ECS 289 Paper Presentation

“How transferable are features in deep neural networks?”

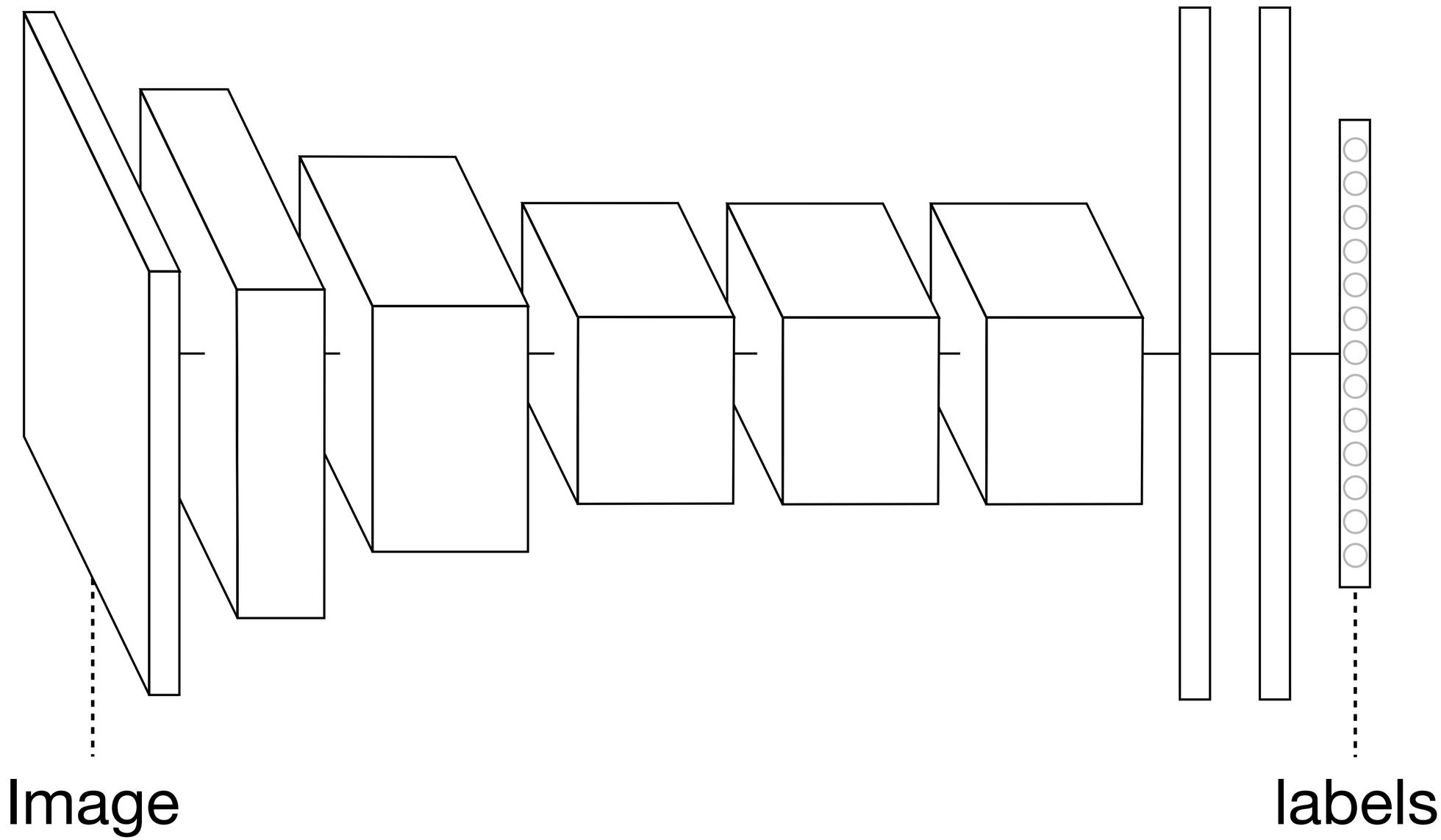
Written by Jason Yosinski, Jeff Clune, Yoshua Bengio, Hod Lipson

Present by Shubo Chen

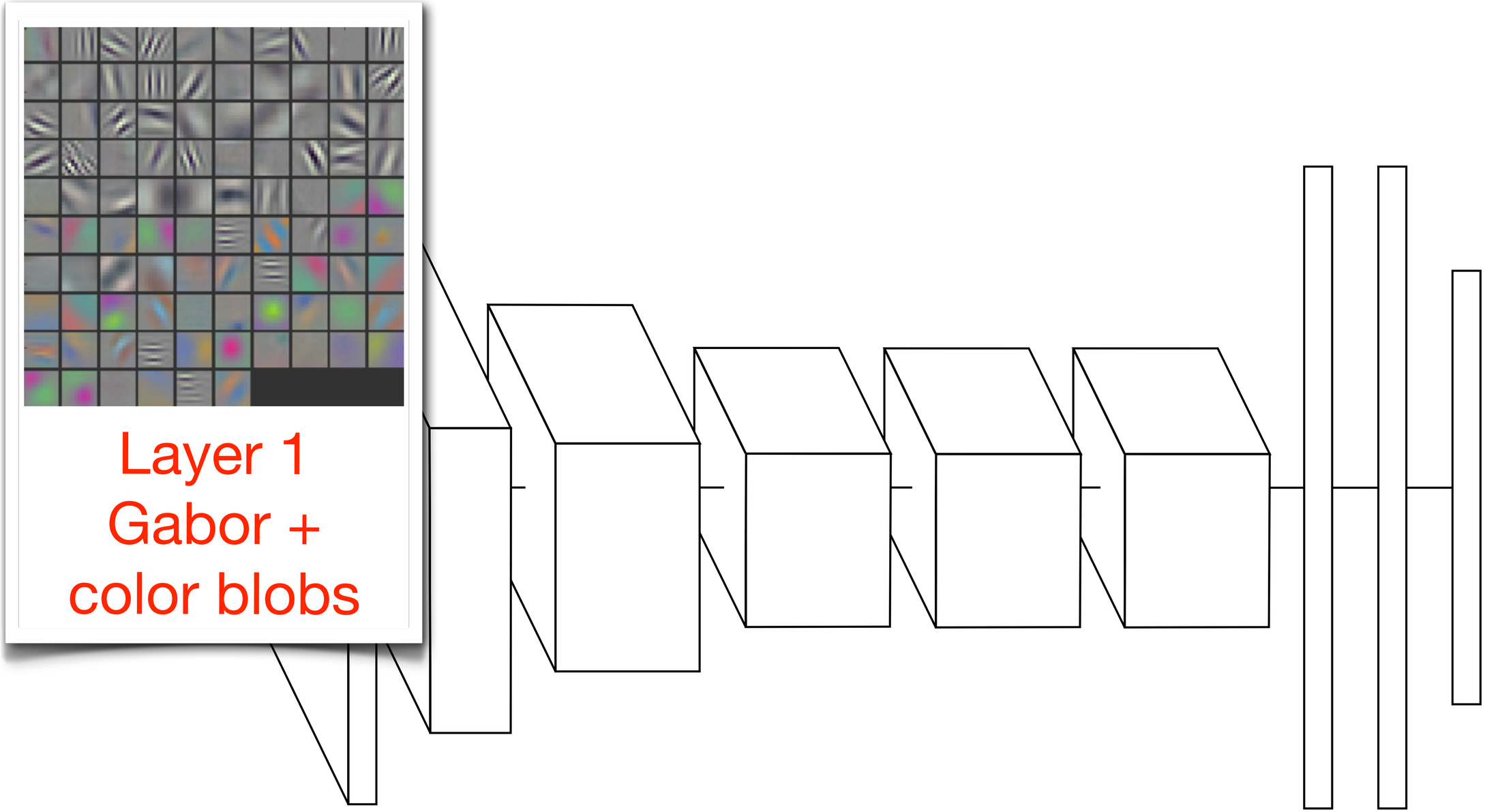
Date: /10/6/2016

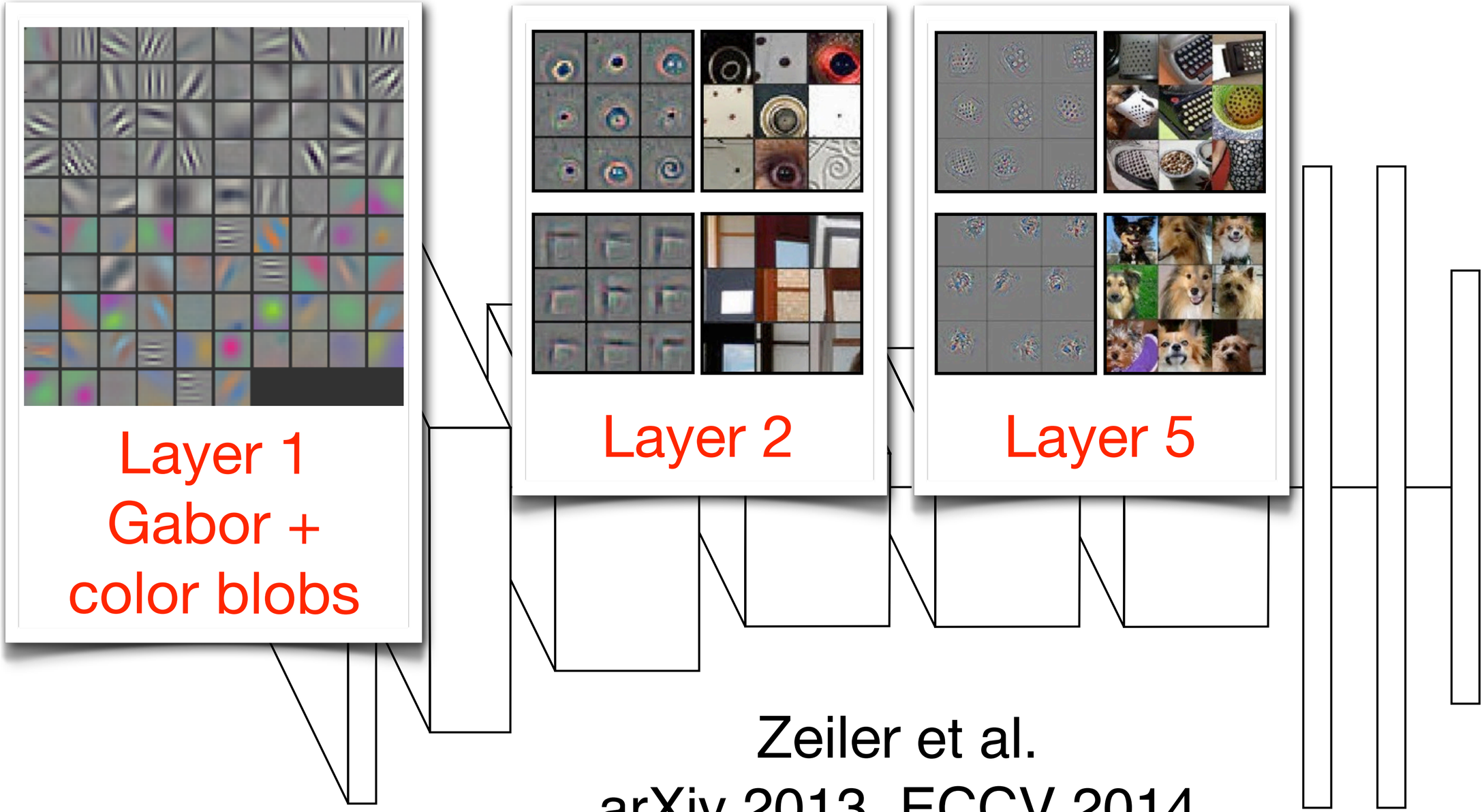
Slides originally made by Jason Yosinski and his collegues

