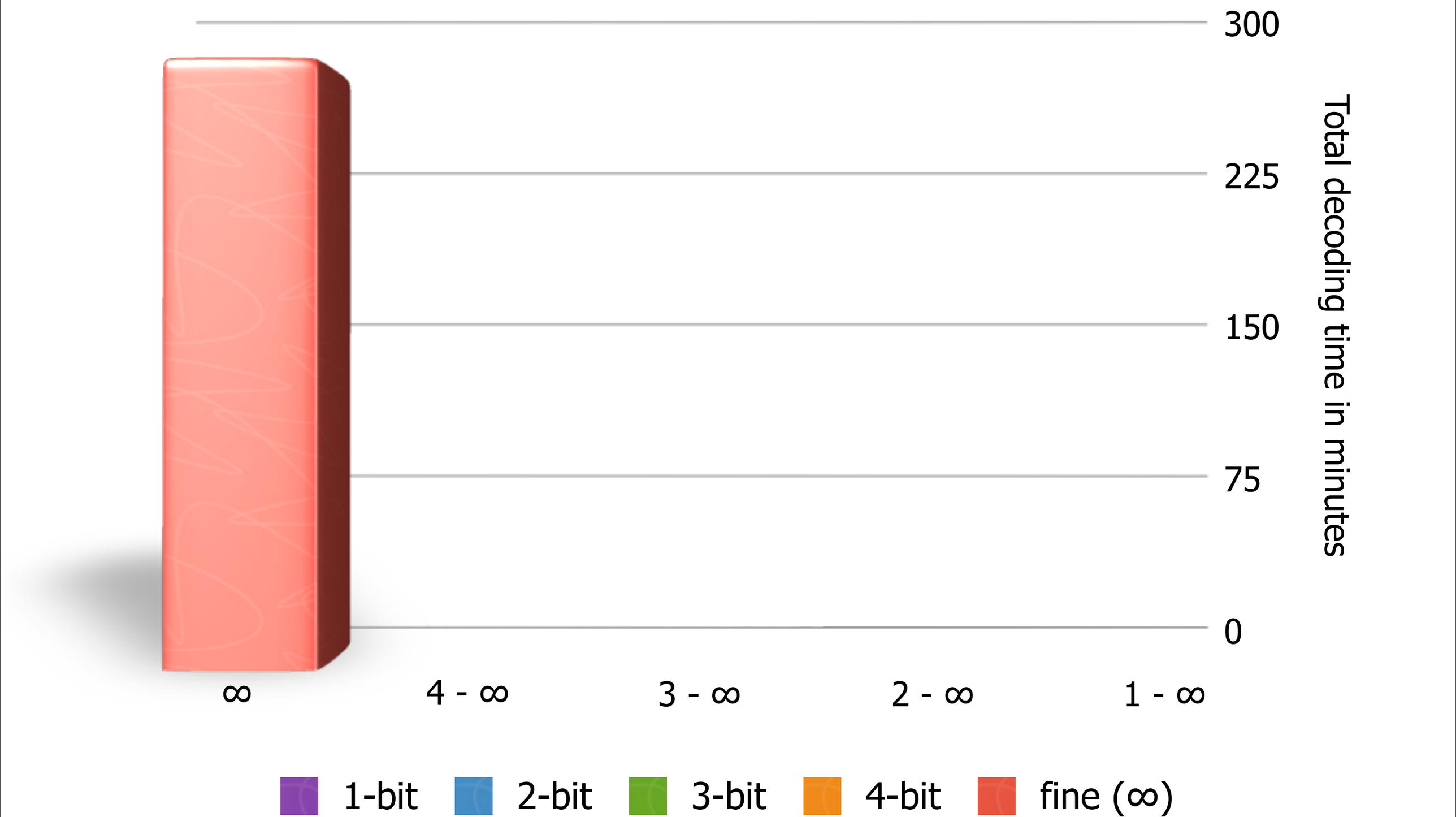

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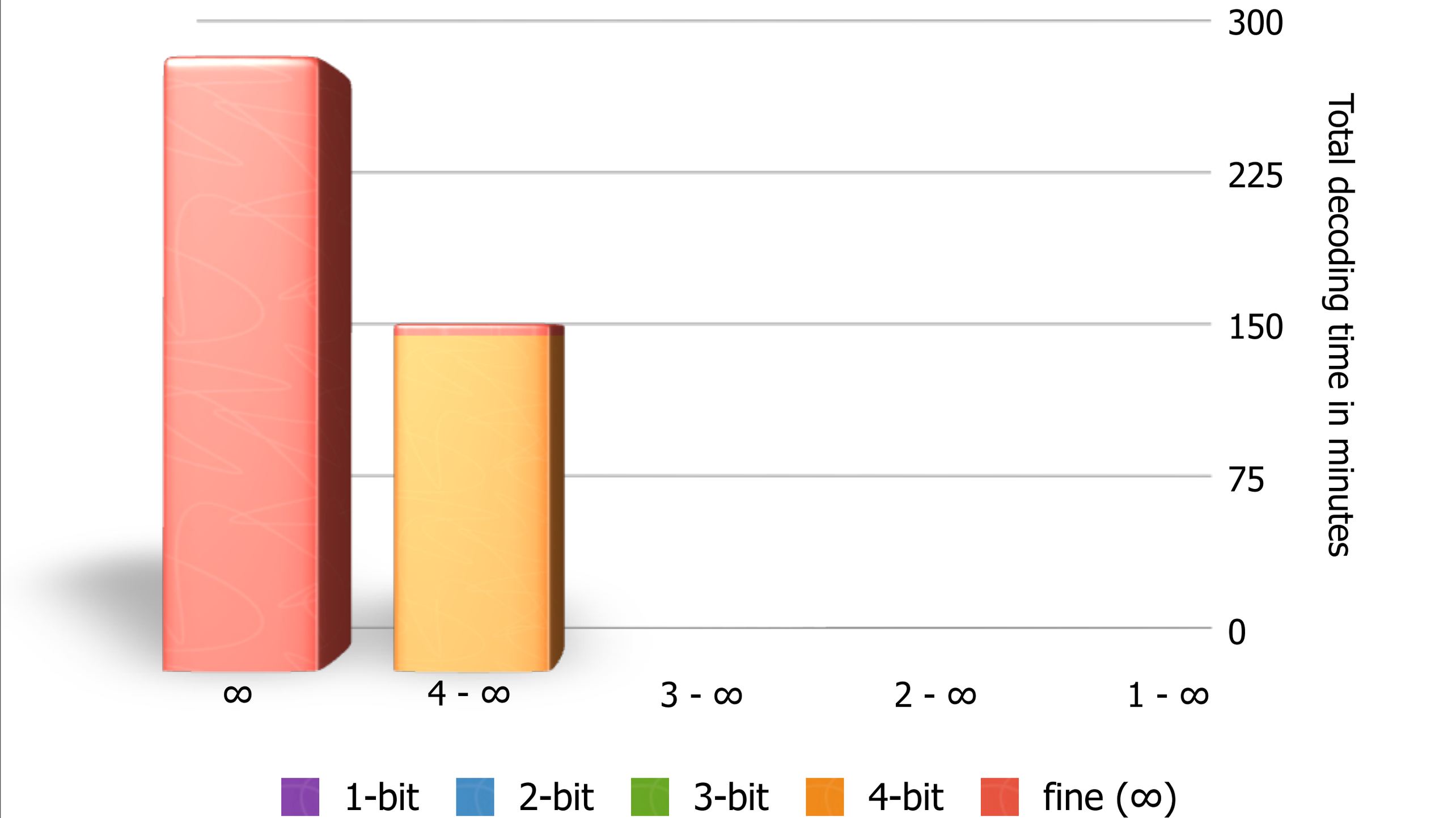

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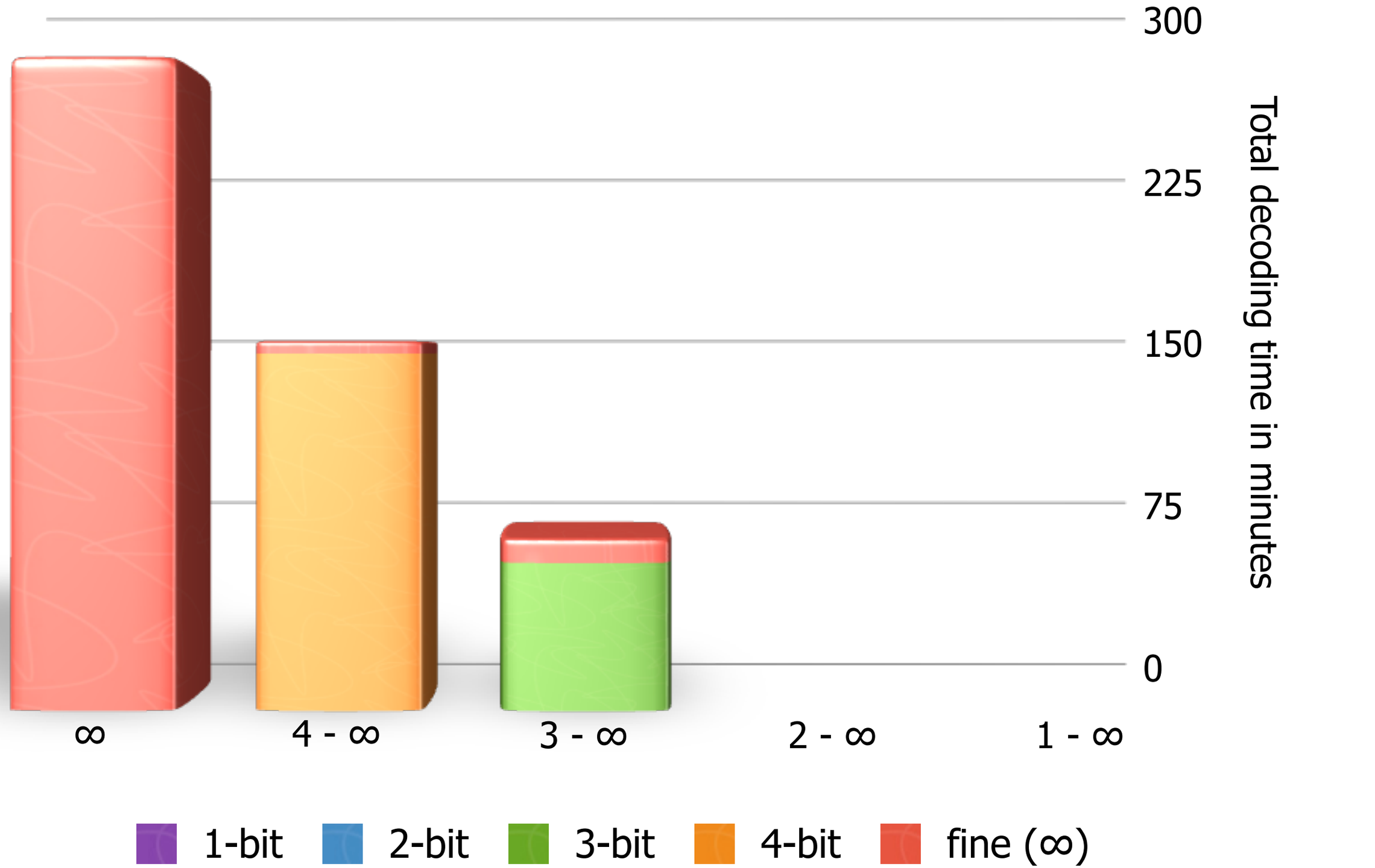

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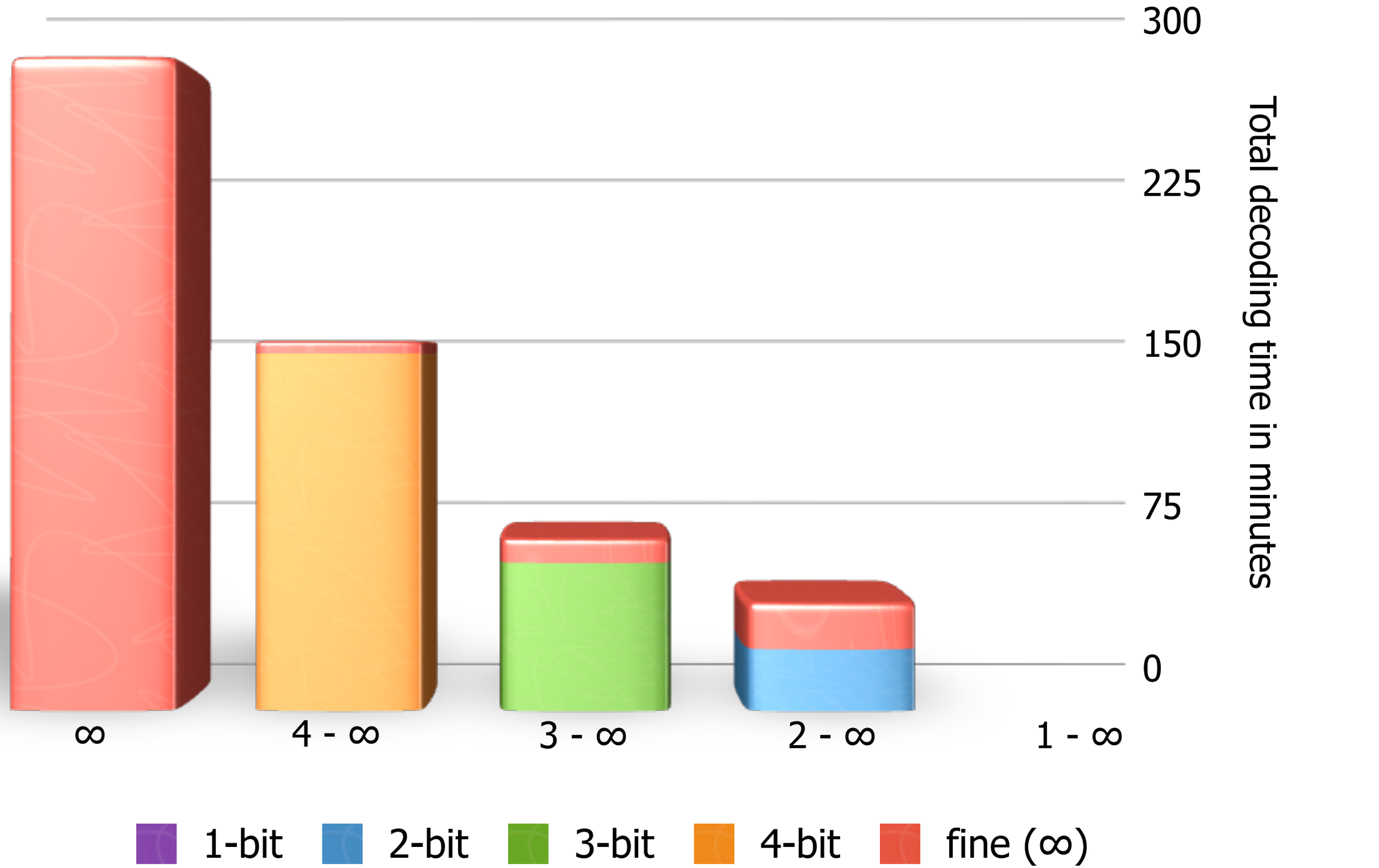

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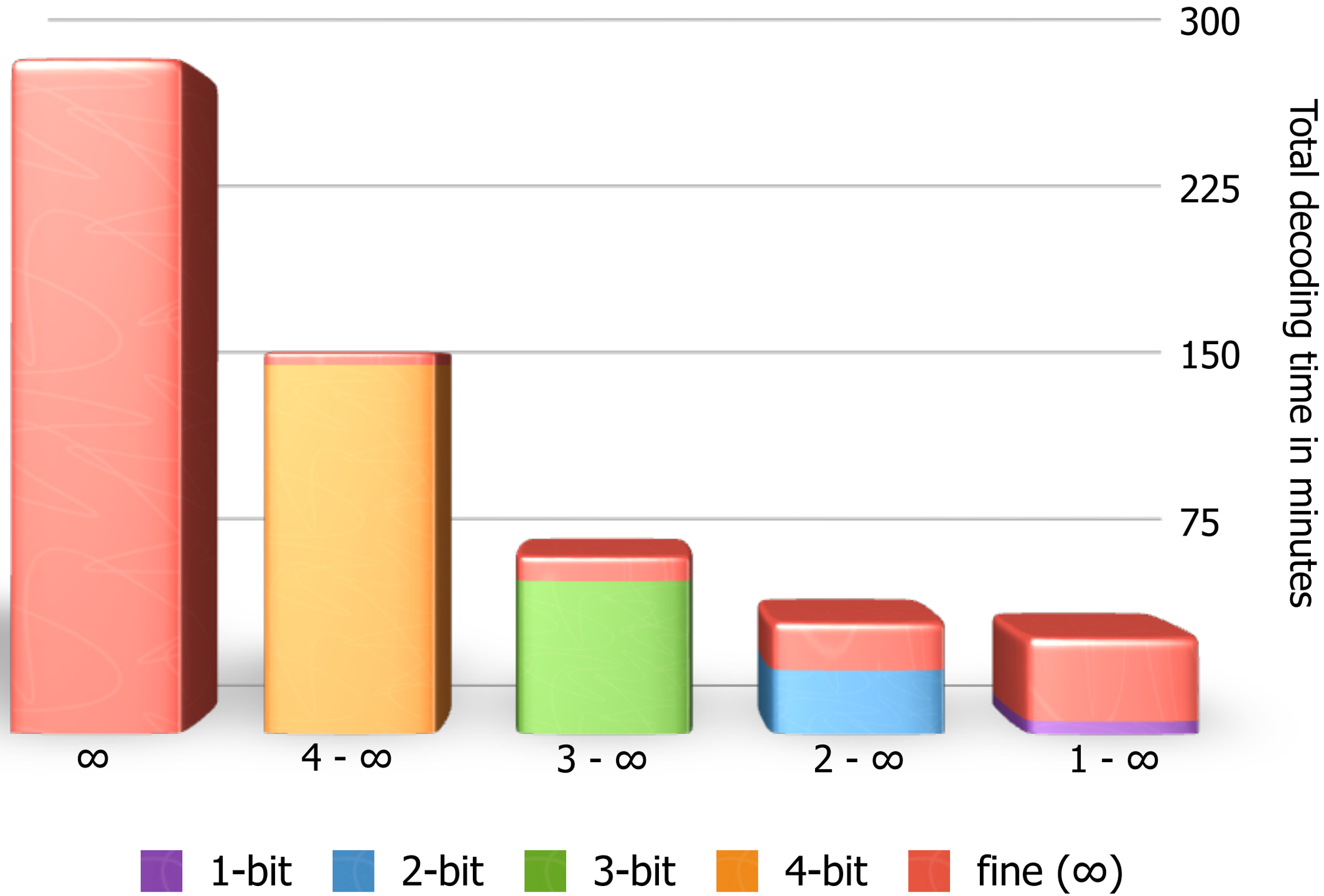

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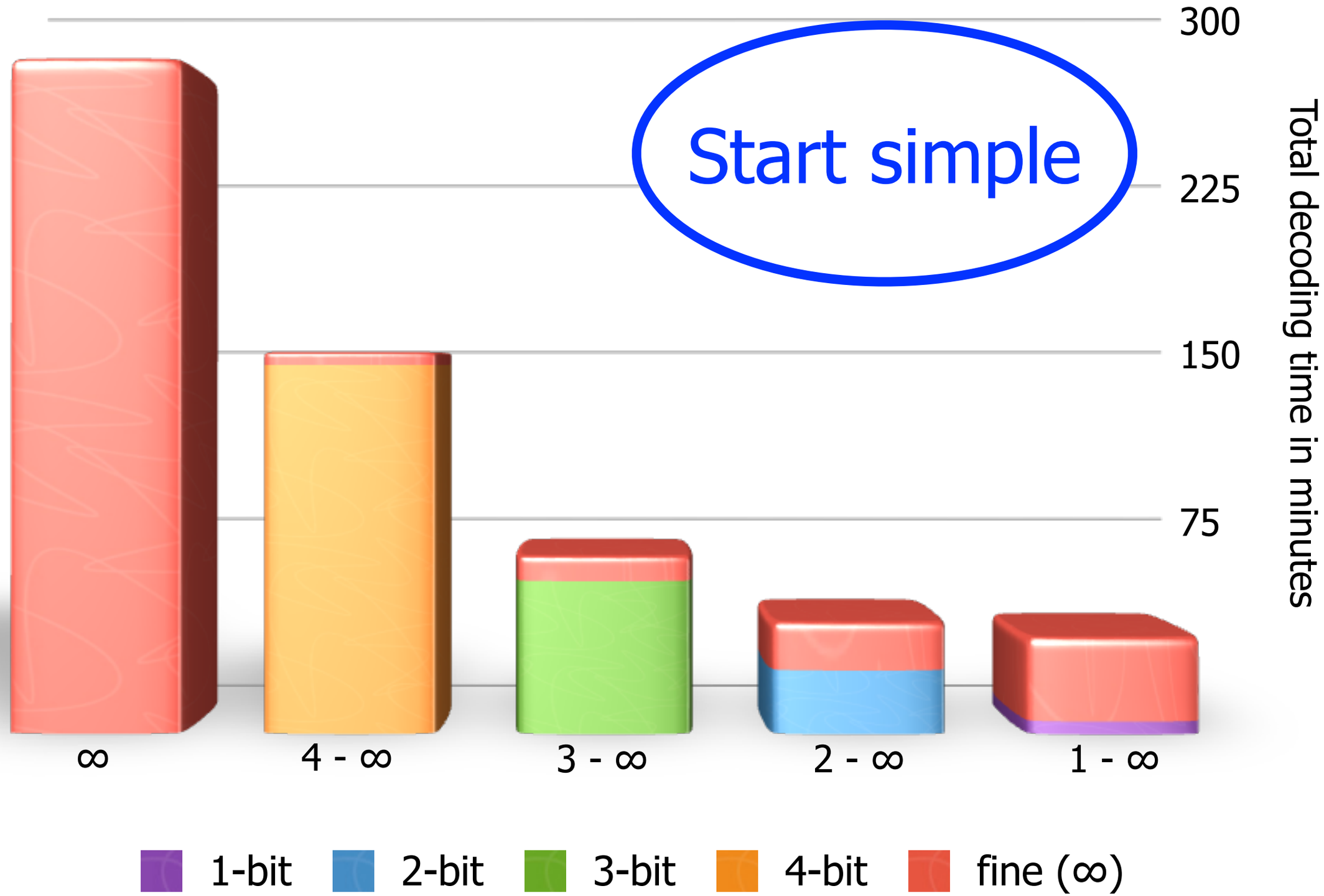
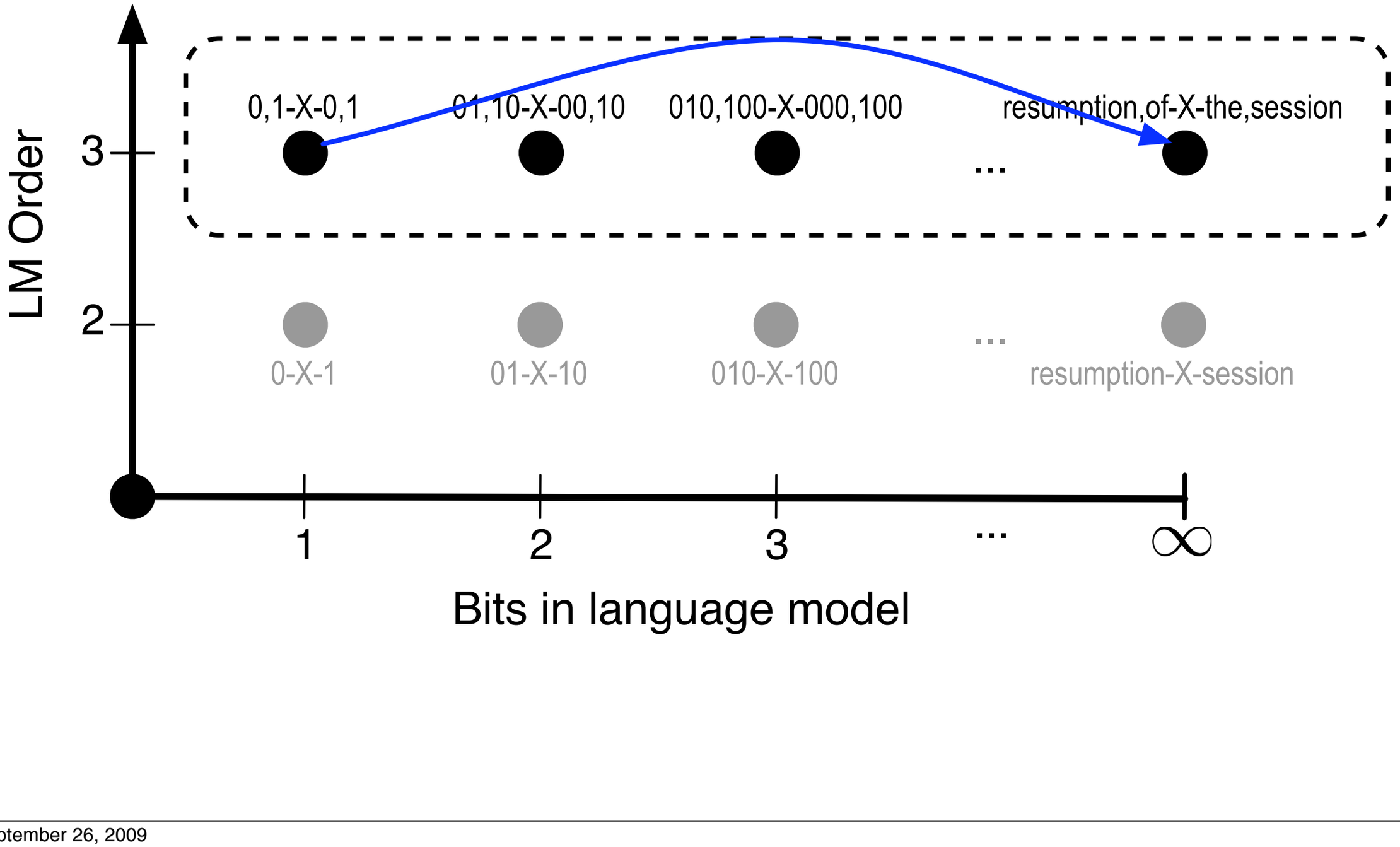
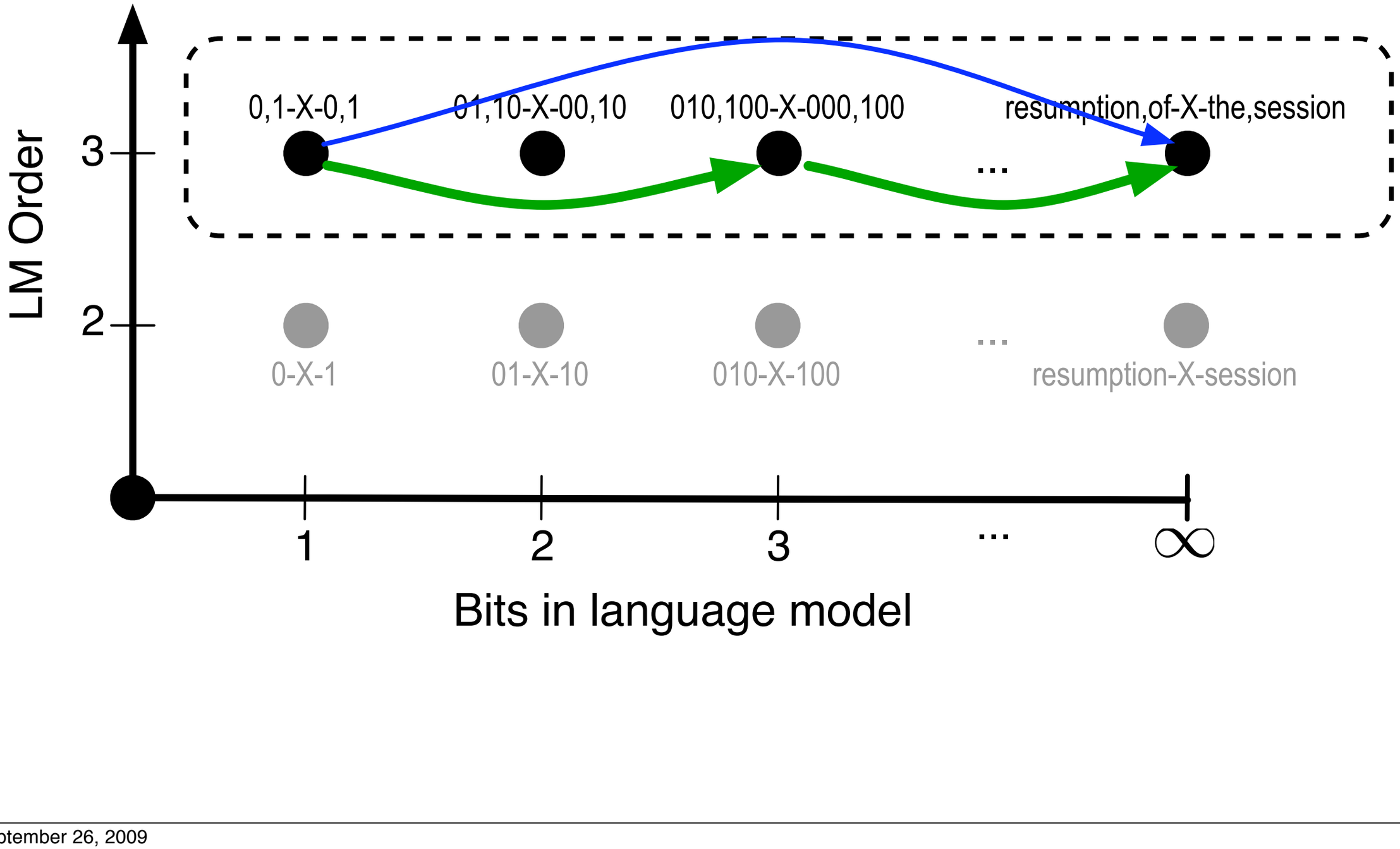