AlexNet

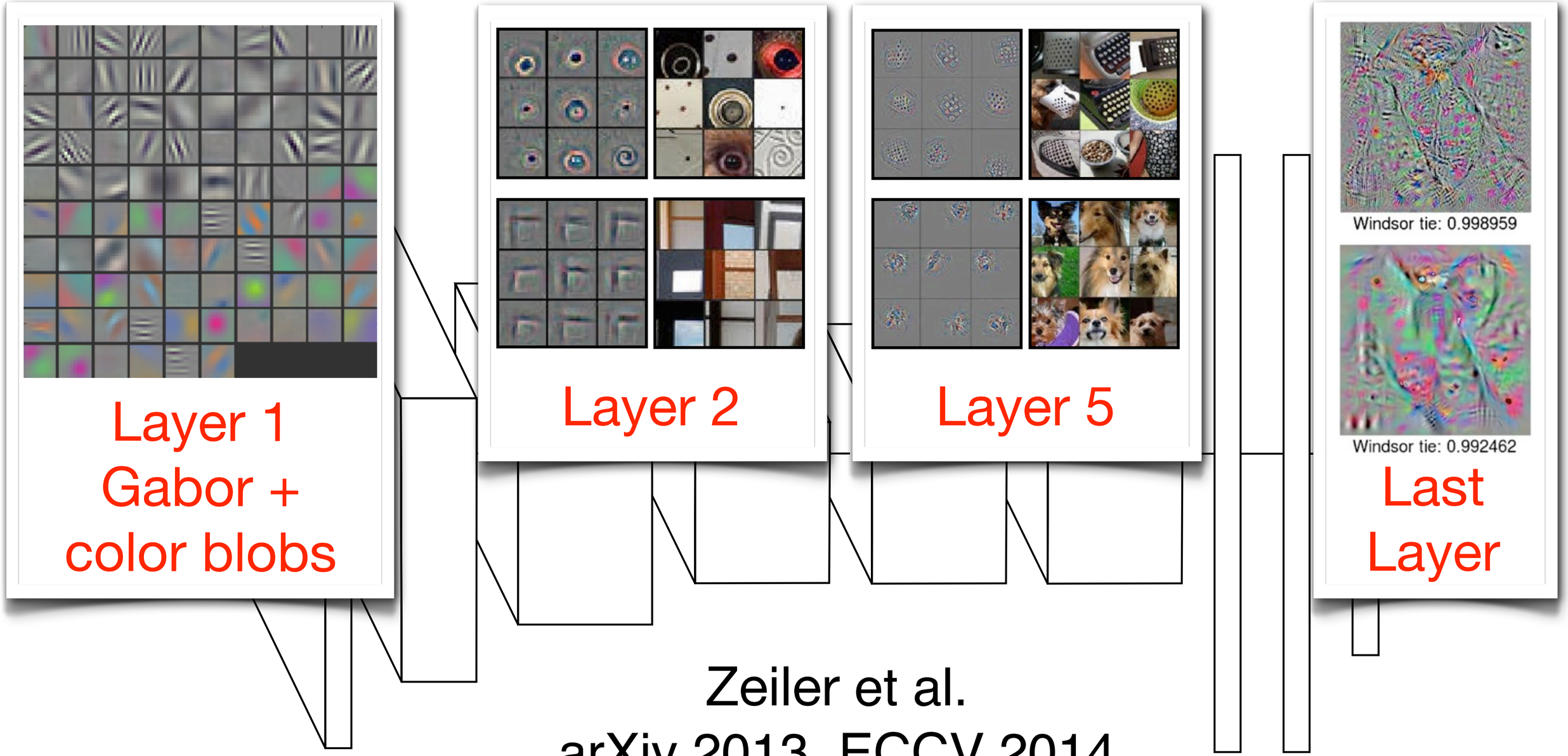


Krizhevsky, Sutskever, Hinton — NIPS 2012


Layer 1
Gabor +
color blobs

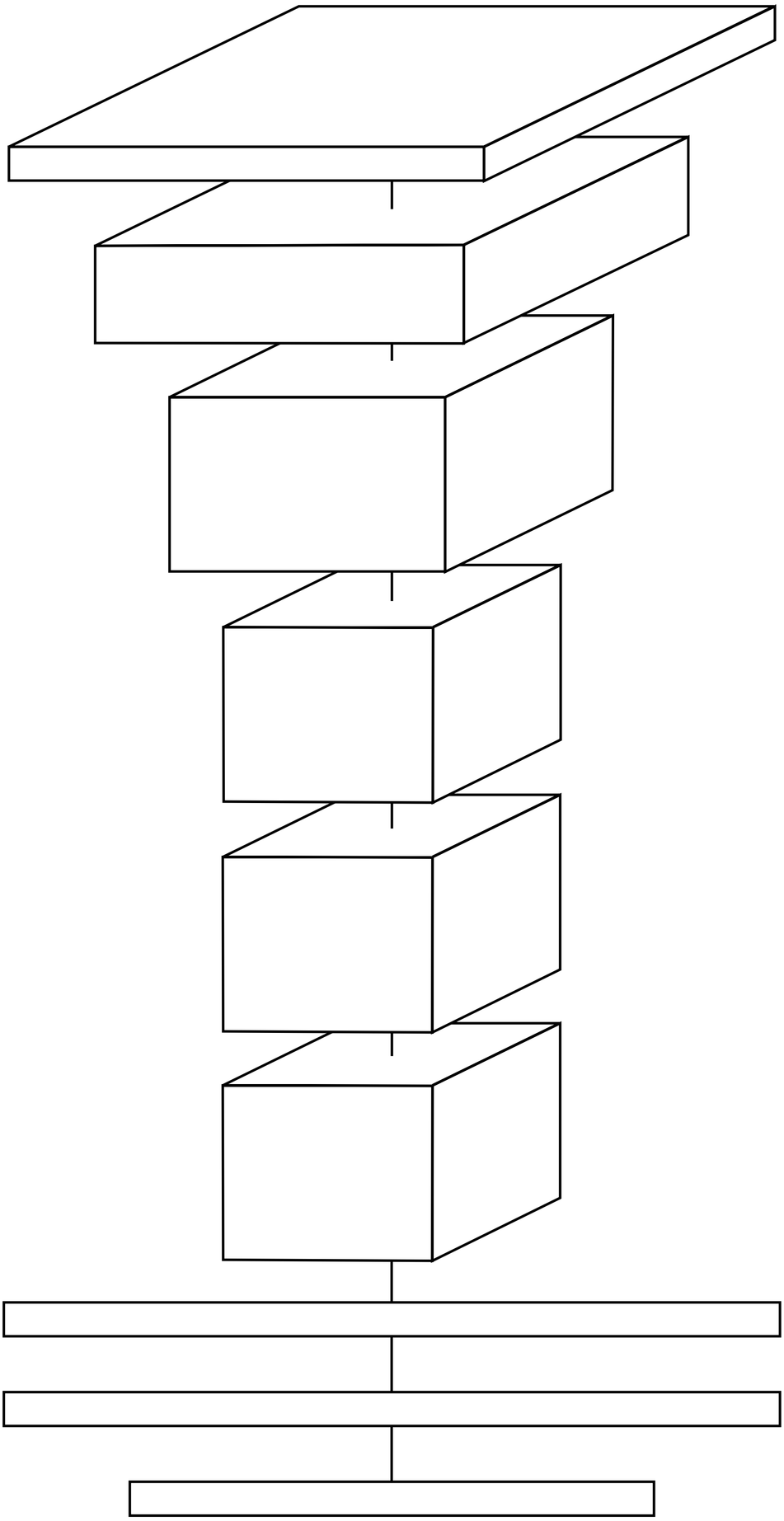


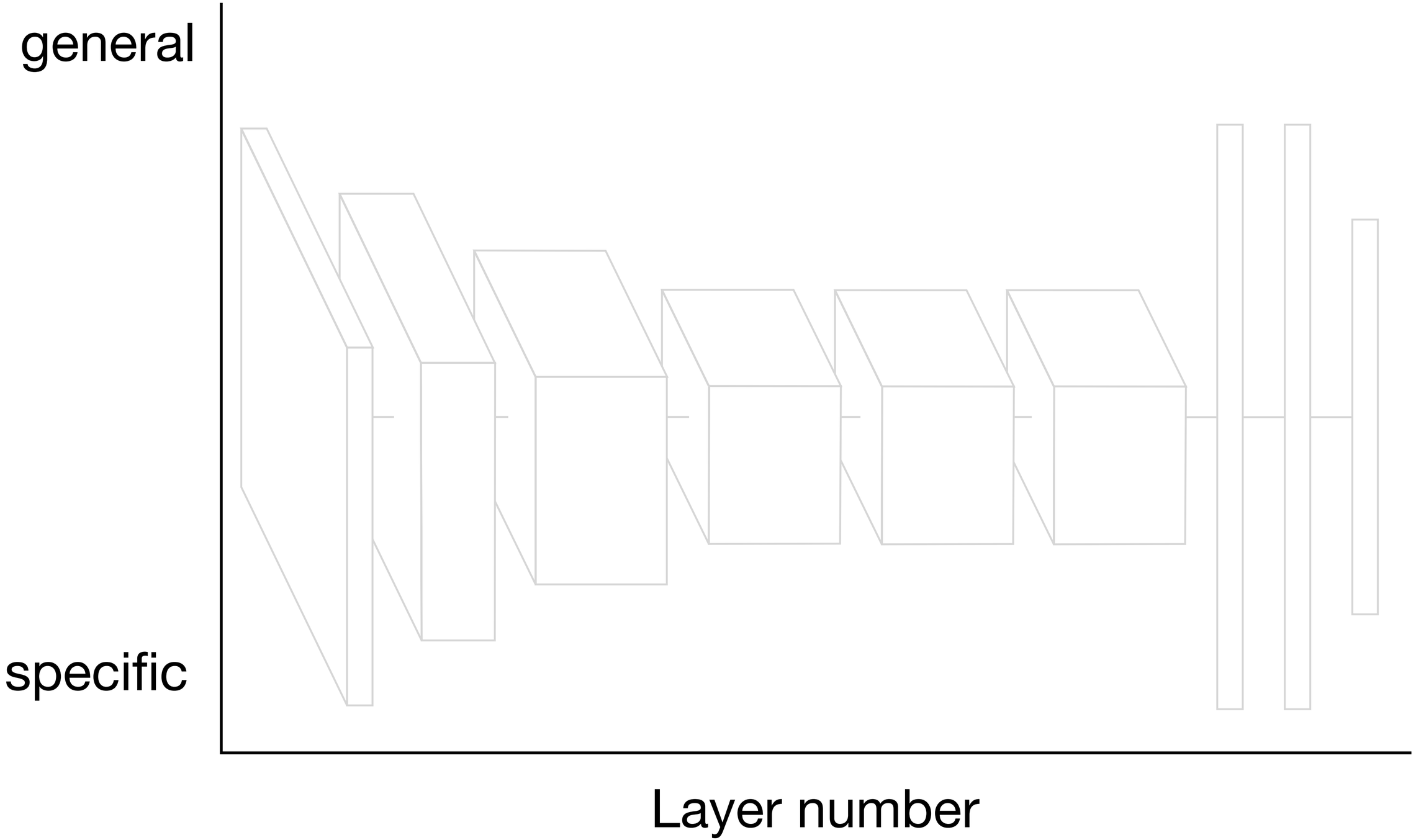
Zeiler et al.
arXiv 2013, ECCV 2014

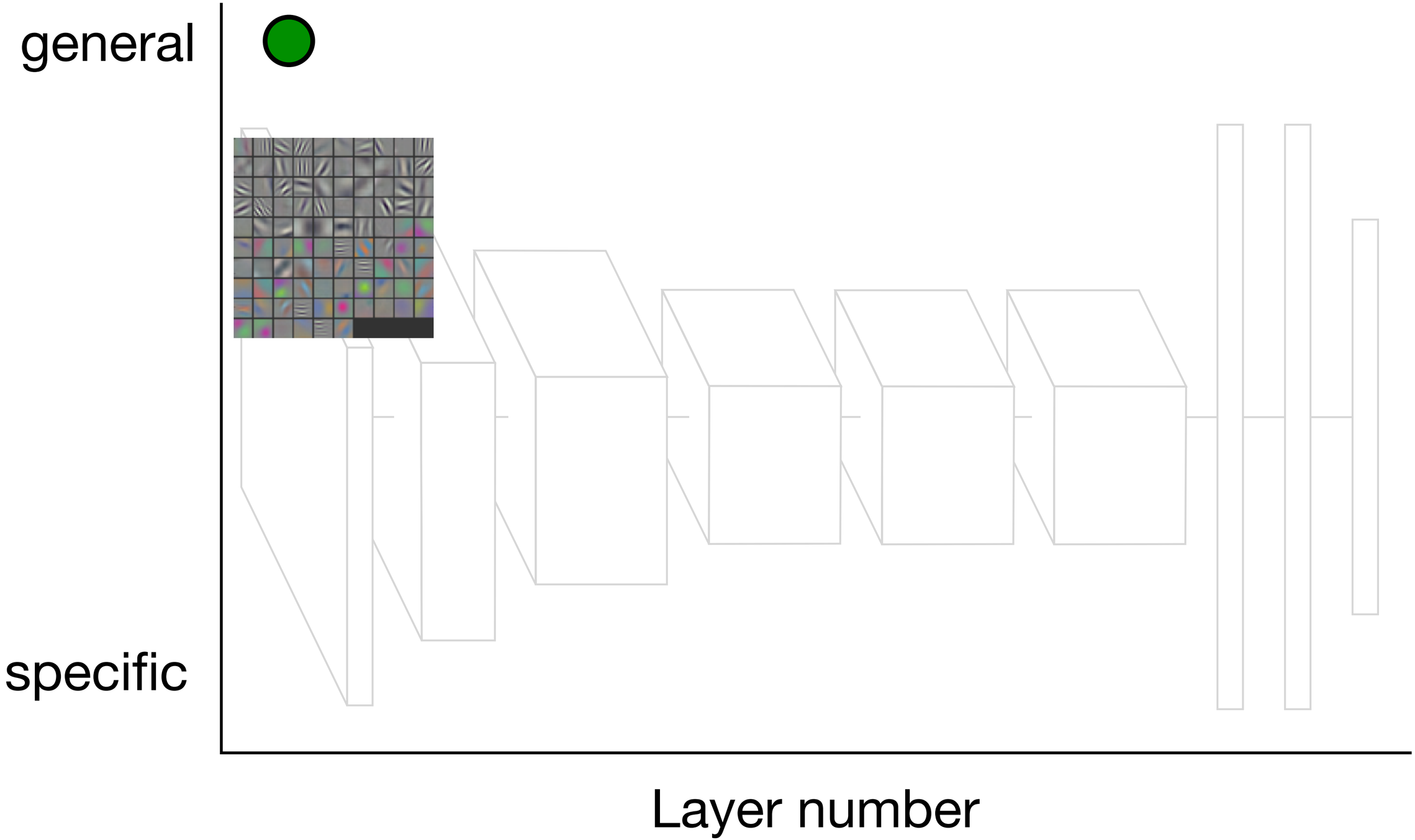


Zeiler et al.
arXiv 2013, ECCV 2014

Nguyen et al.
arXiv 2014




general
specific
Layer number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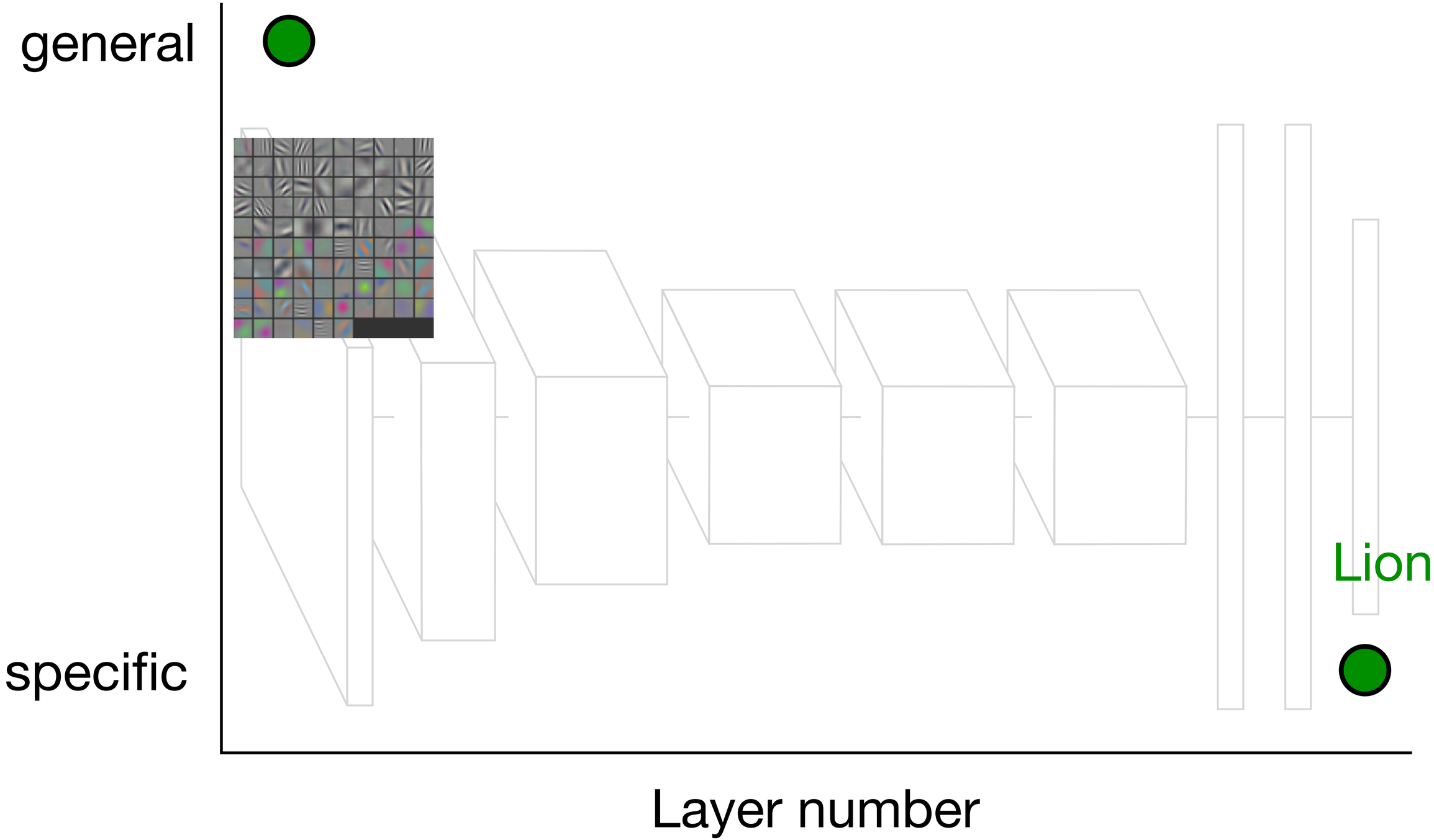