How many passes?

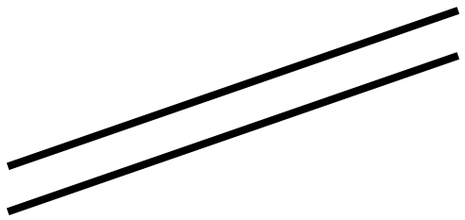


How many passes?



How many passes?

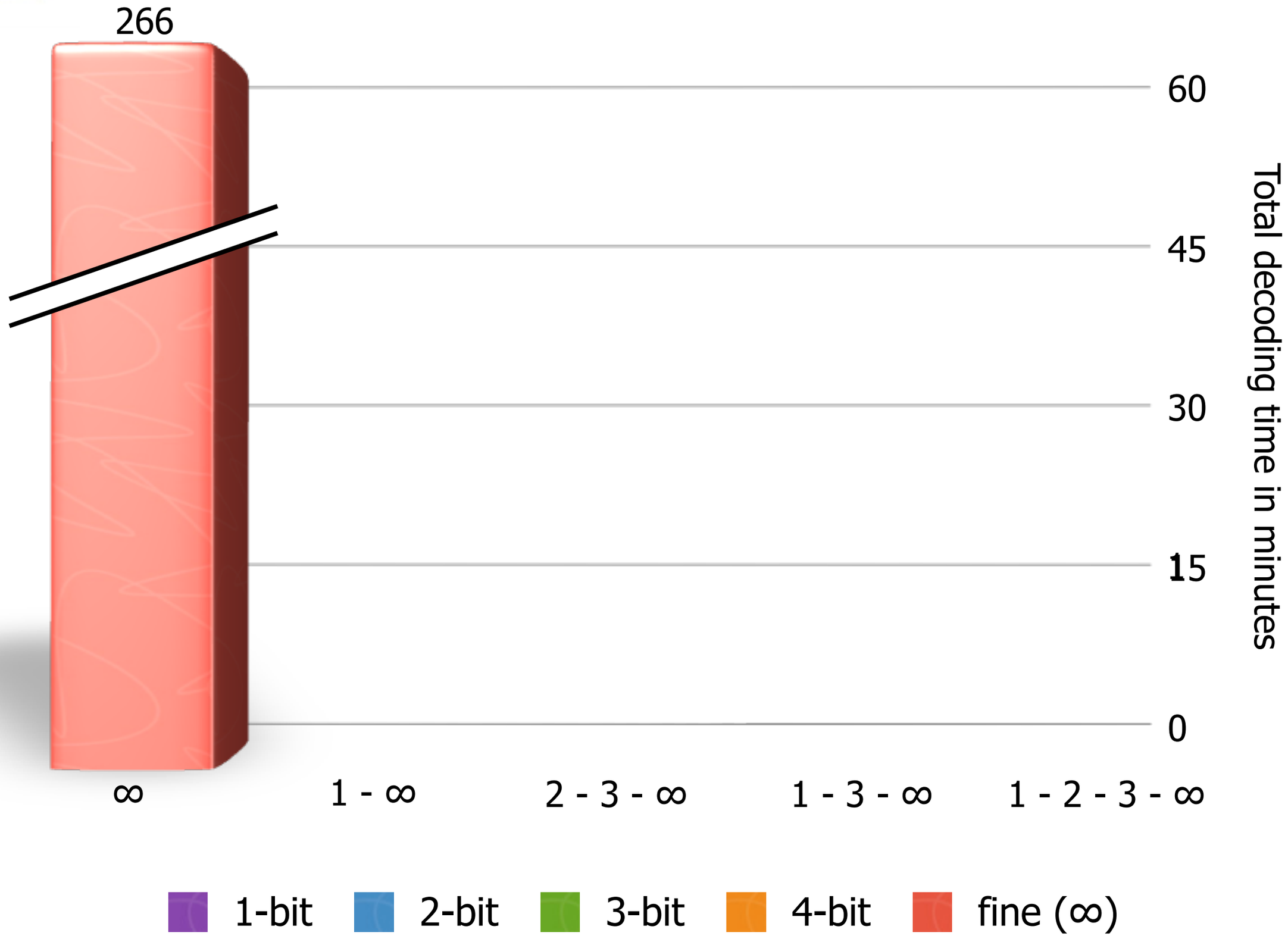
266



1

1-bit 2-bit 3-bit 4-bit fine (∞)

How many passes?



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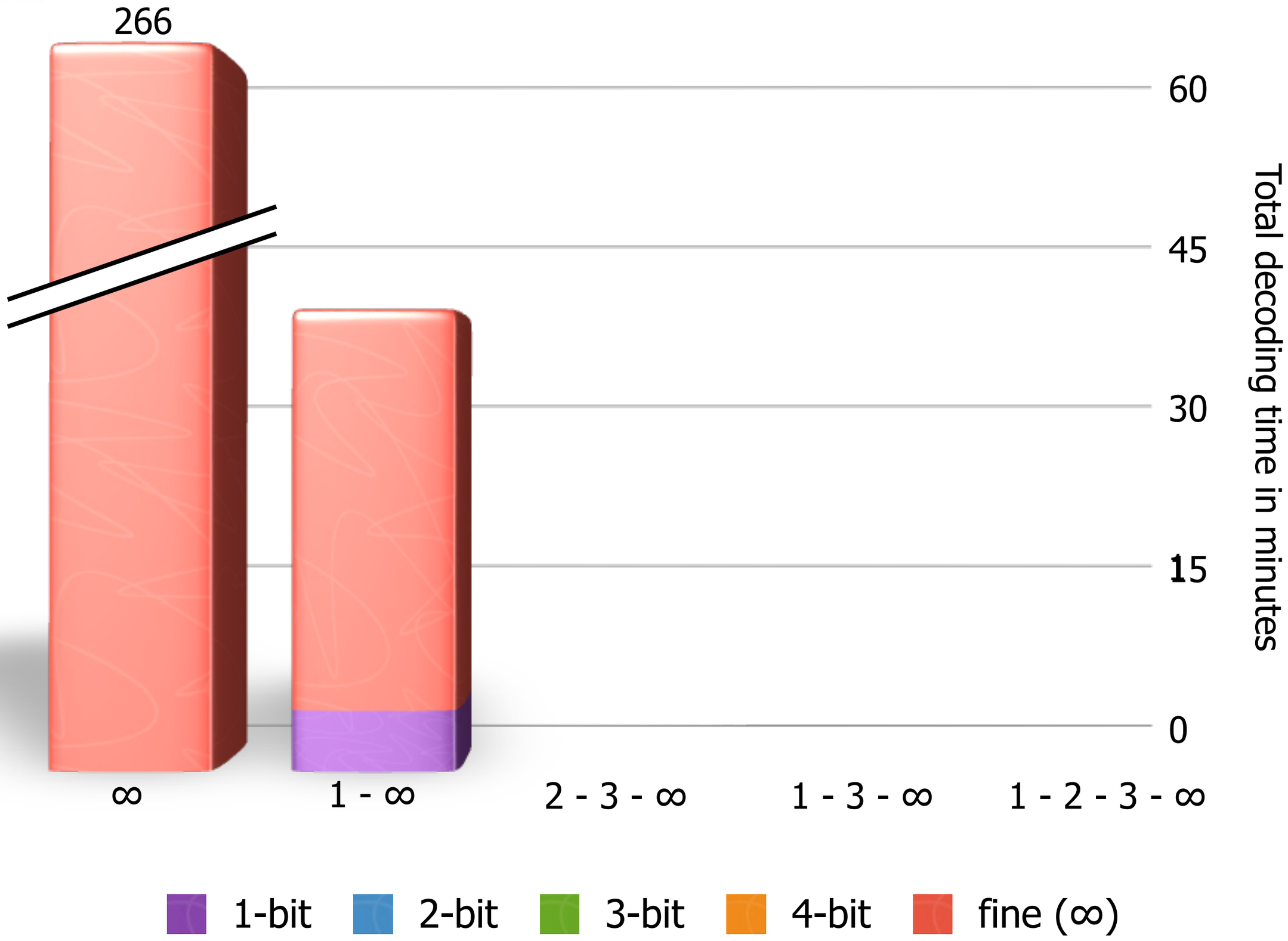
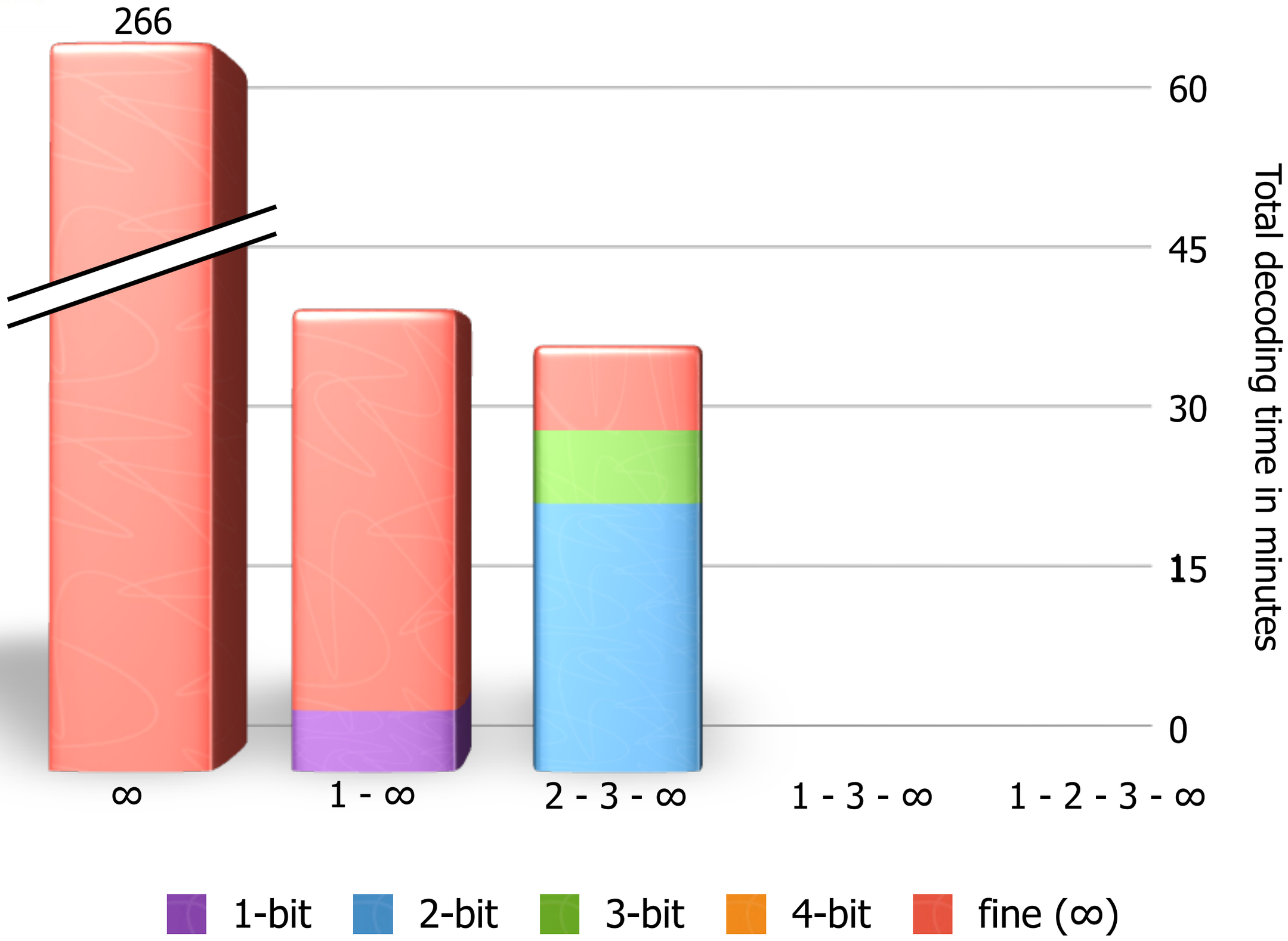


How many passes?



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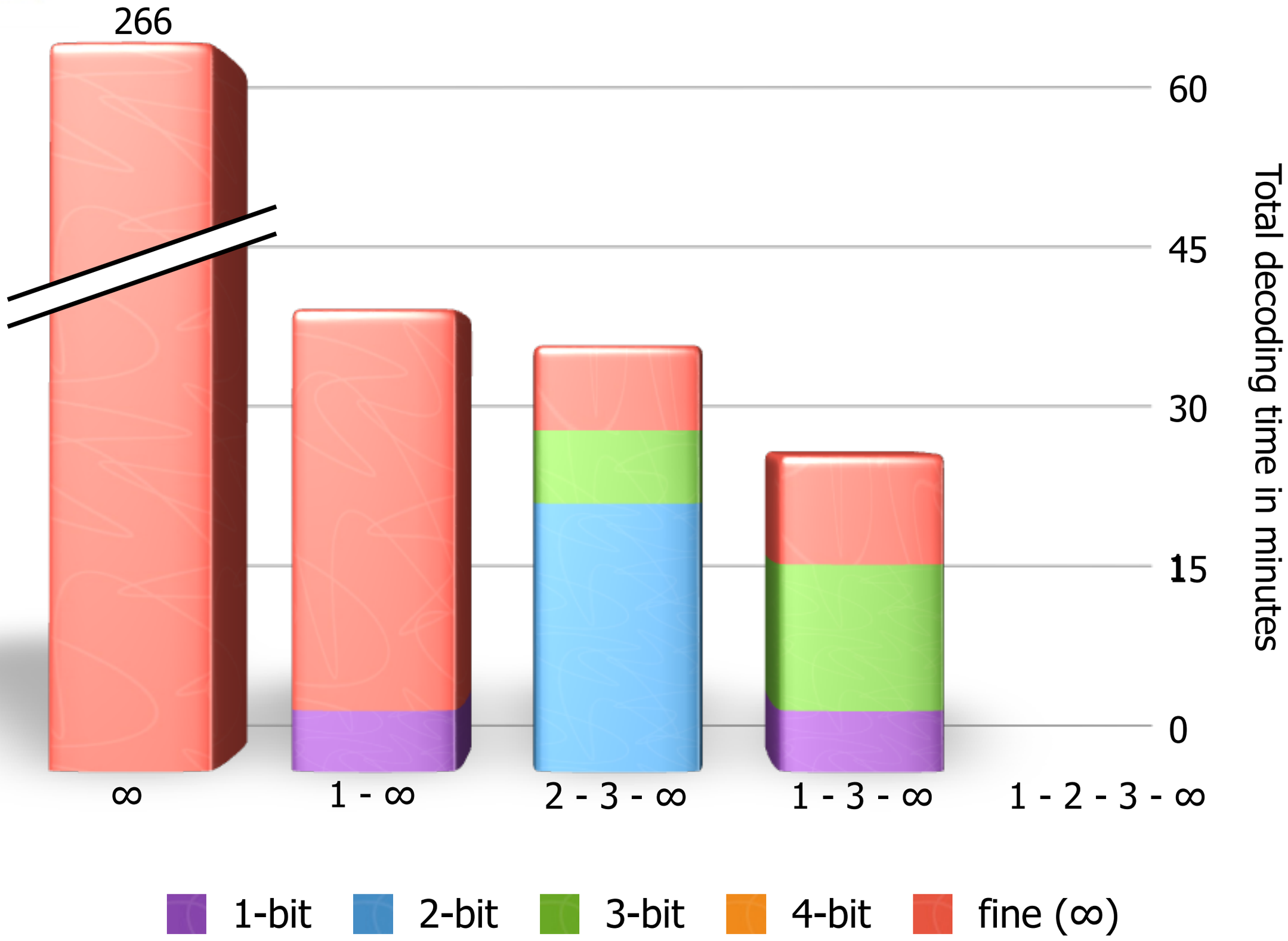