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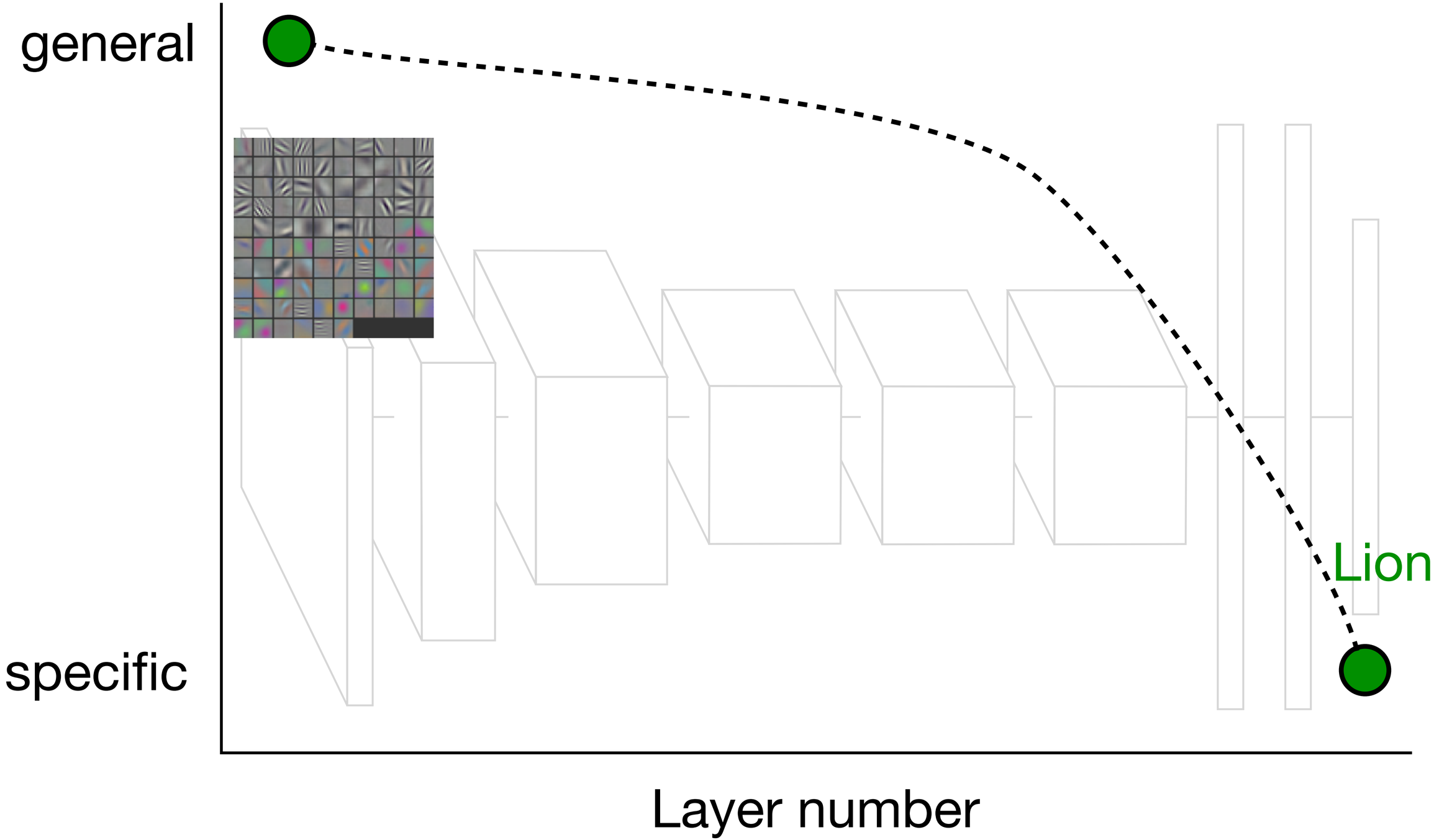
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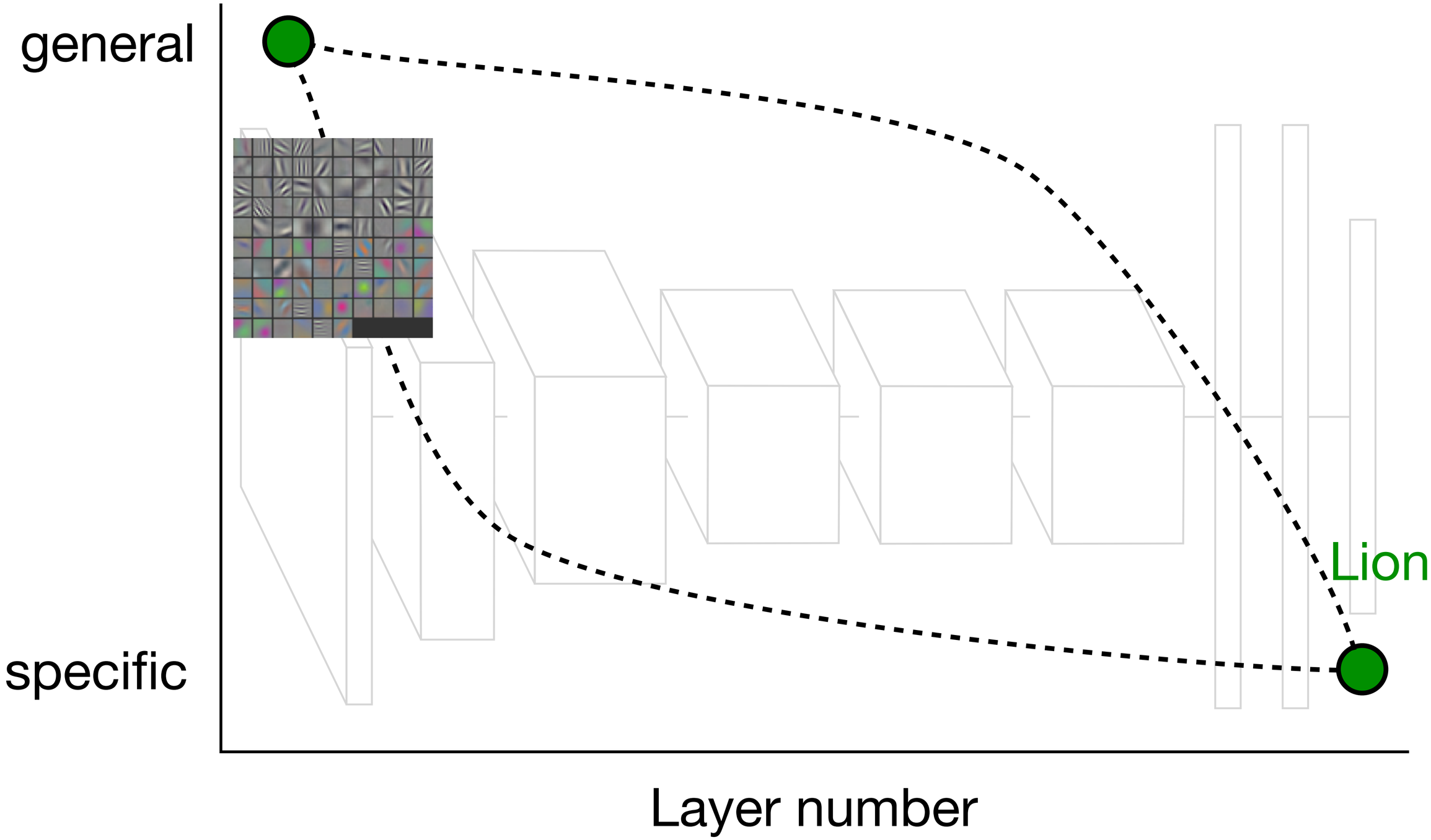
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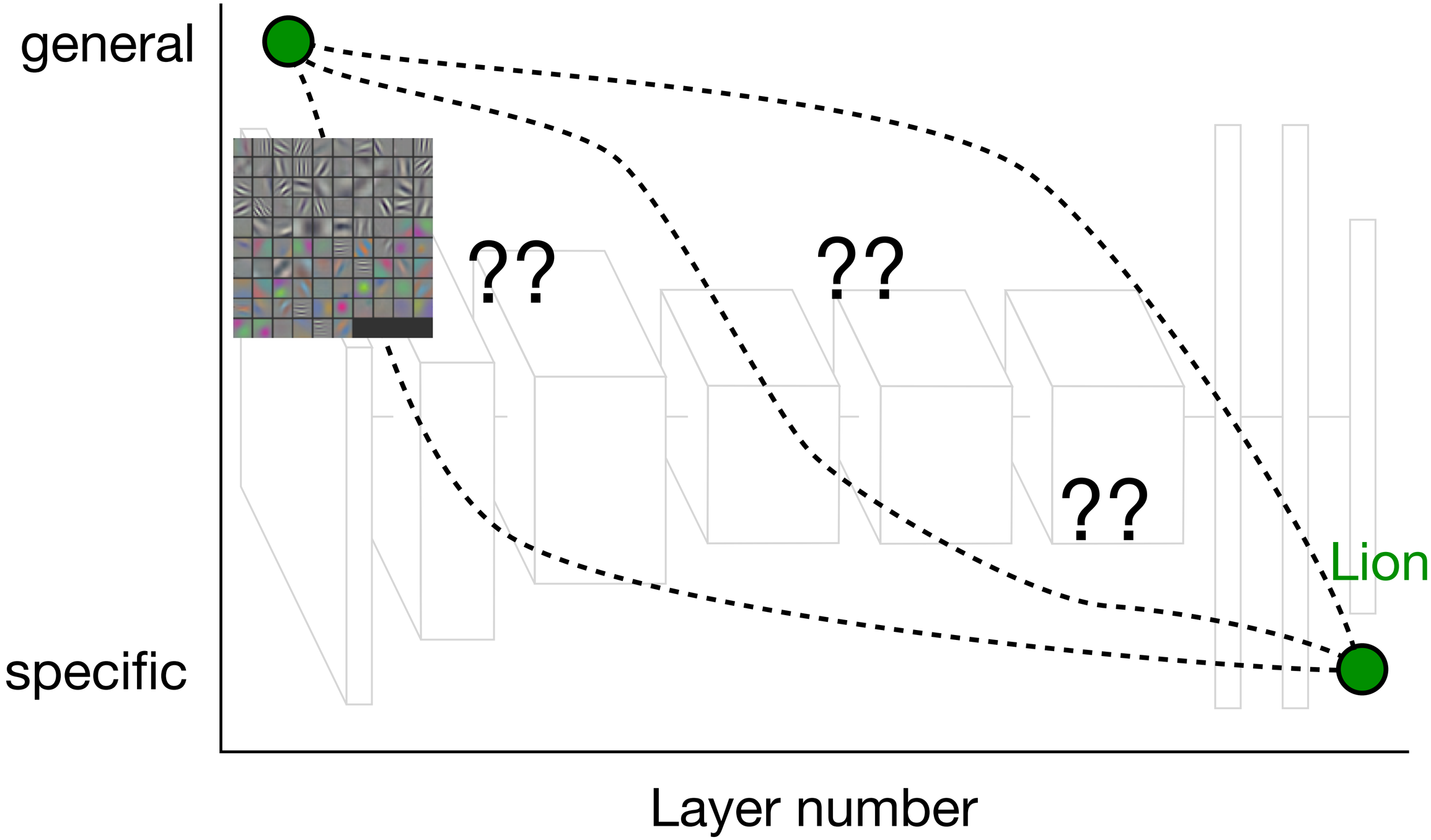
general
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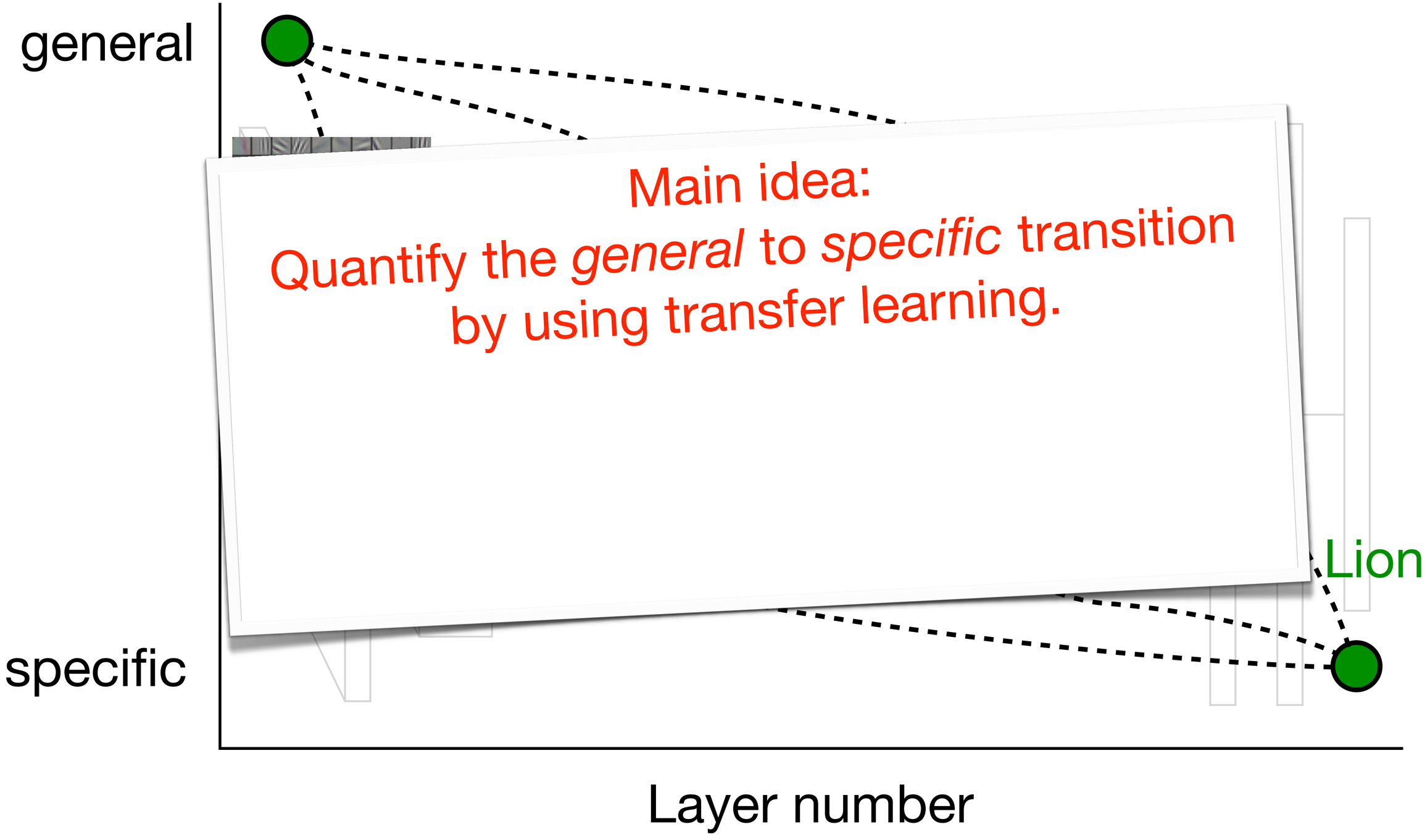
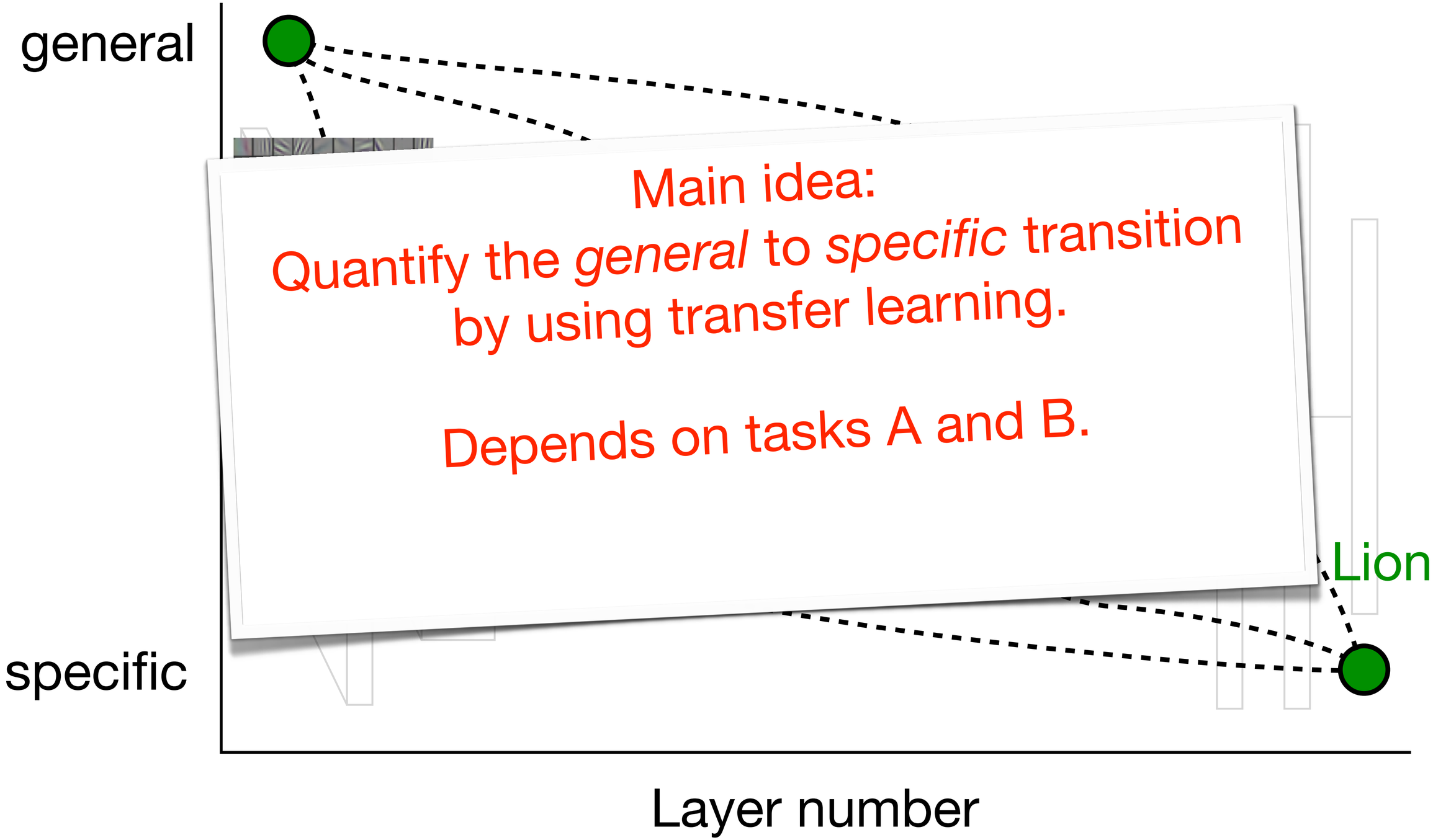