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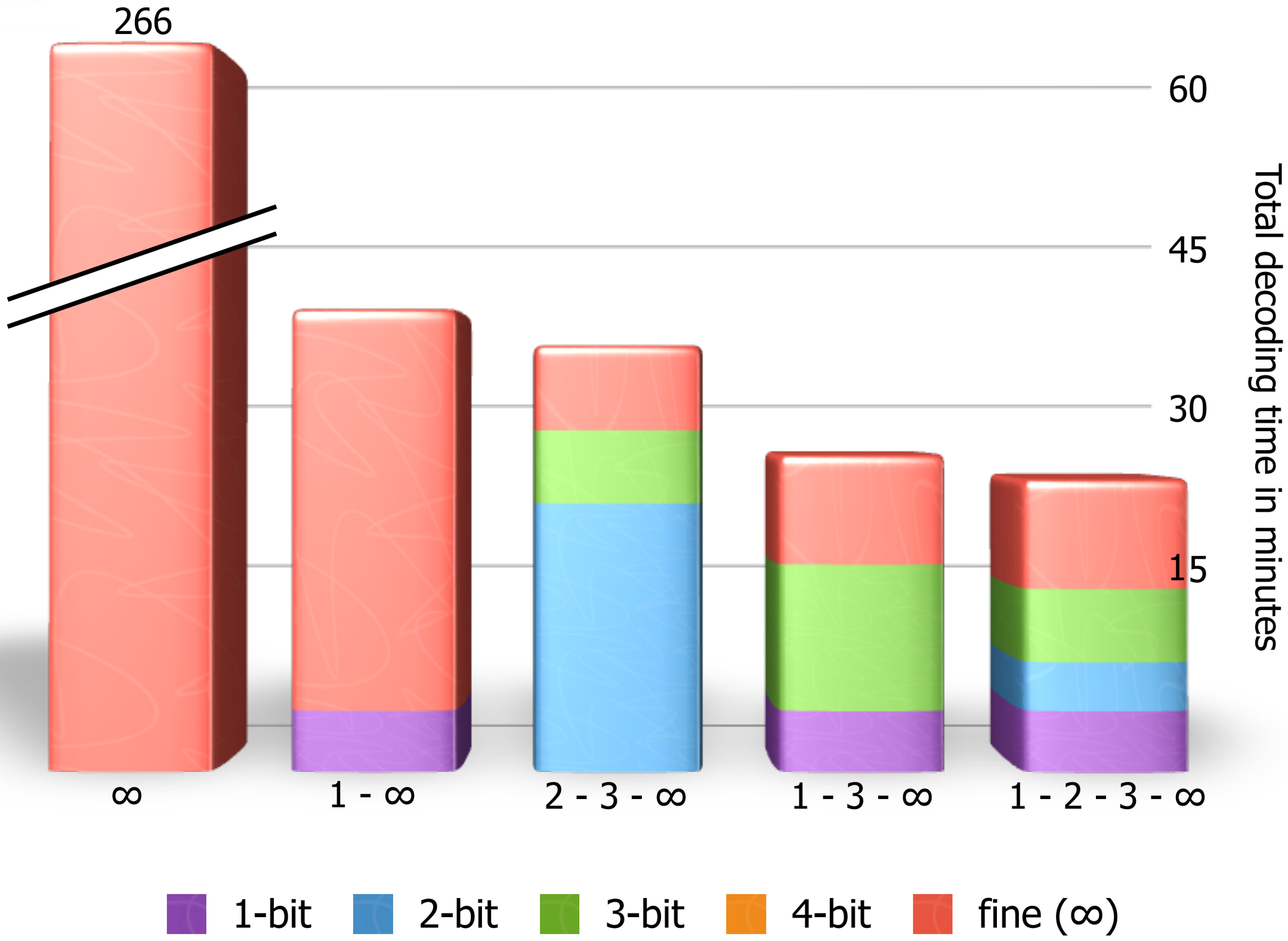
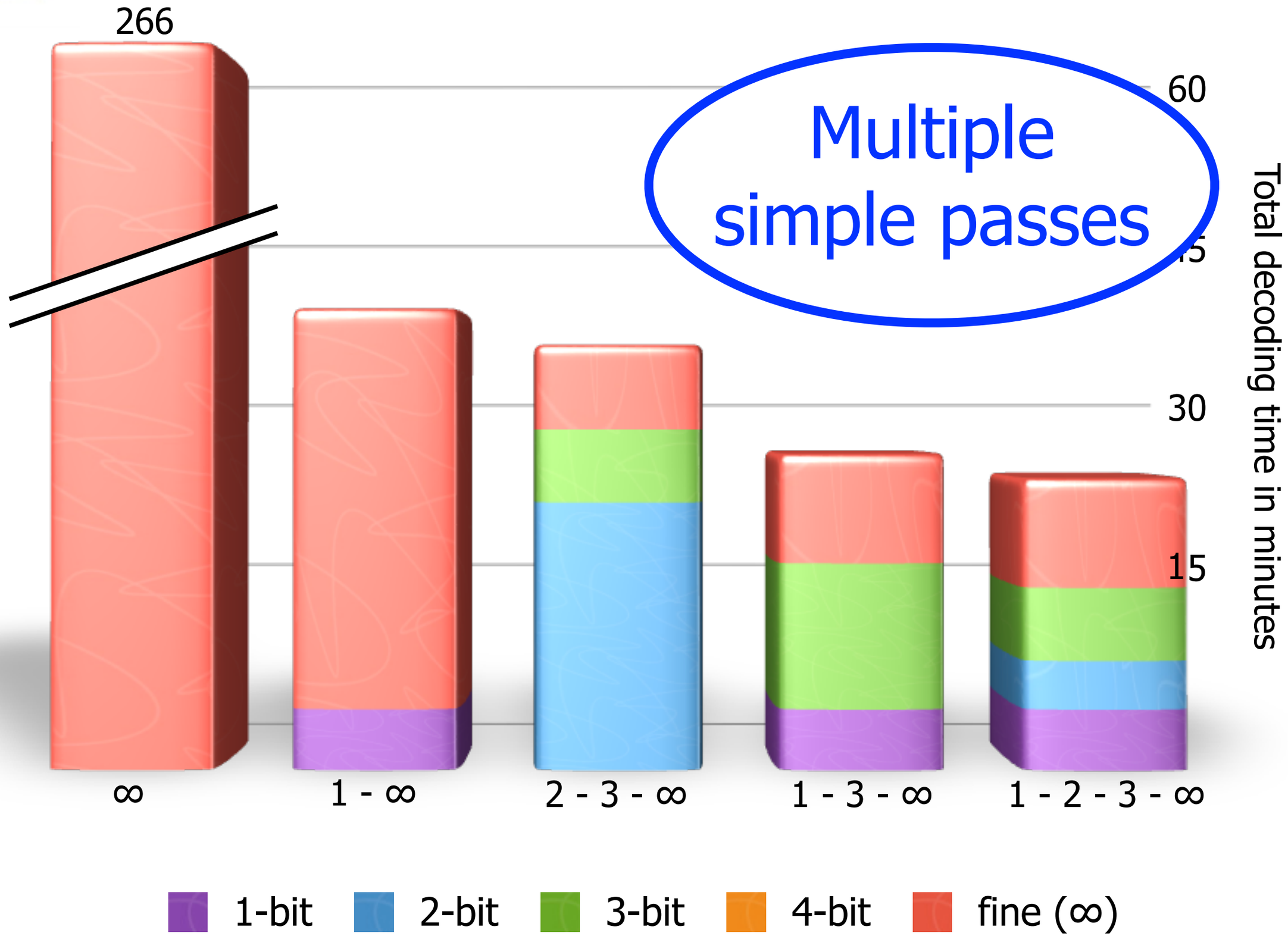
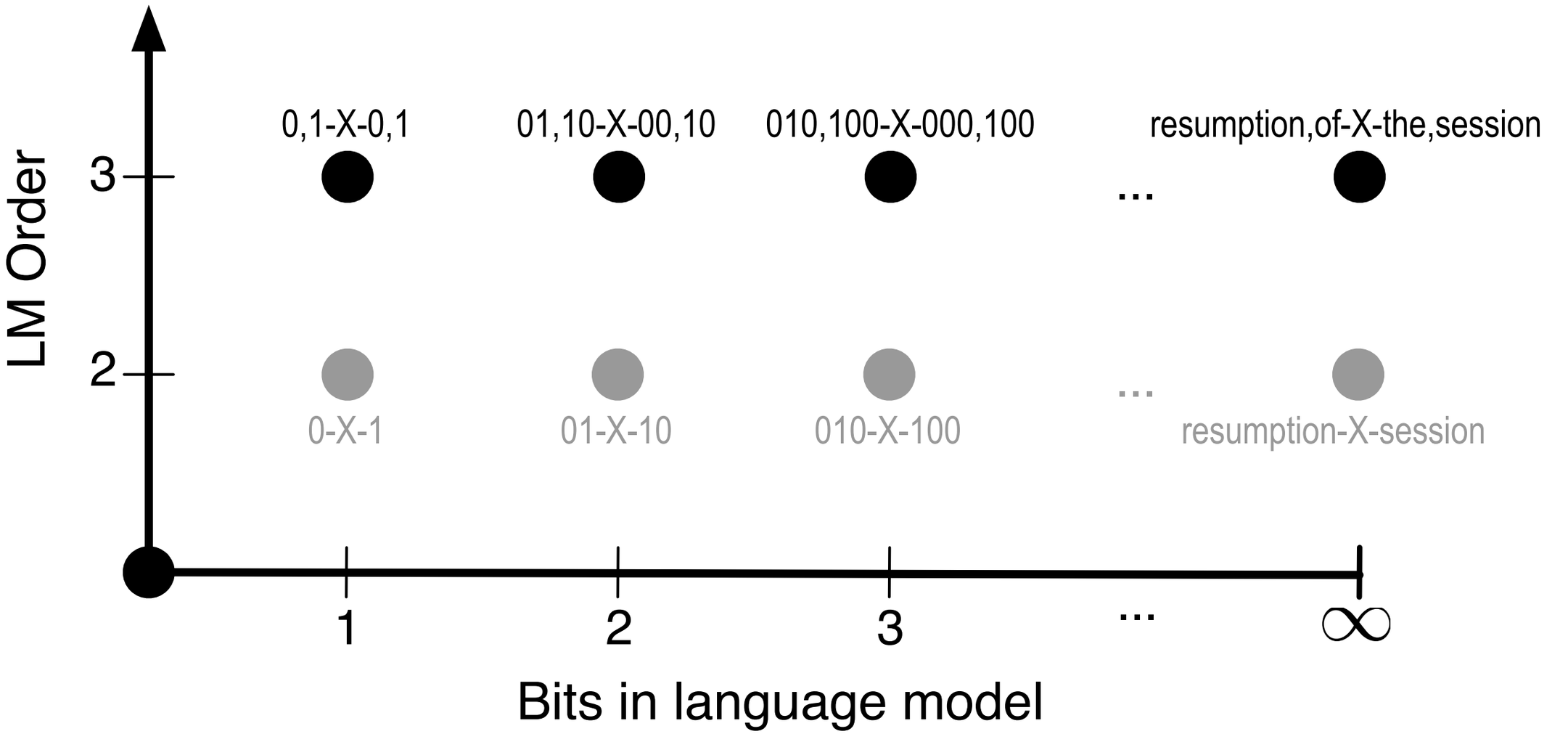


How many passes?



Use Encoding or Order?



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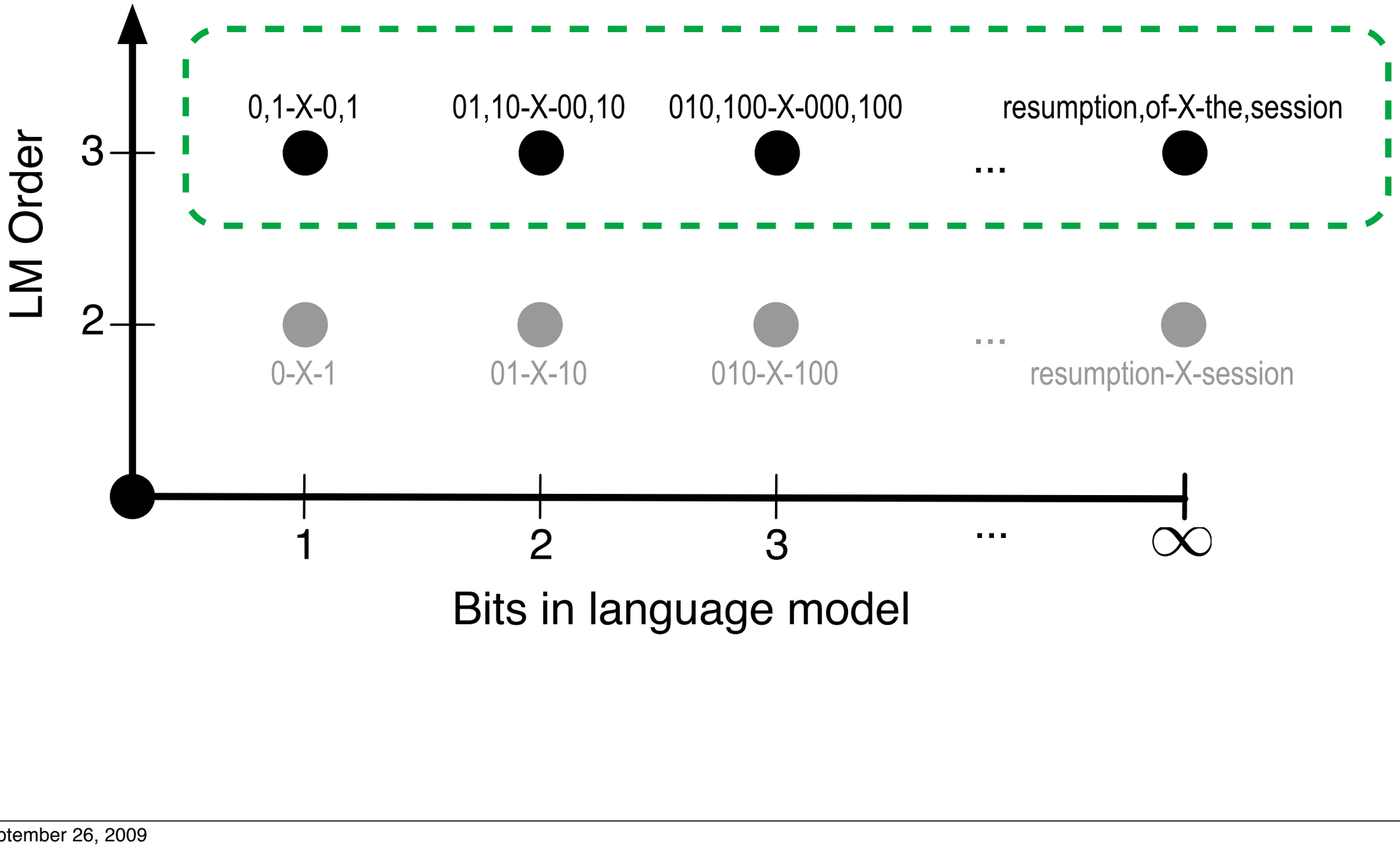
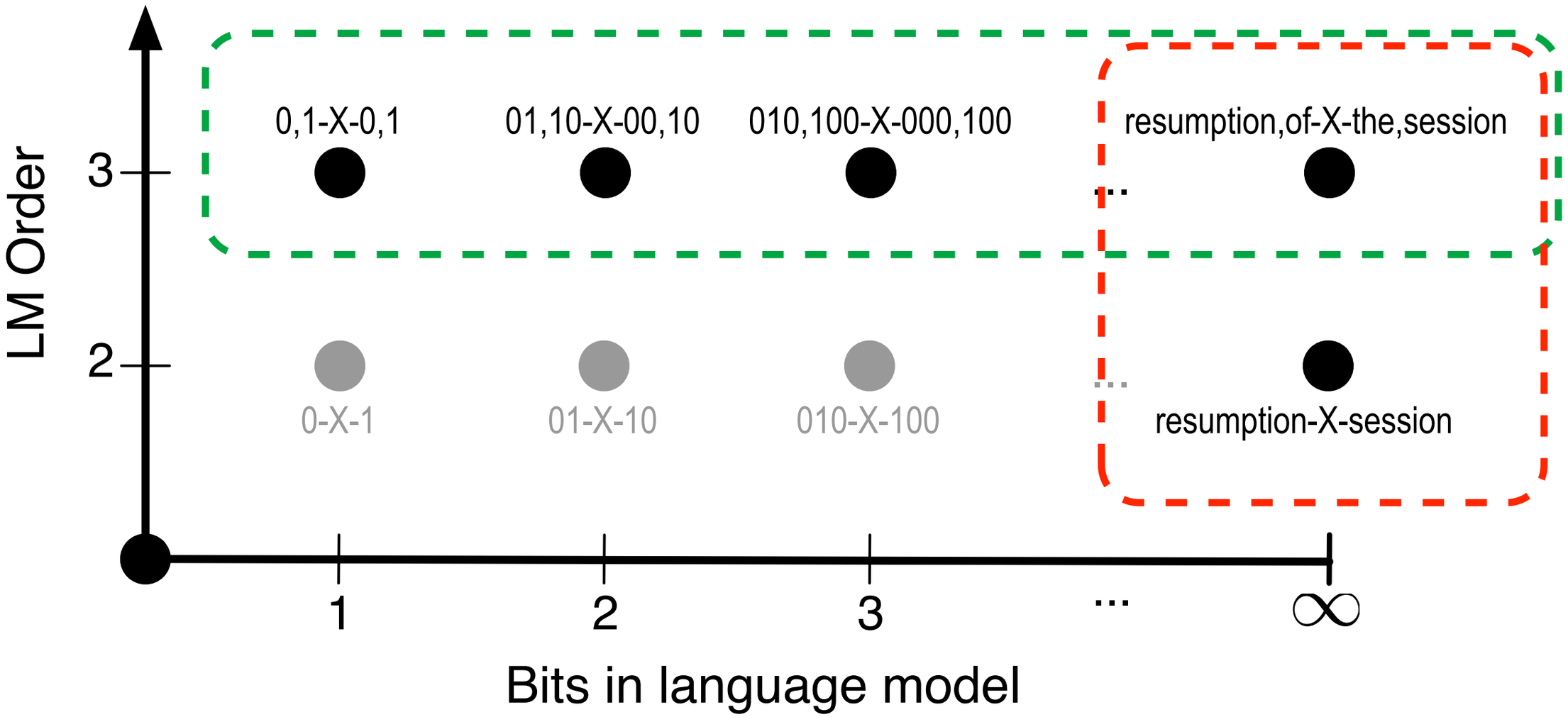


Use Encoding or Order?