Main idea:
Quantify the *general* to *specific* transition
by using transfer learning.



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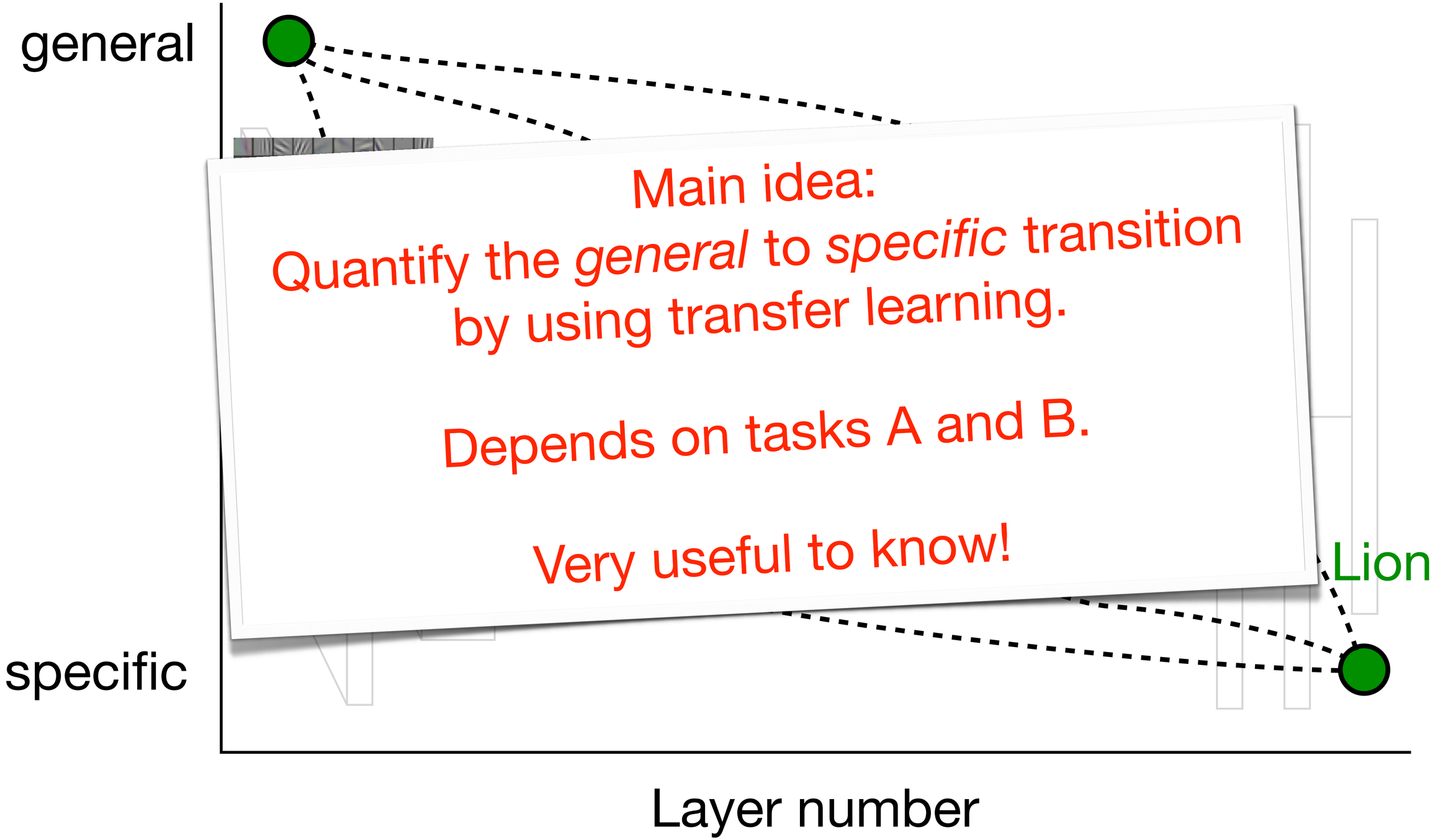
Quantify the *general* to *specific* transition by using transfer learning.

Depends on tasks A and B.



Main idea:
Quantify the *general* to *specific* transition by using transfer learning.