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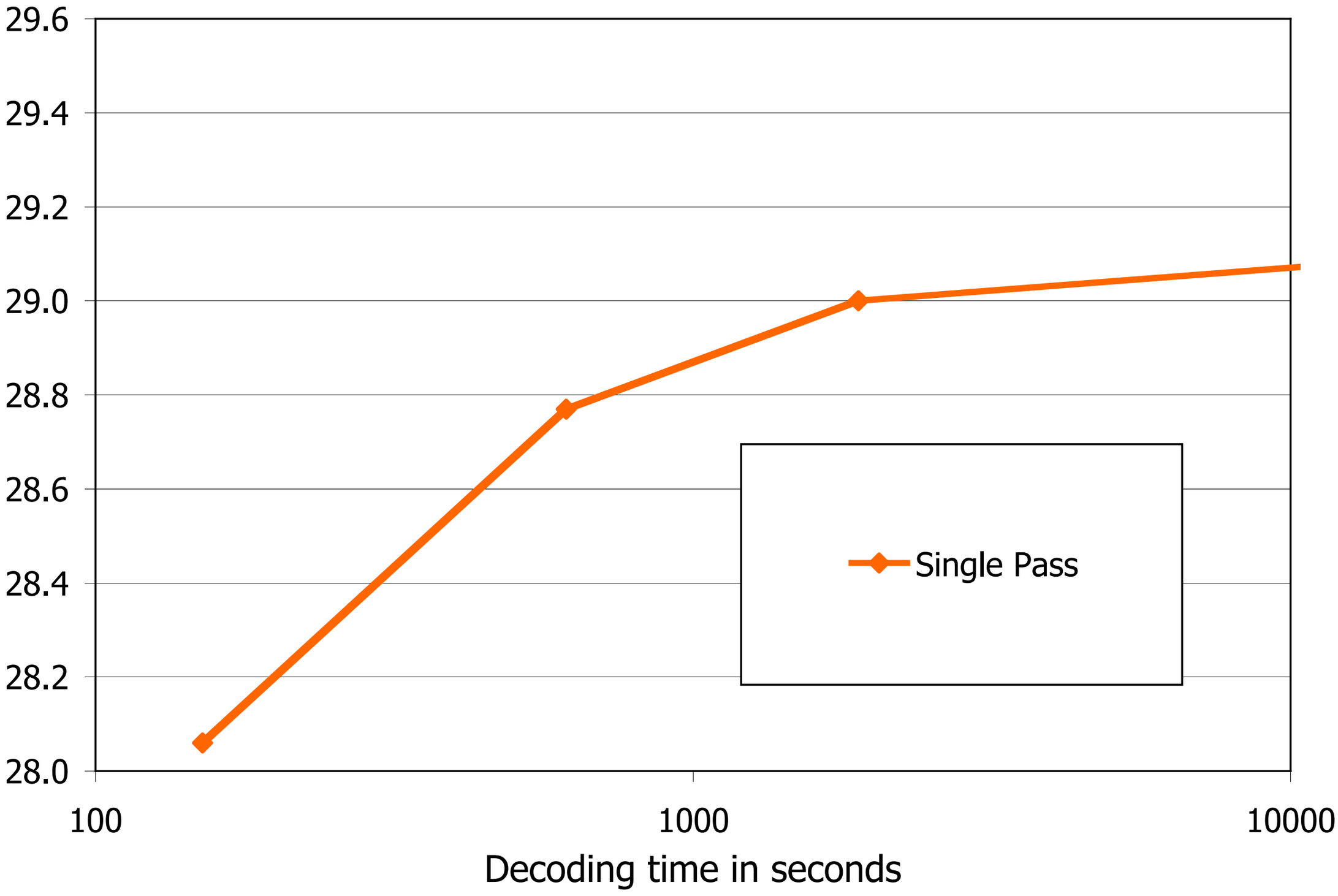

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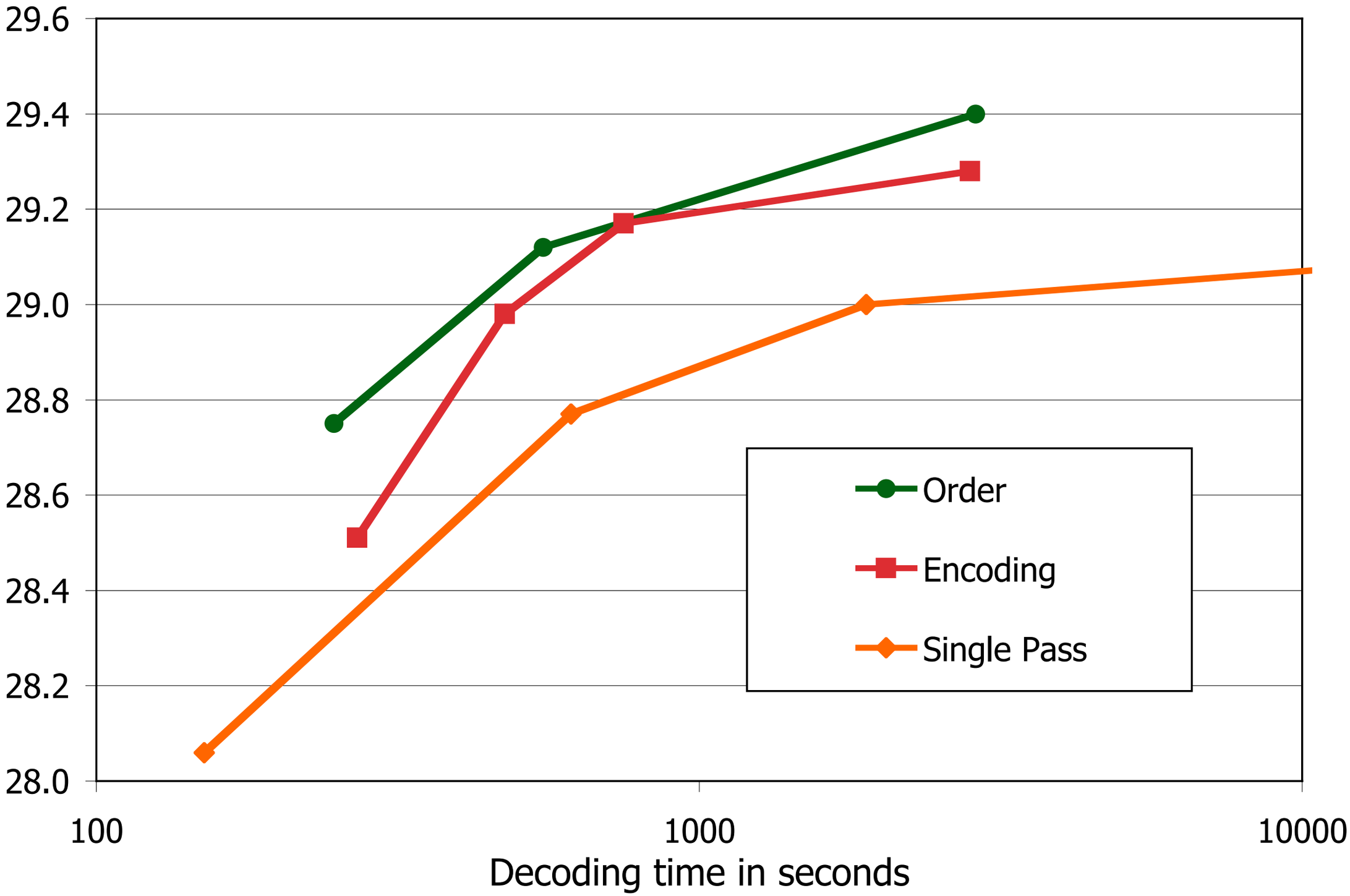

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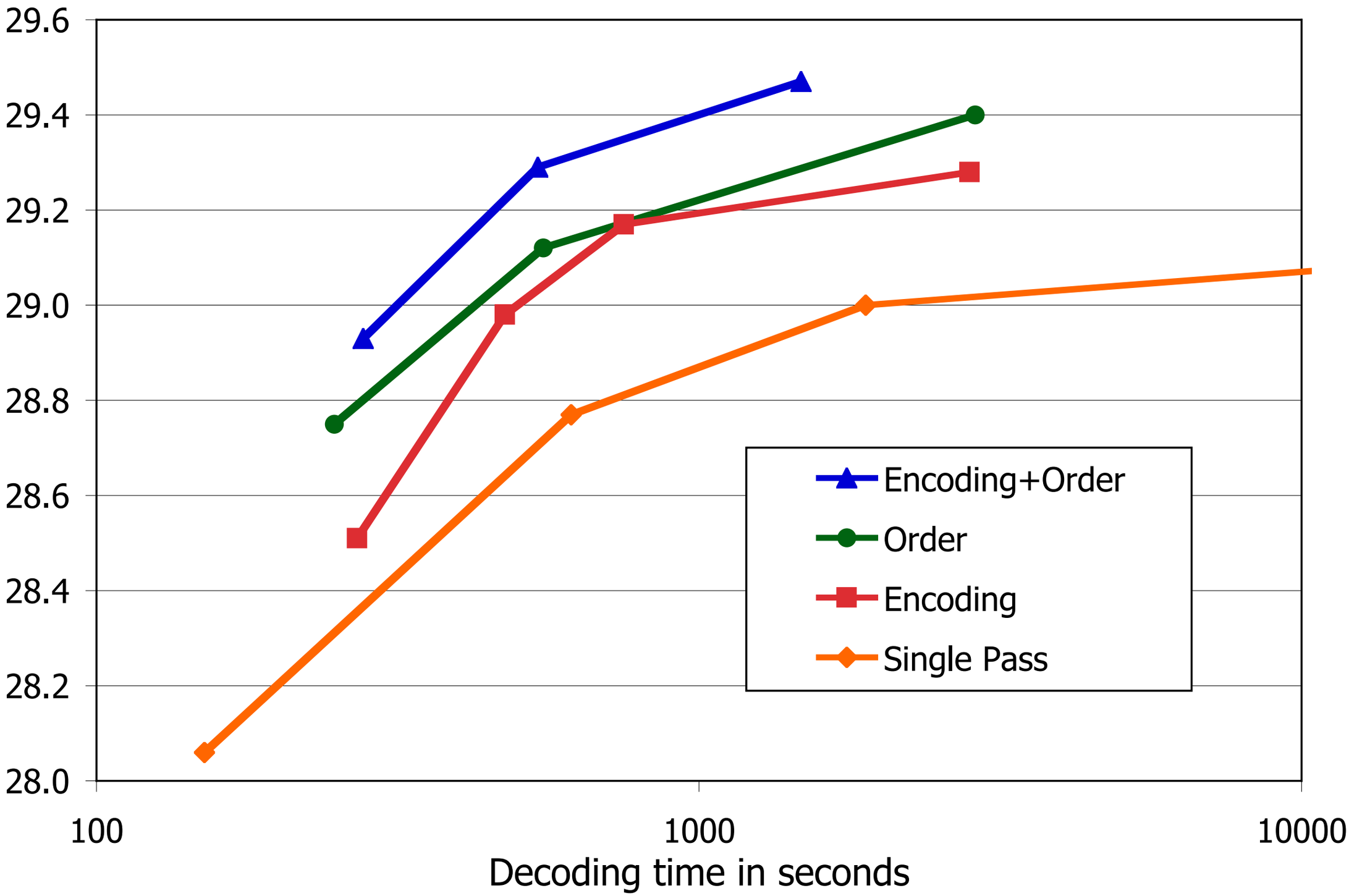