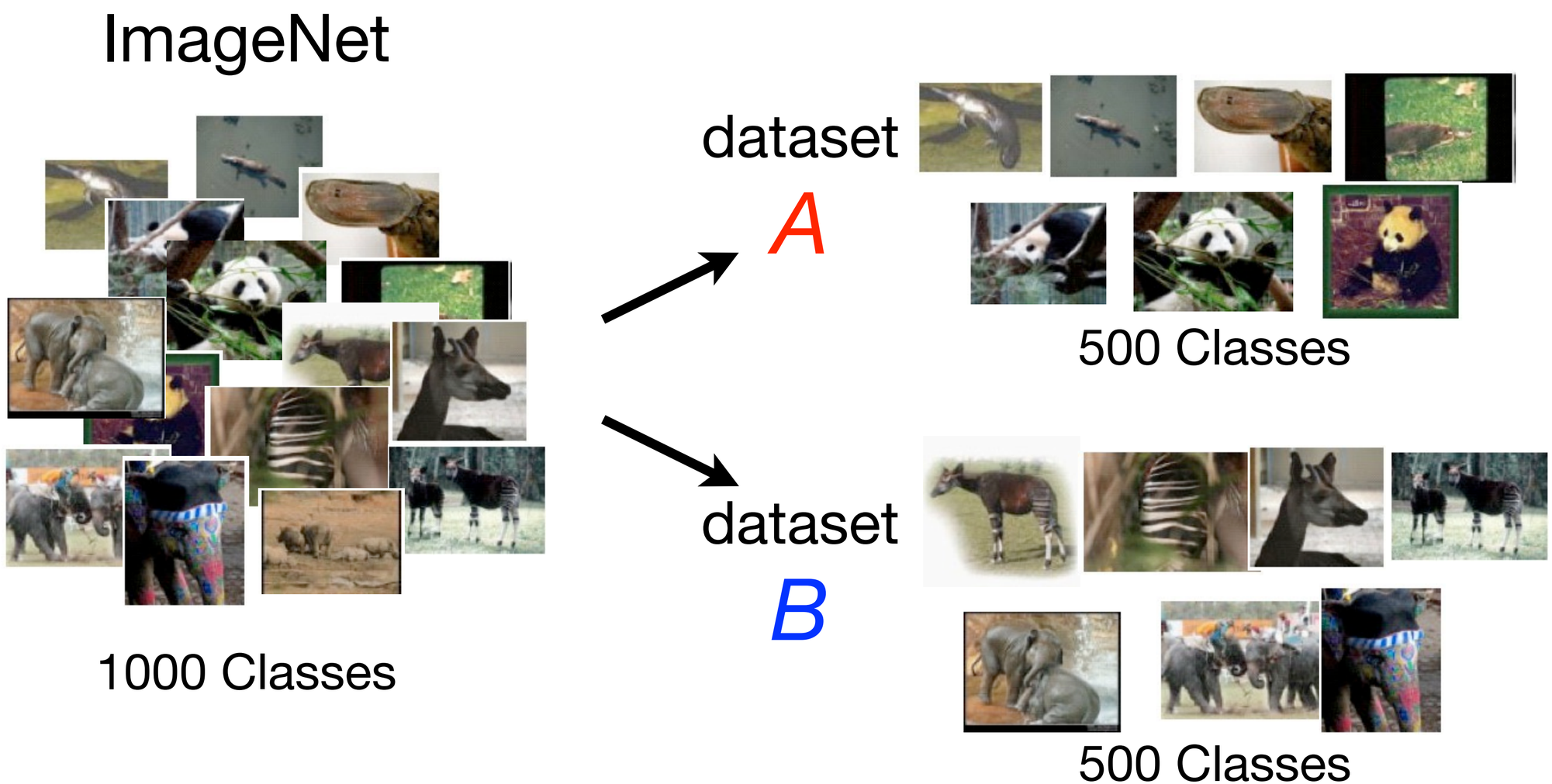
Depends on tasks A and B.

Very useful to know!

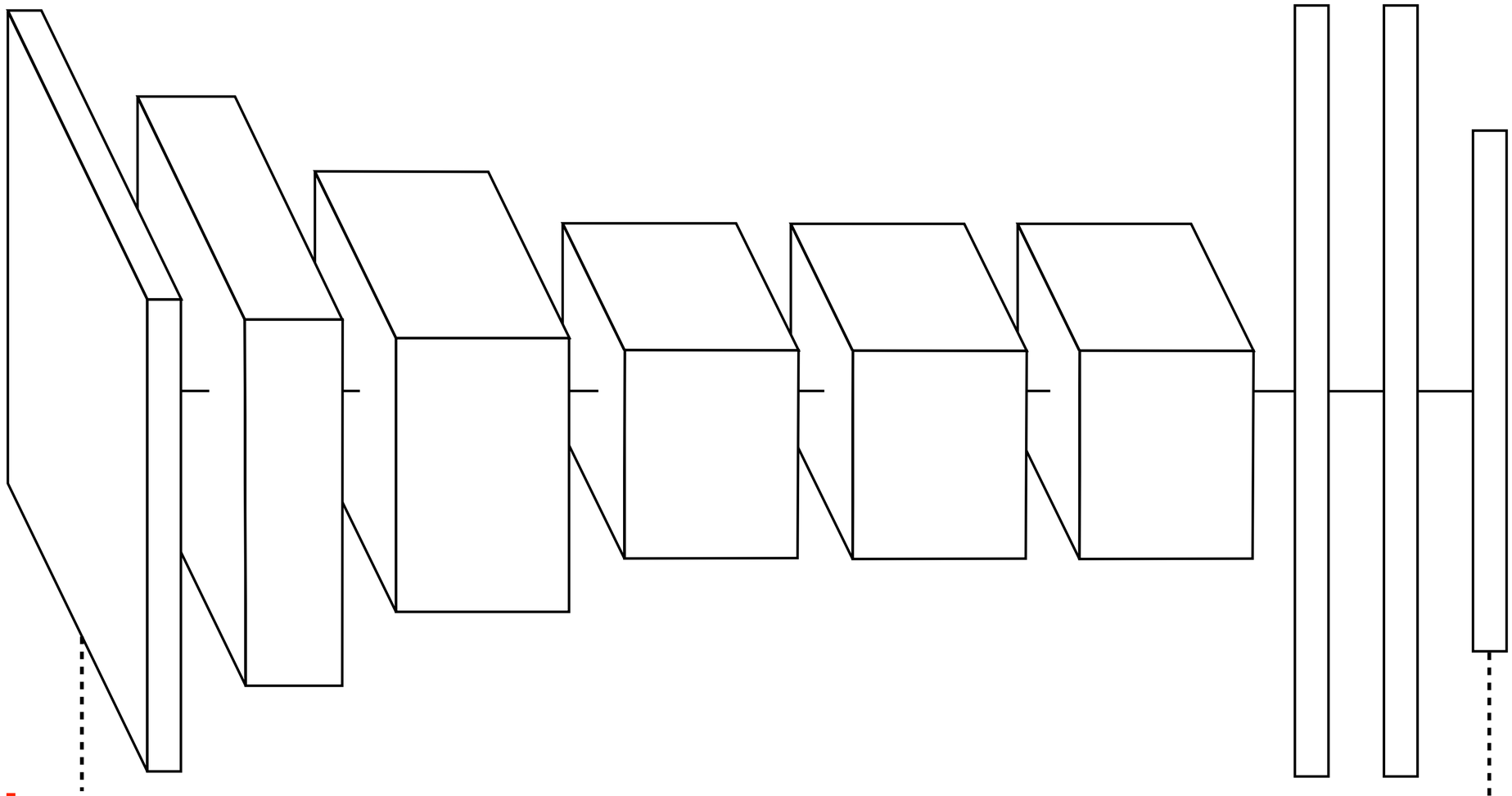
ImageNet

1000 Classes

Deng et al., 2009

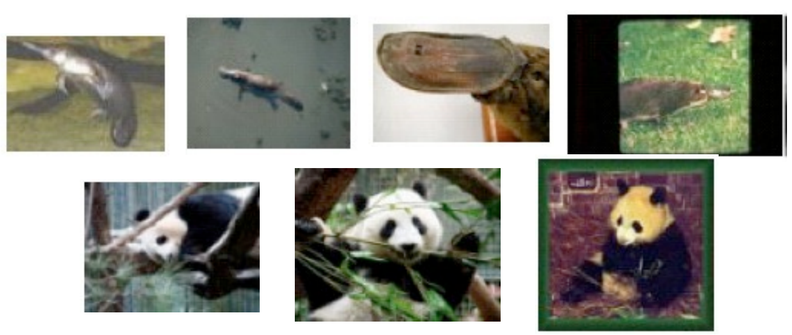


Deng et al., 2009



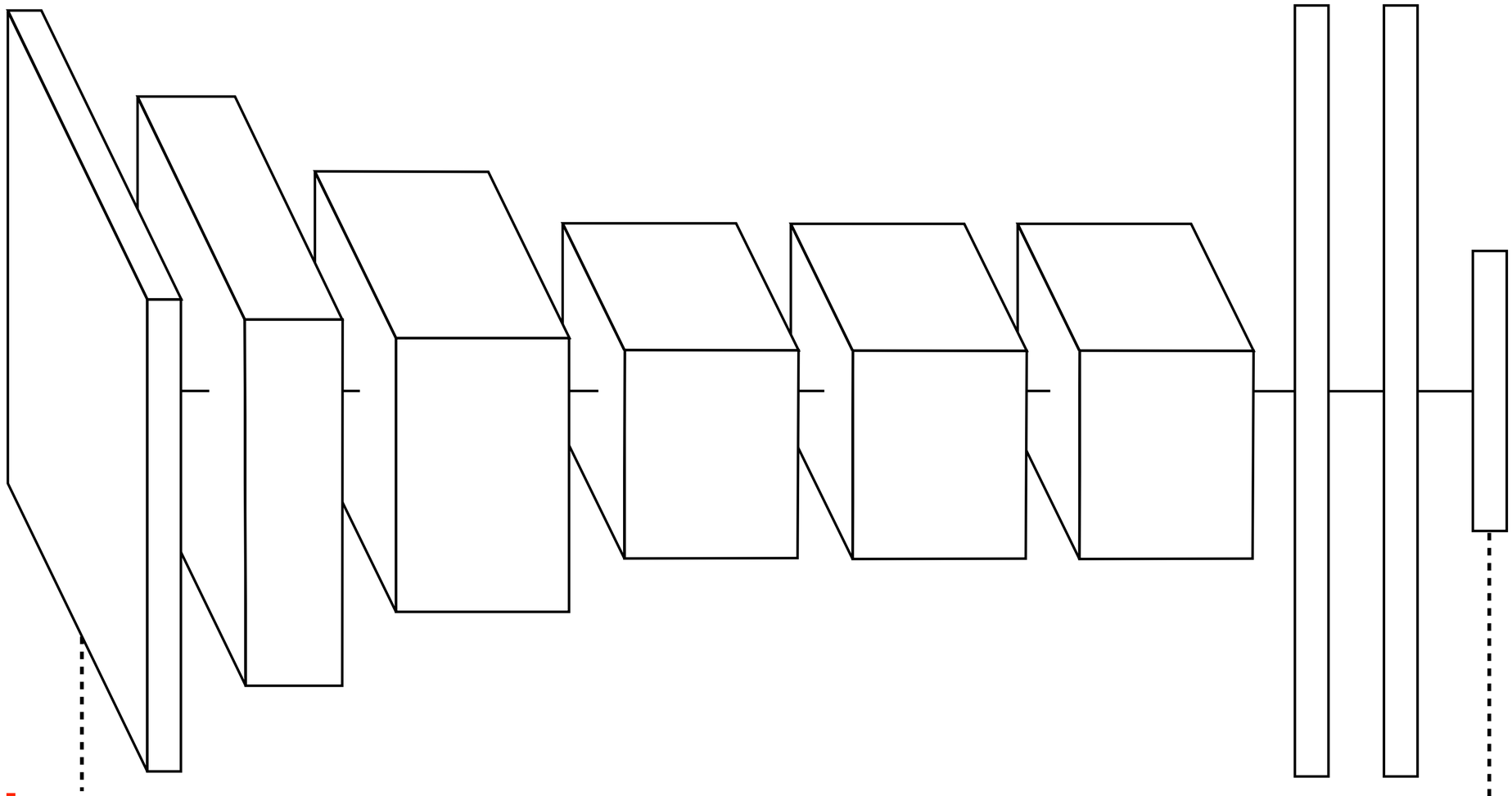
A Images

A Labels



500 Classes

Train using Caffe framework (Jia et al.)



A Images

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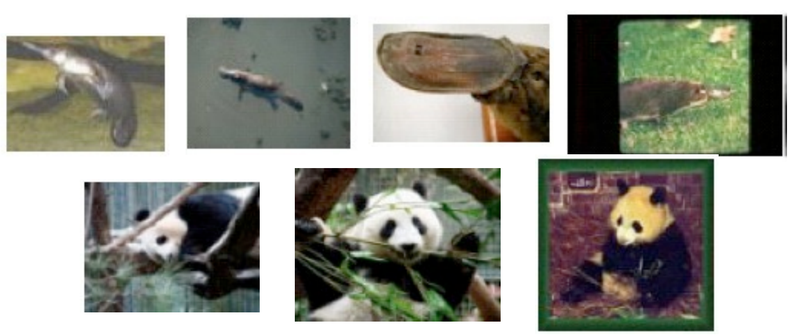

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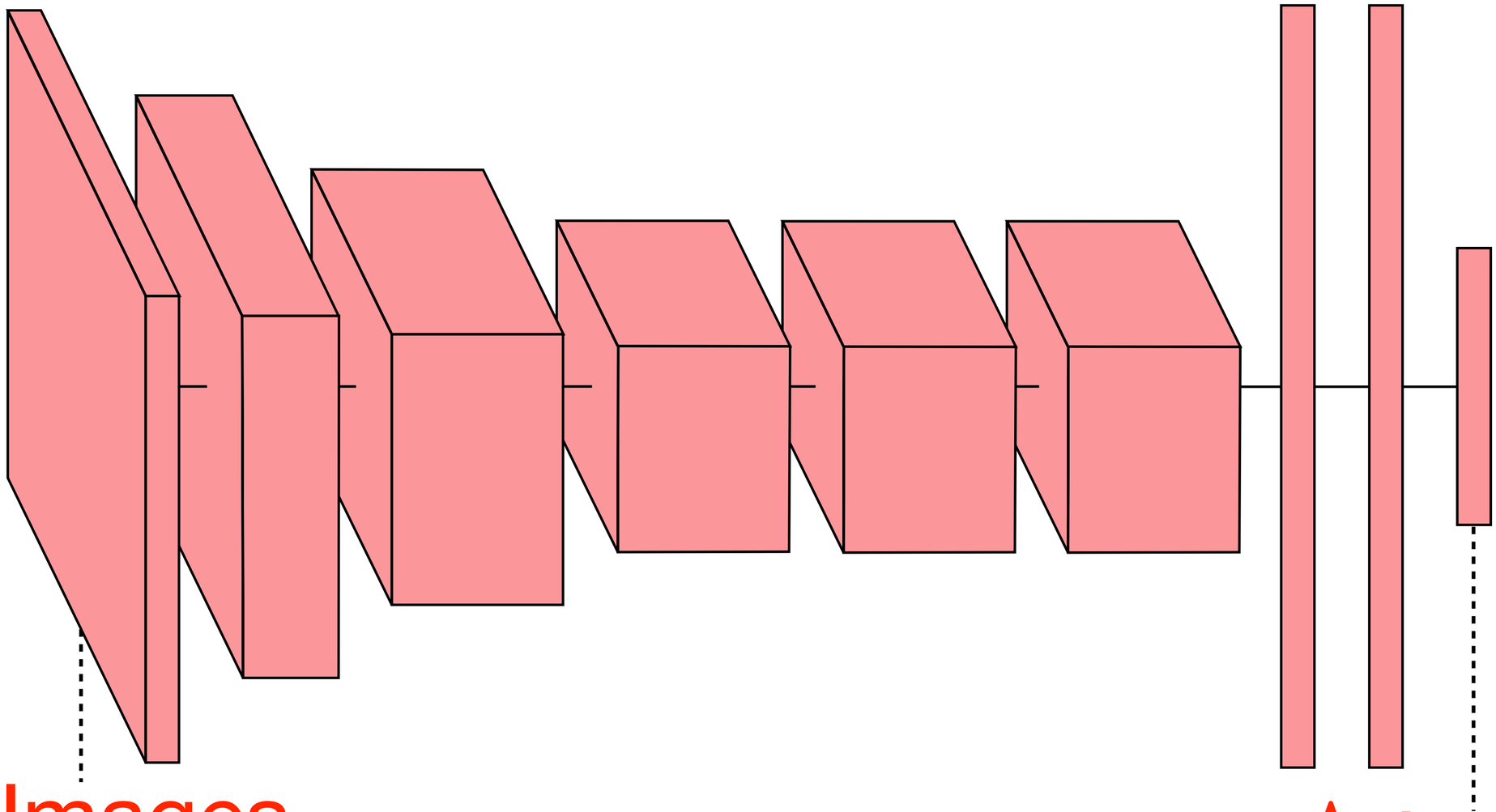
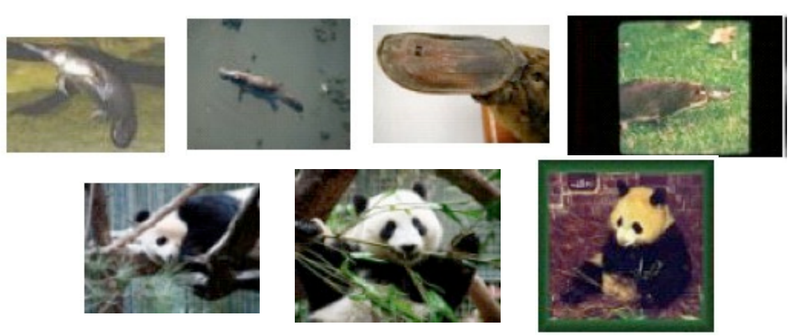


A Images

A Labels



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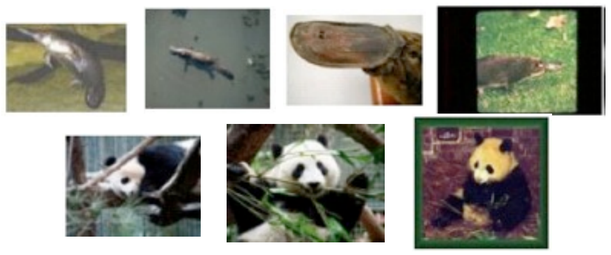
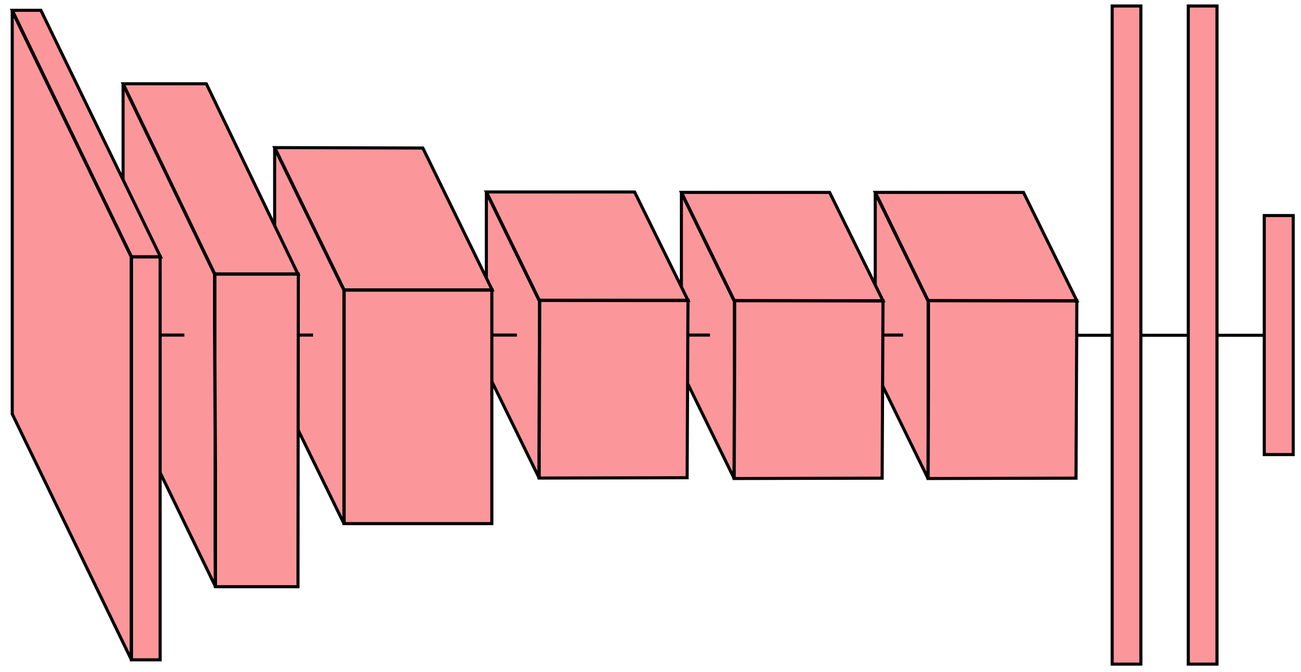
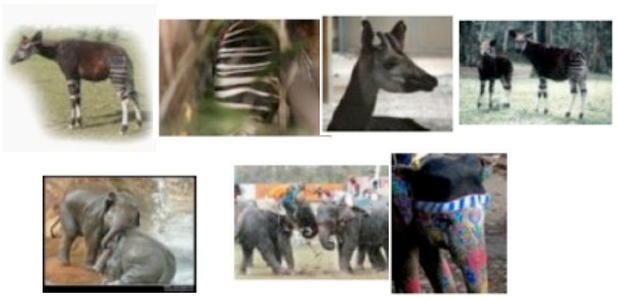