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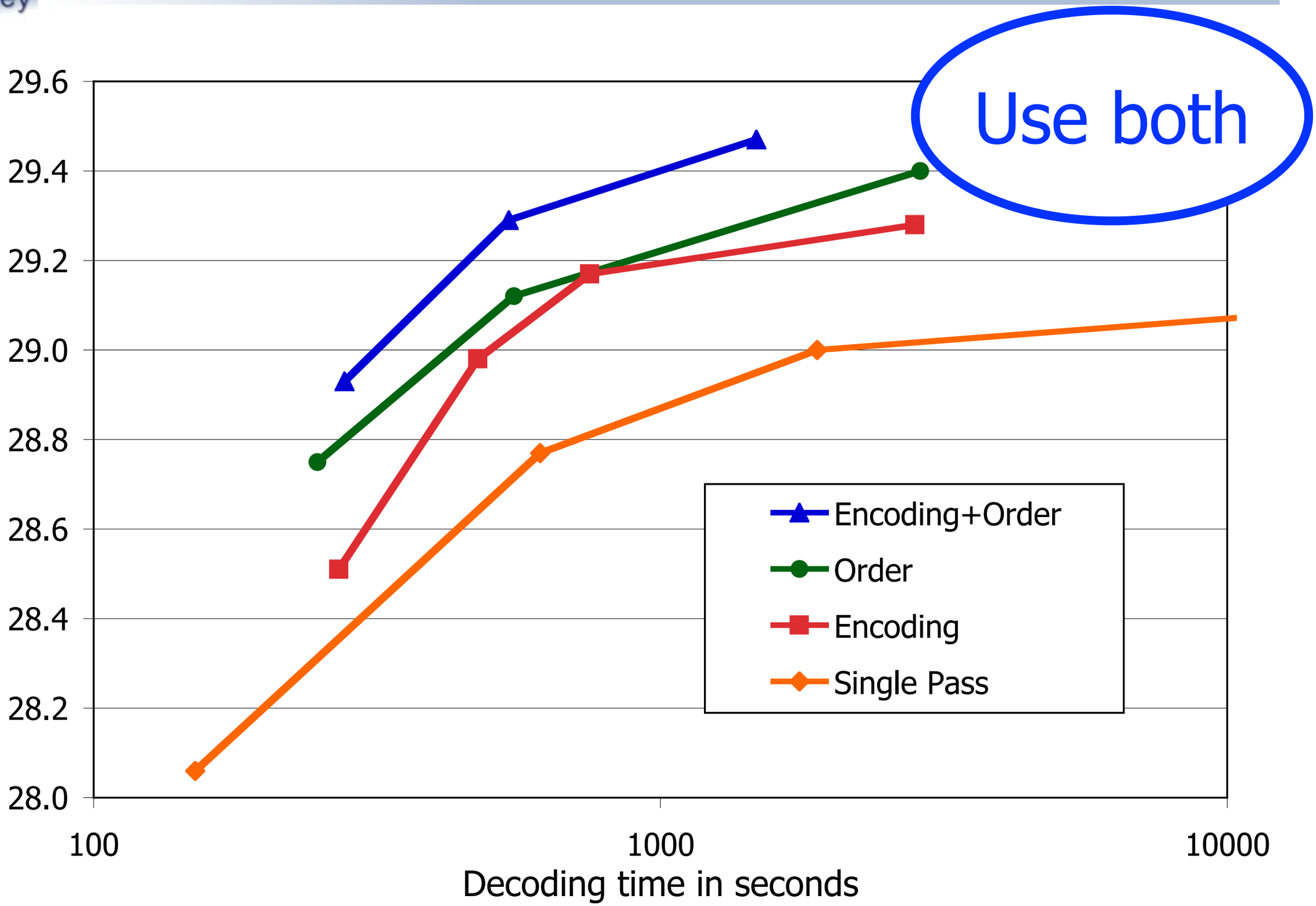
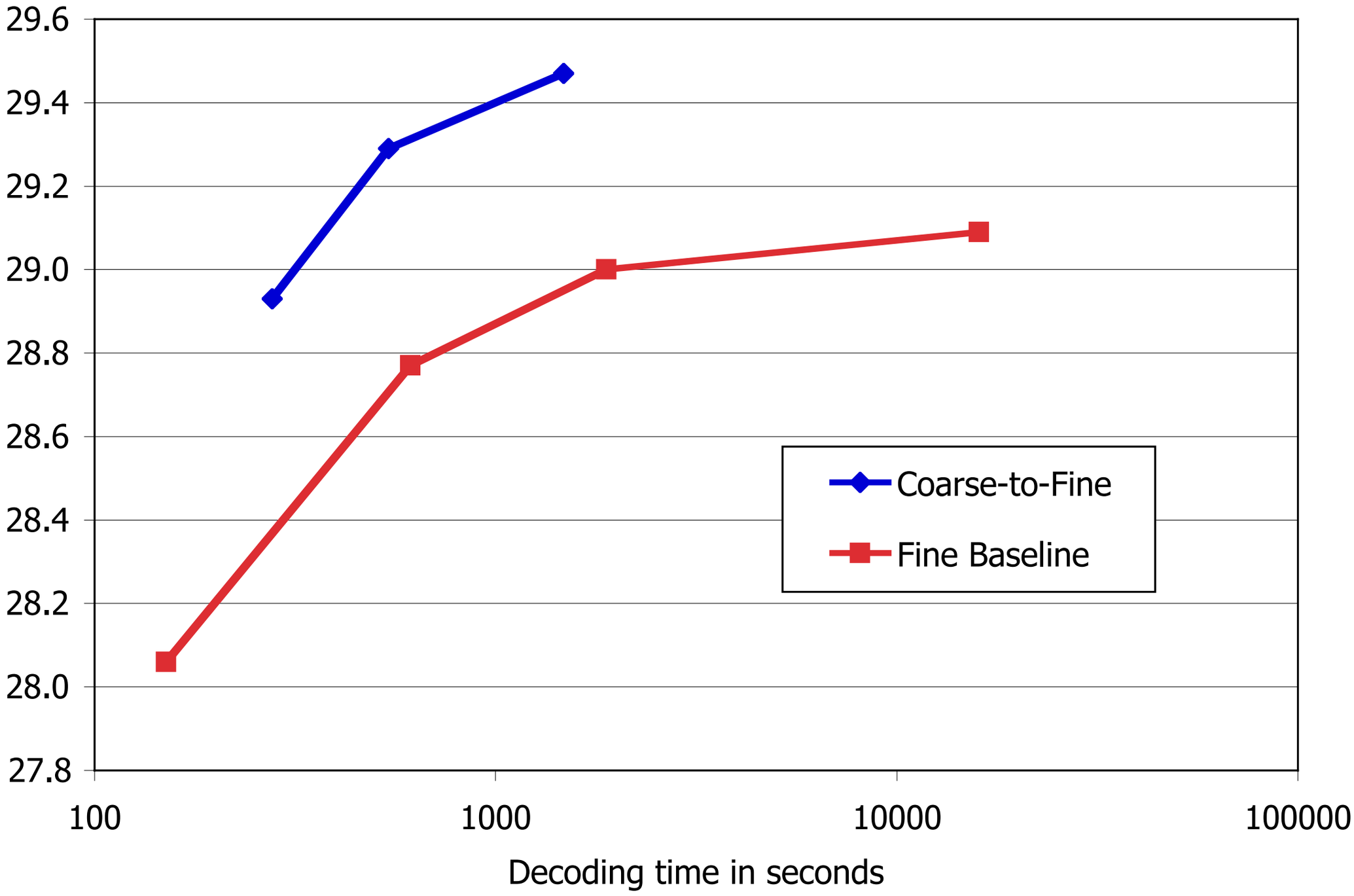
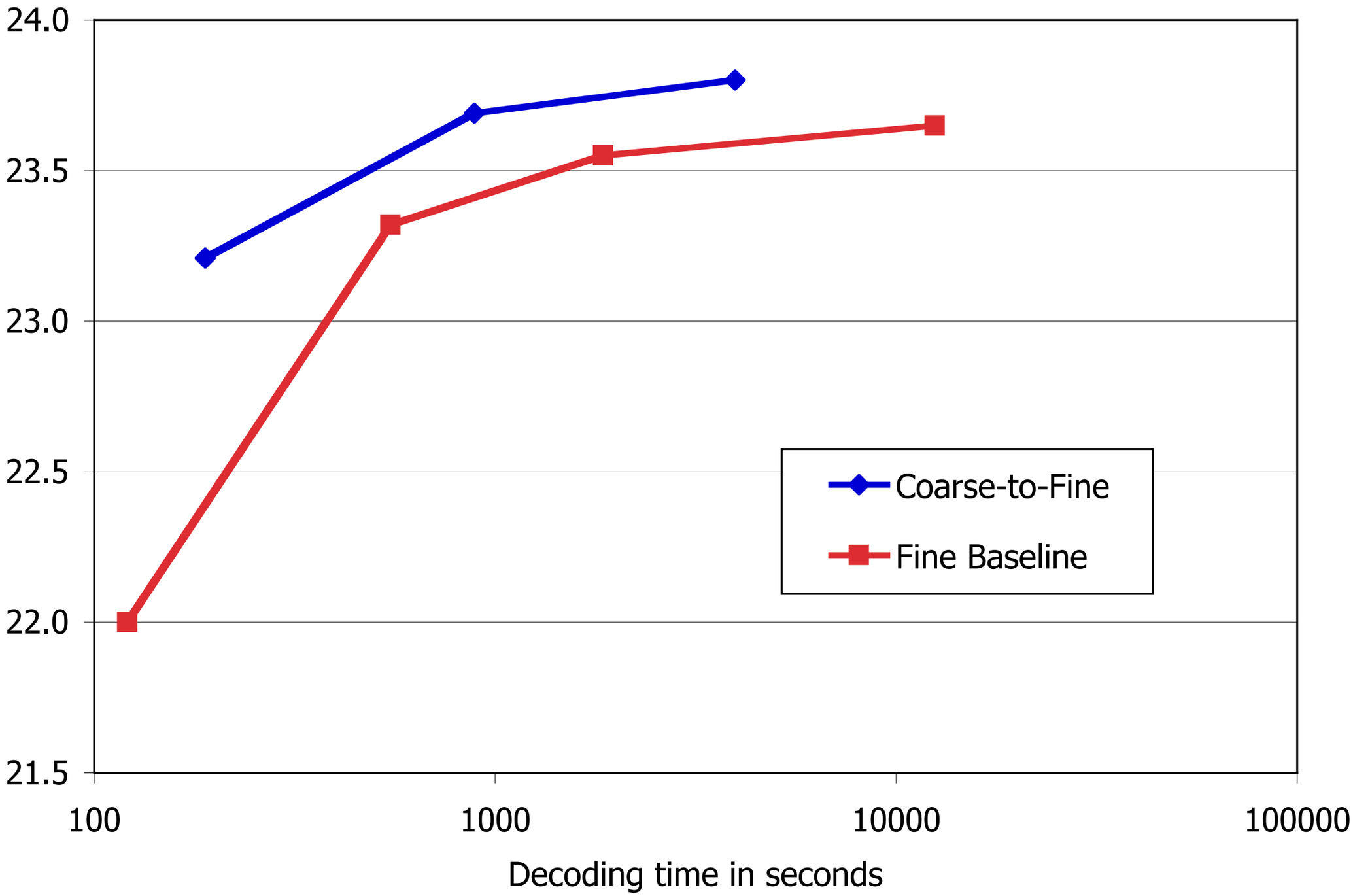