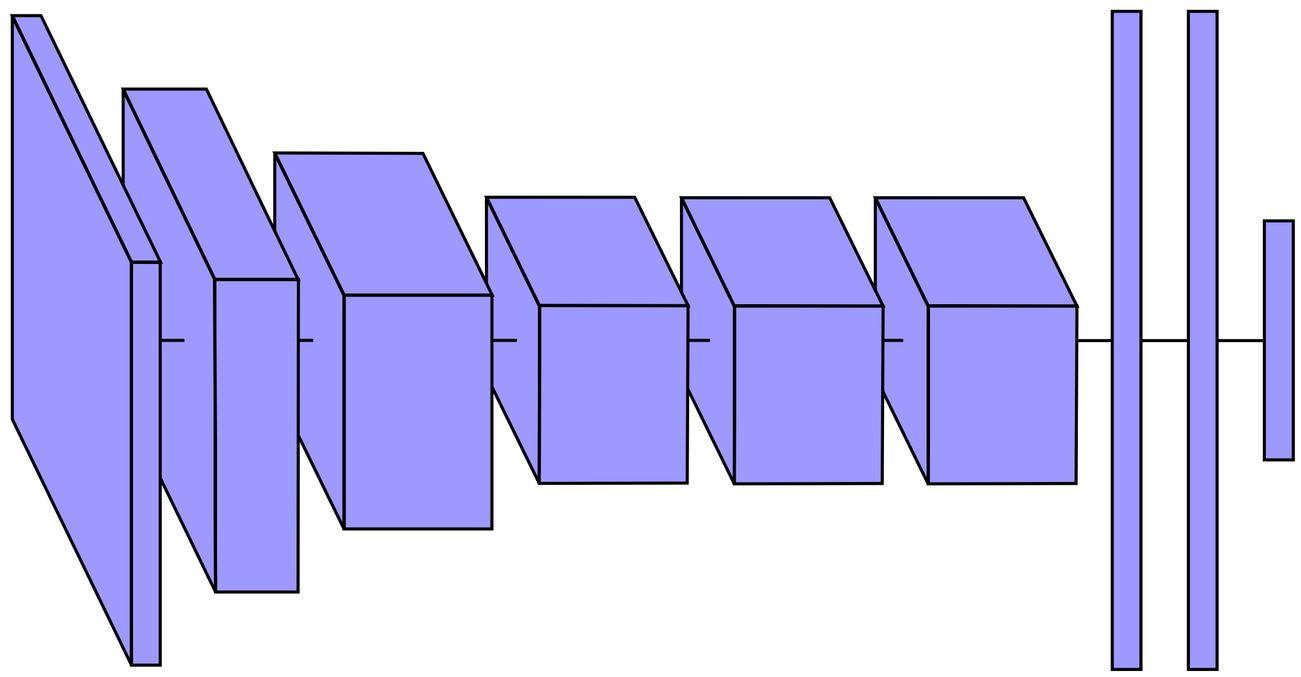
A Images



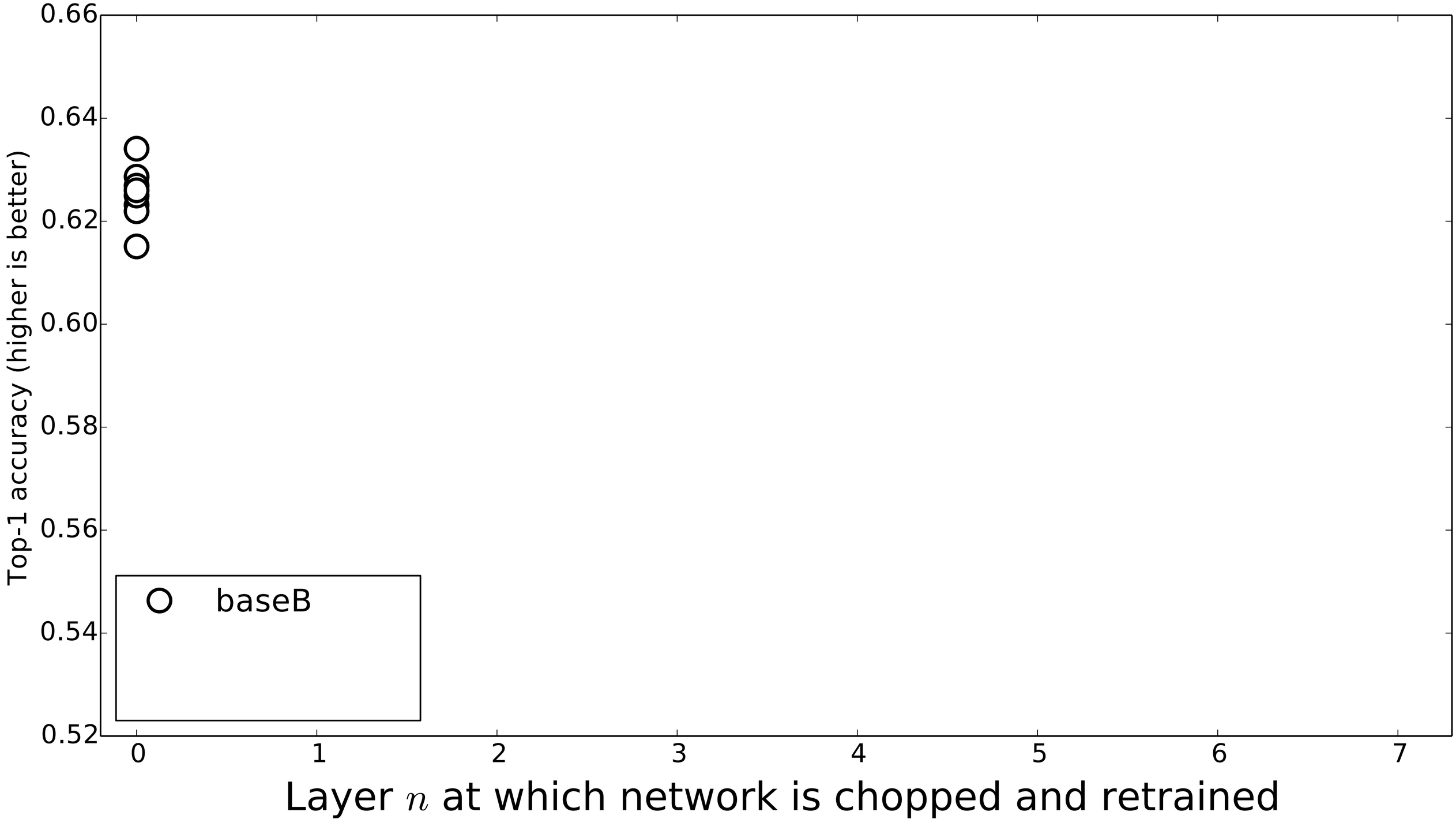
baseA



B Images



baseB


0.66
0.64
0.62
0.60
0.58
0.56
0.54
0.52
Top-1 accuracy (higher is better)
baseB
0
1
2
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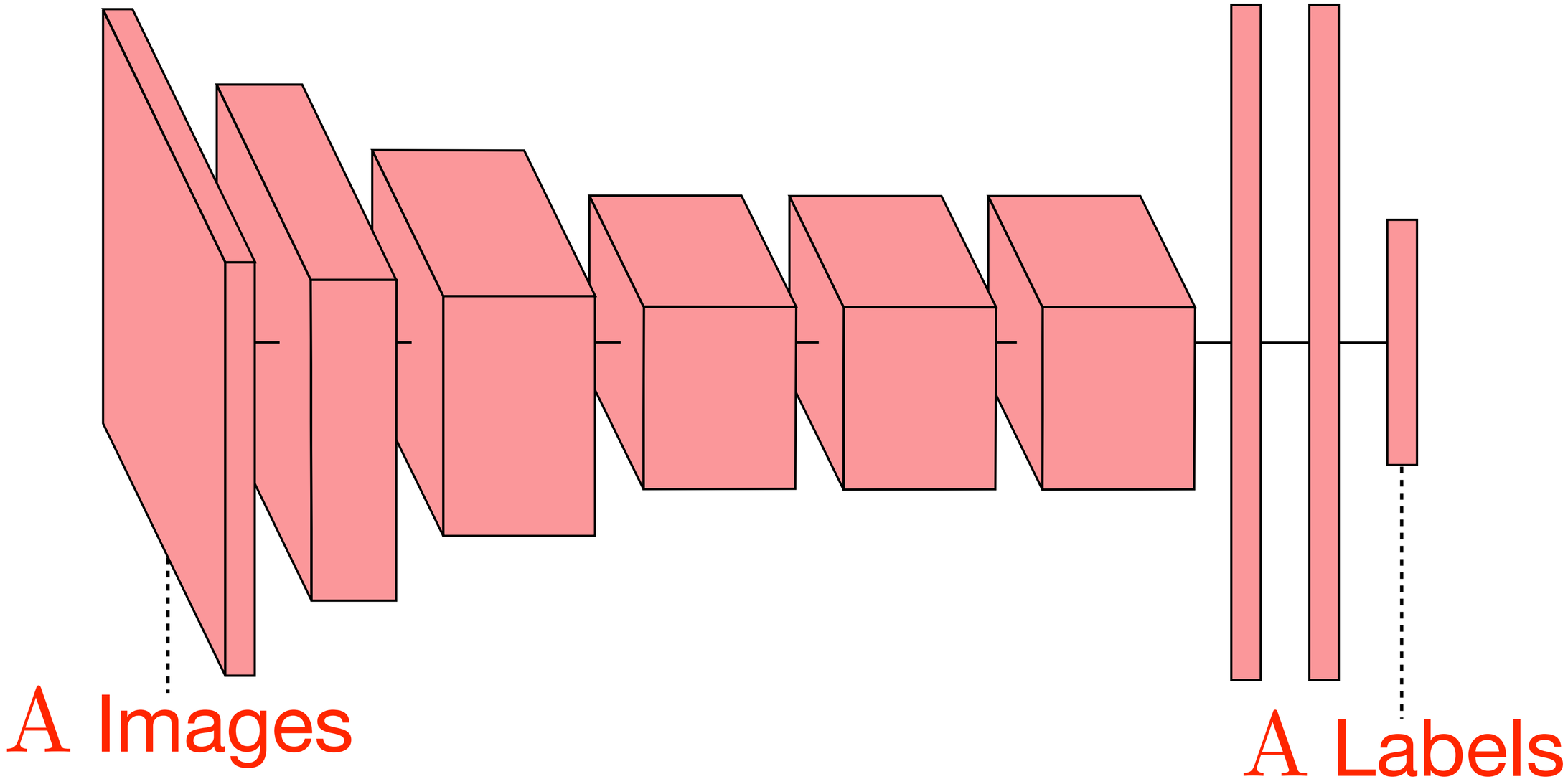
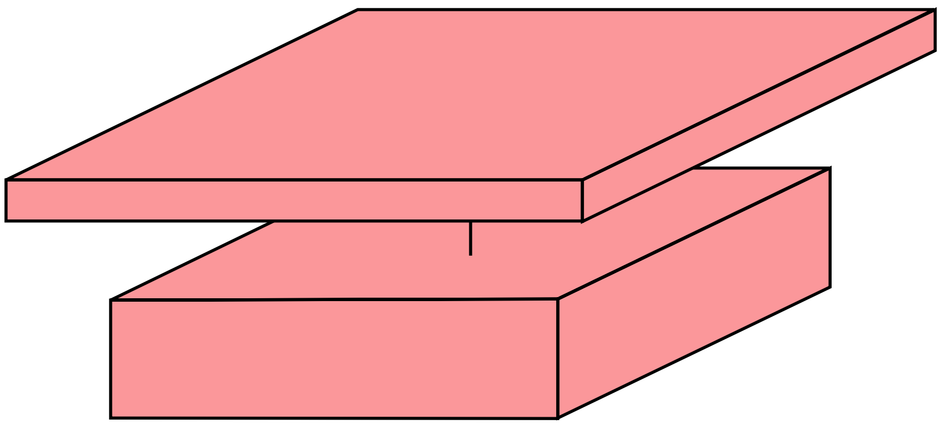
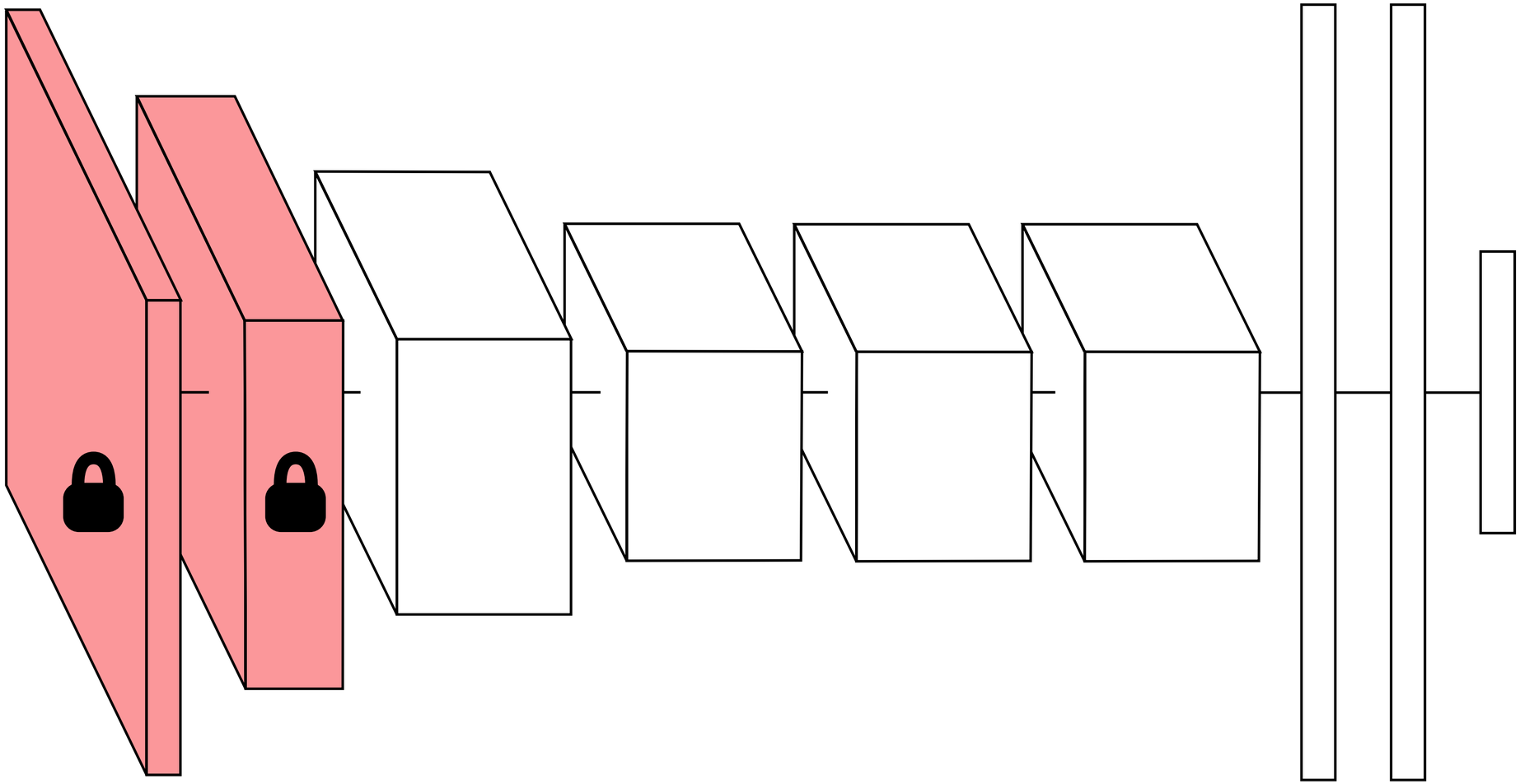
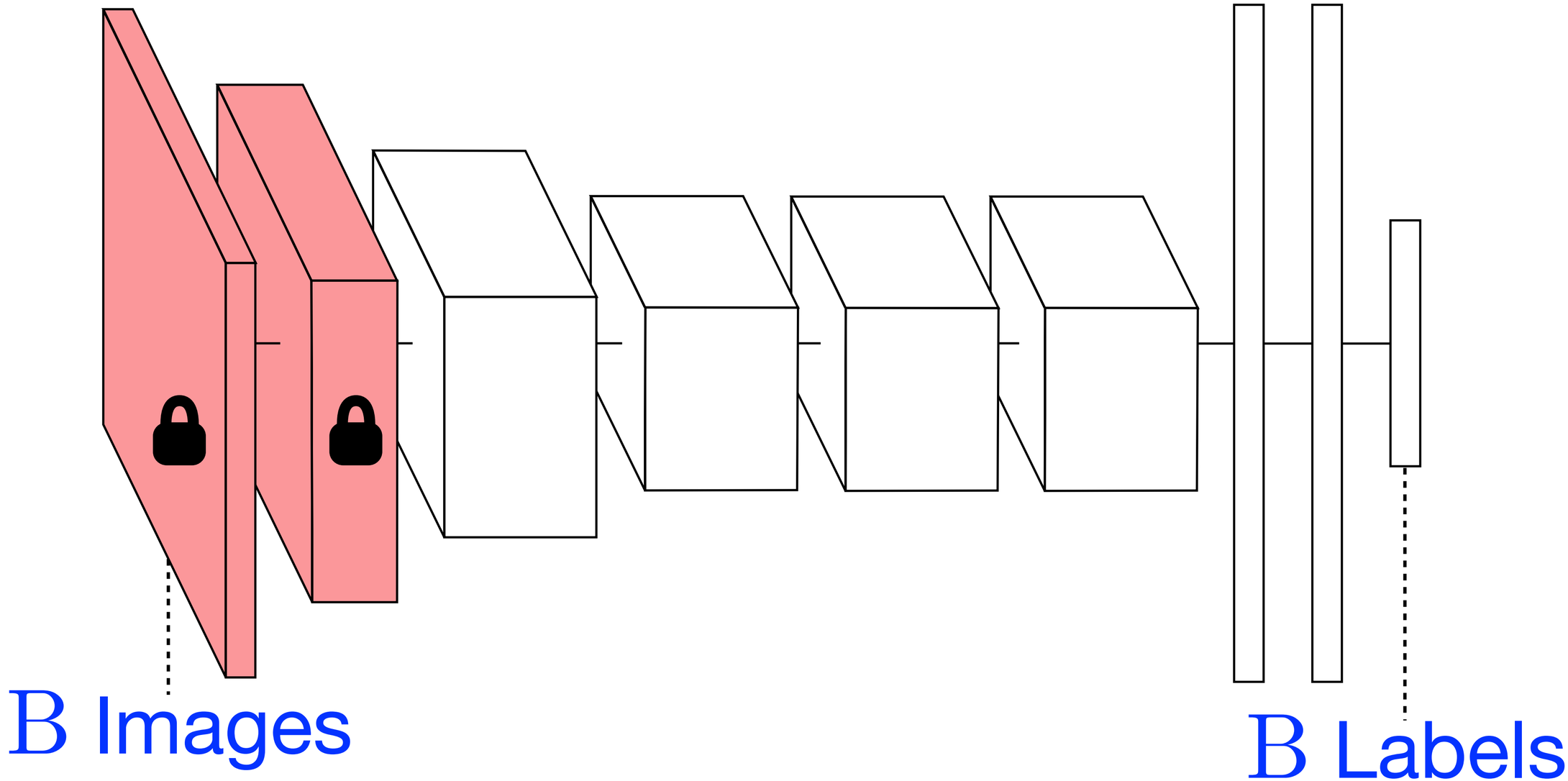
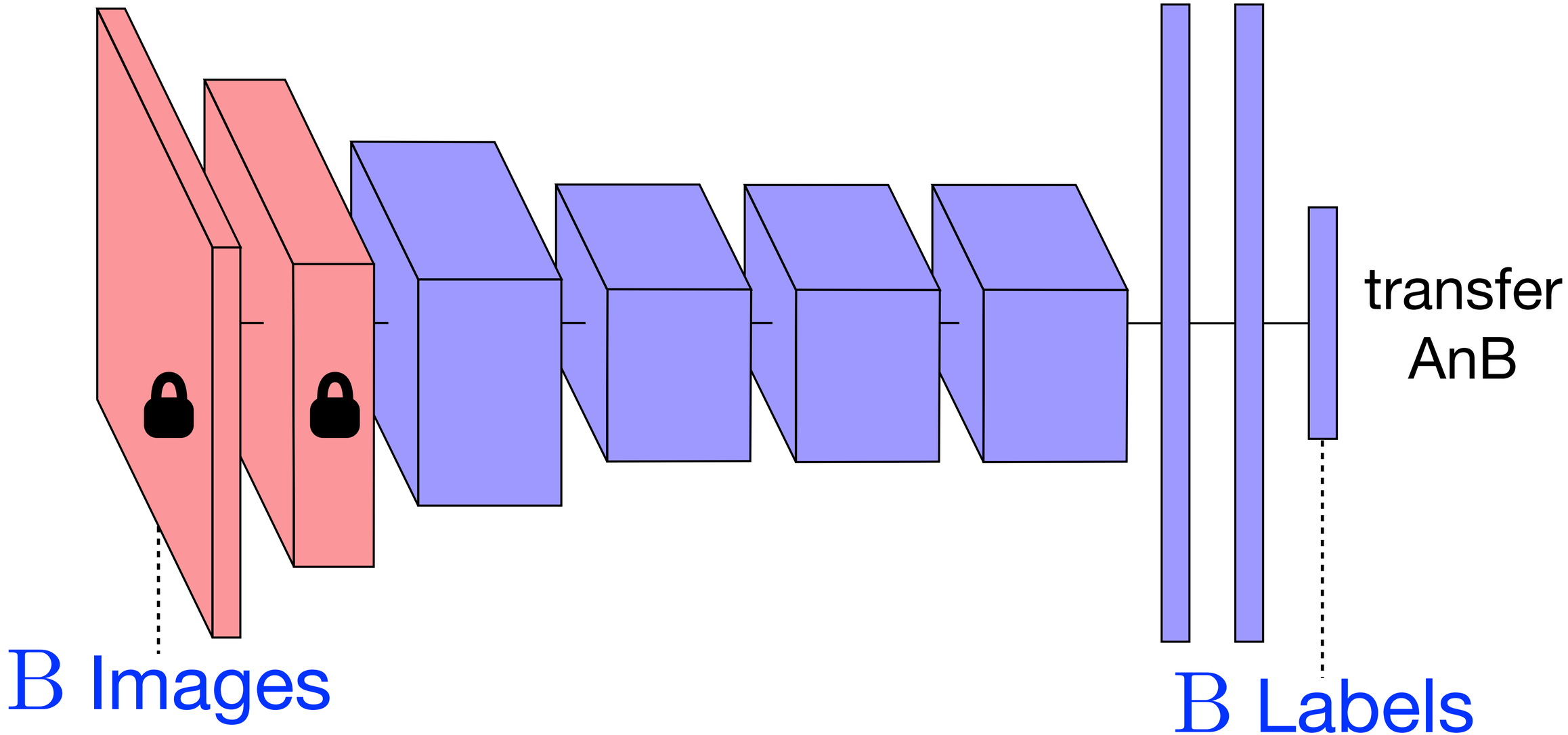
7
Layer n at which network is chopped and retrained