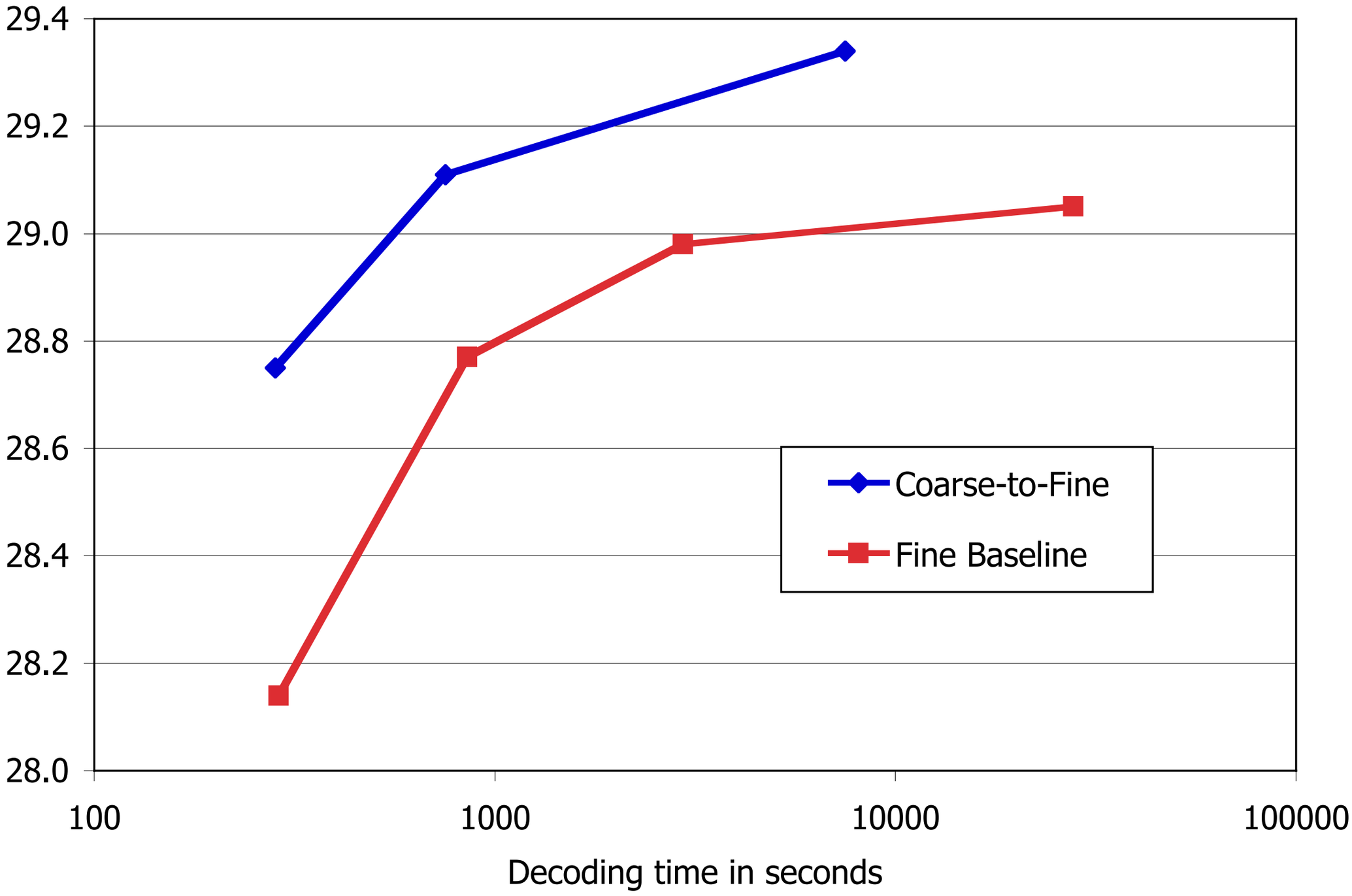
Final Results (Spanish)



Final Results (German)



Final Results (French)



Conclusions

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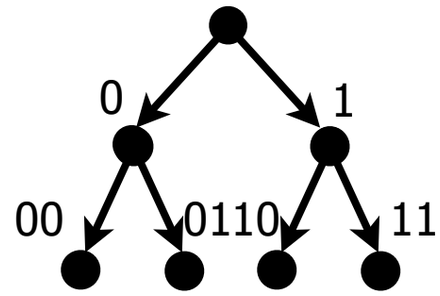
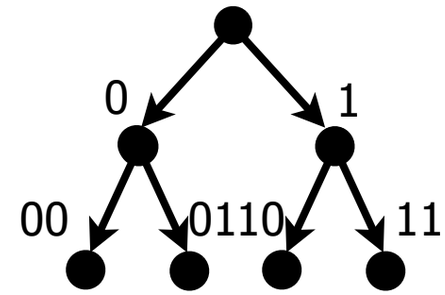
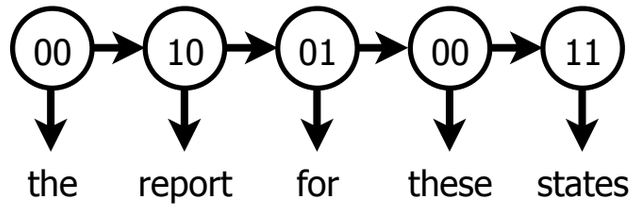
- Hierarchical clusters enable fast coarse-to-fine translation by reducing the vocabulary size



Conclusions

- Hierarchical clusters enable fast coarse-to-fine translation by reducing the vocabulary size
- Better clusters = better pruning





Conclusions

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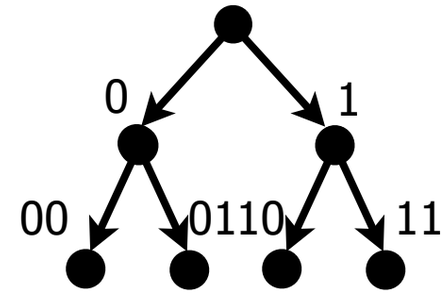
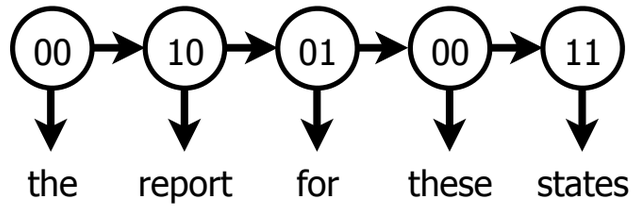
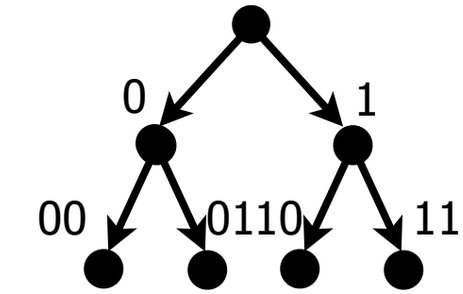


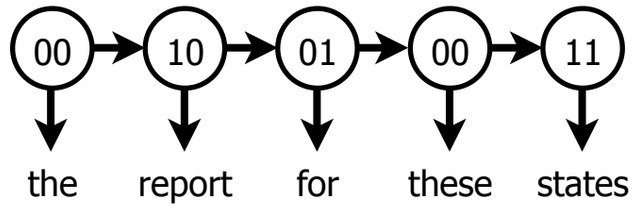


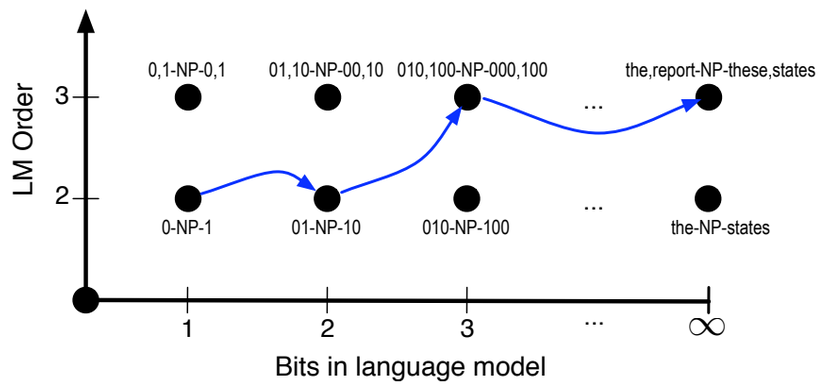
- Better clusters = better pruning
- Multiple, simple passes give the largest speed-ups
- Cluster size and n-gram order projections are complementary

Conclusions

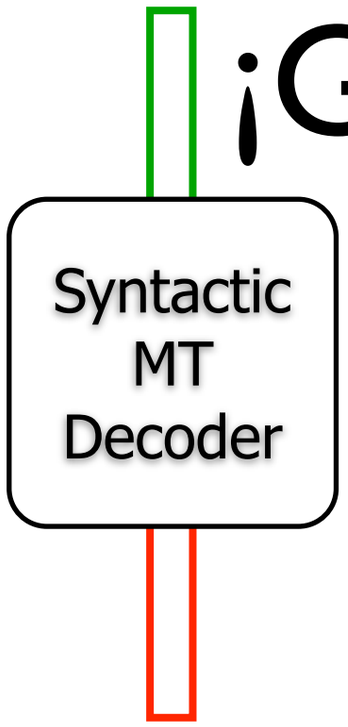
- Hierarchical clusters enable fast coarse-to-fine translation by reducing the vocabulary size
- Better clusters = better pruning
- Multiple, simple passes give the largest speed-ups
- Cluster size and n-gram order projections are complementary
- Minimal memory requirements







The End



¡Gracias!

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Thanks!

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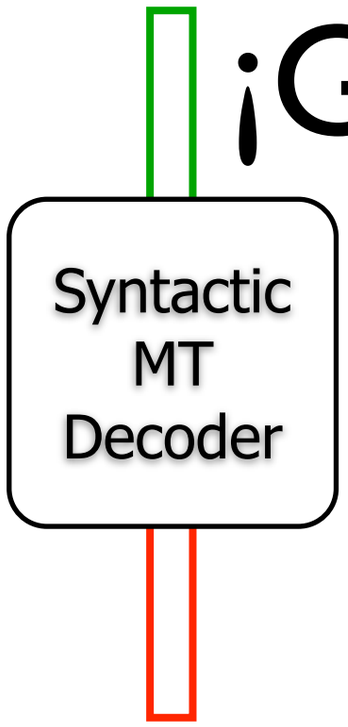

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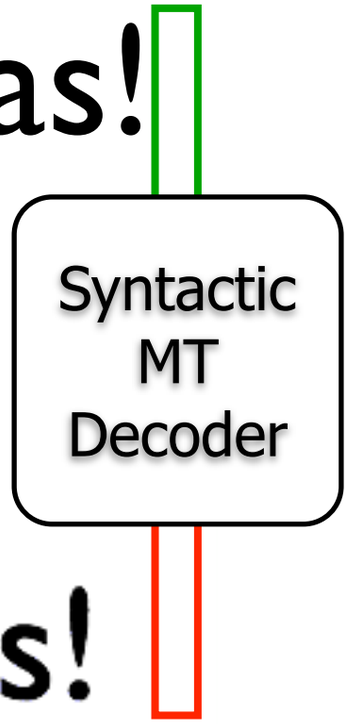

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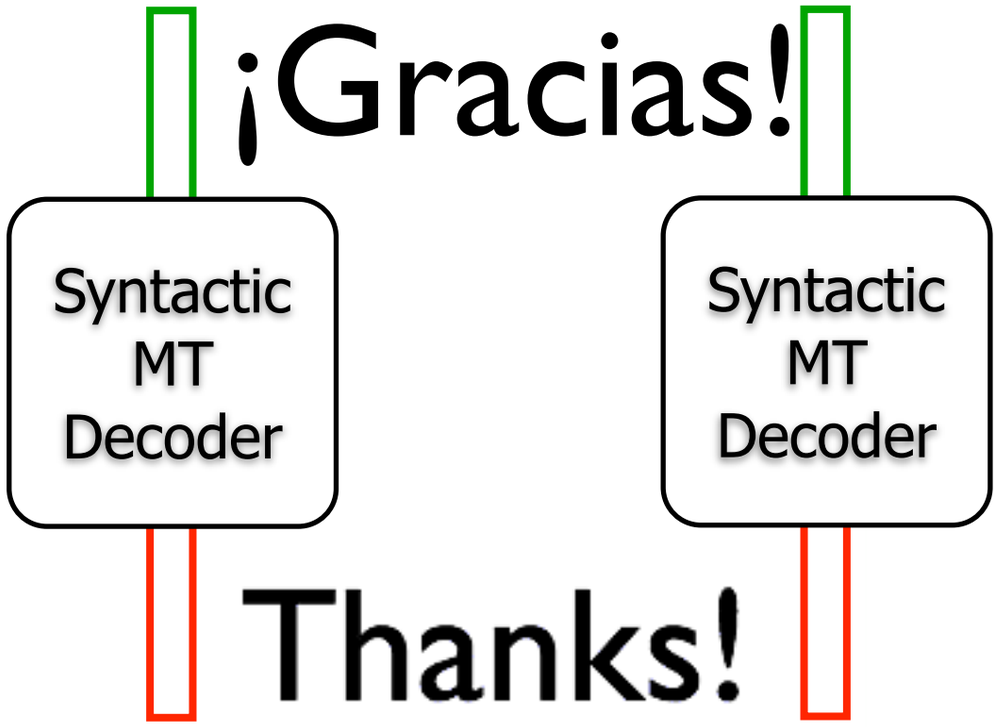

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