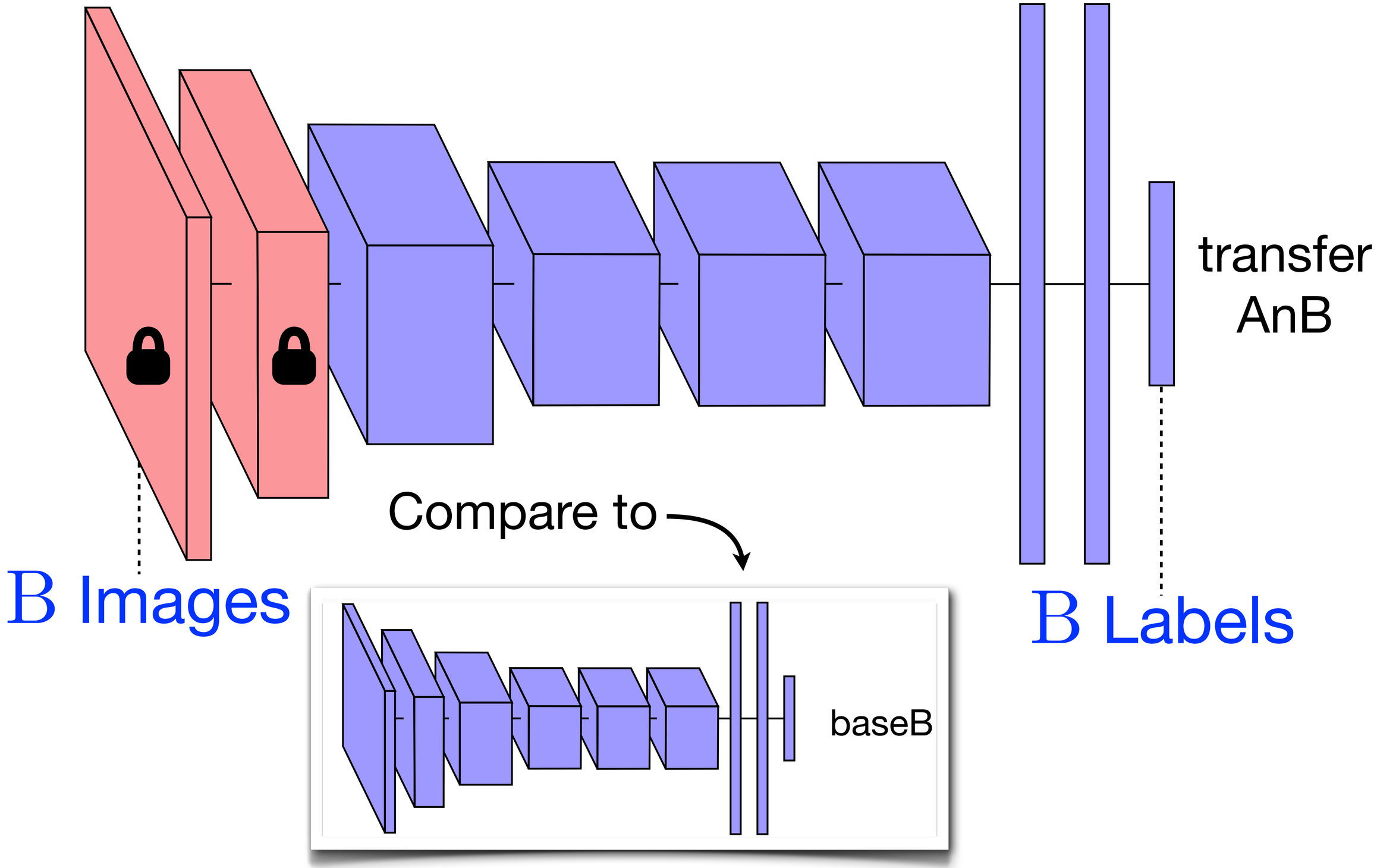

A Images
A Labels

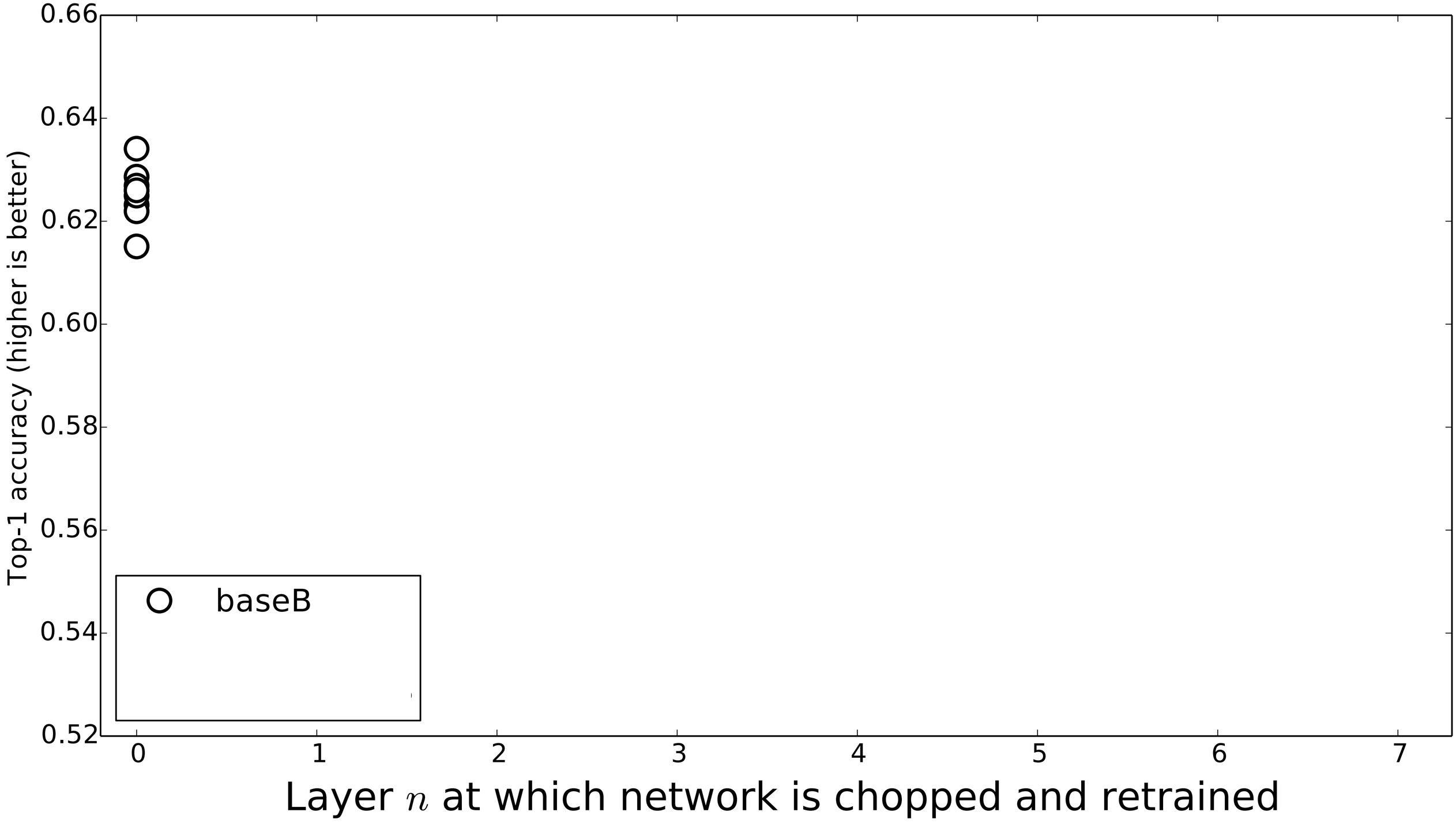





B Images
B Labels


transfer
AnB
B Images
B Labels


transfer
AnB
Compare to
B Images
B Labels
baseB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Top-1 accuracy (higher is better)
baseB
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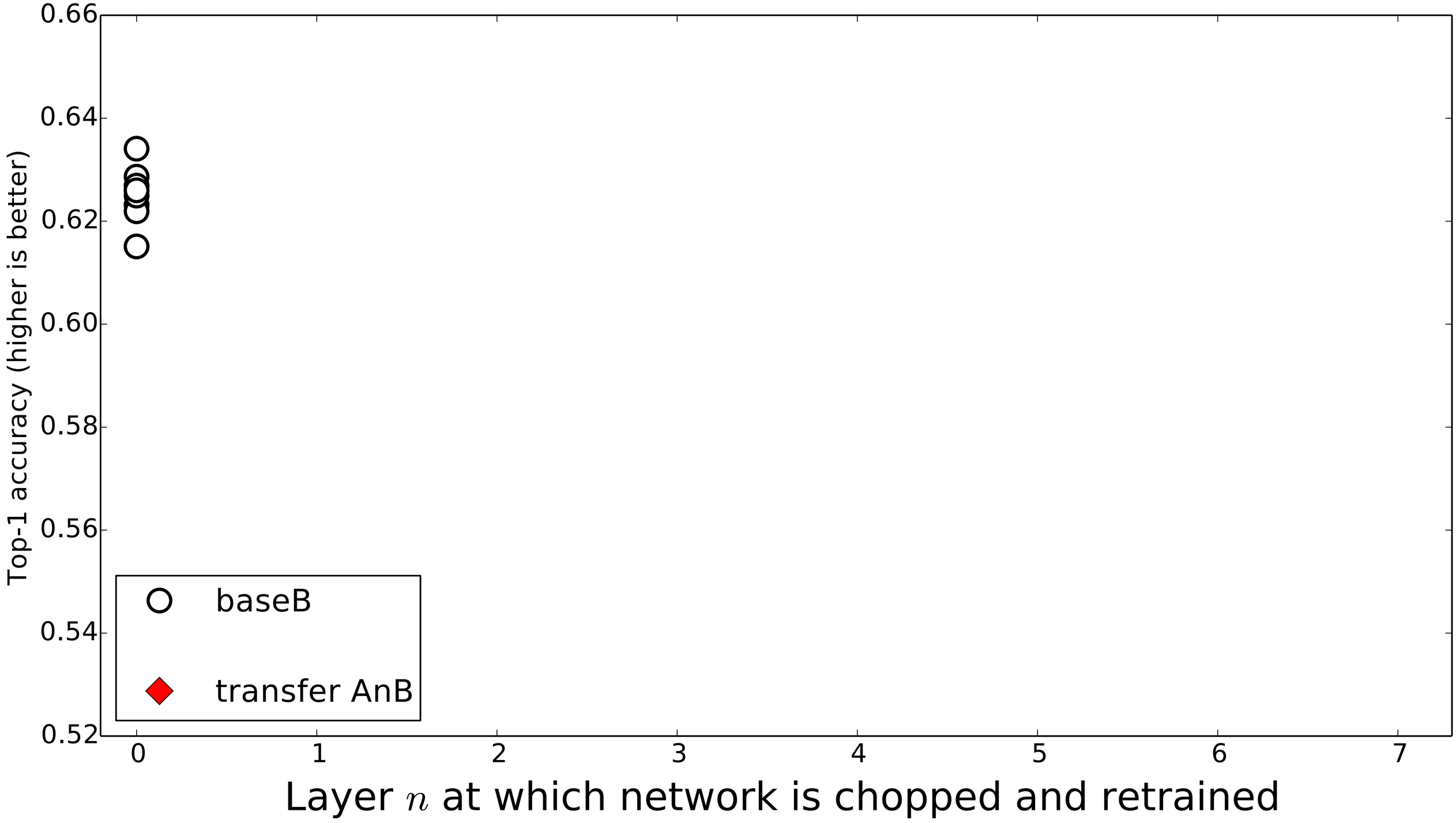
Layer n at which network is chopped and retrained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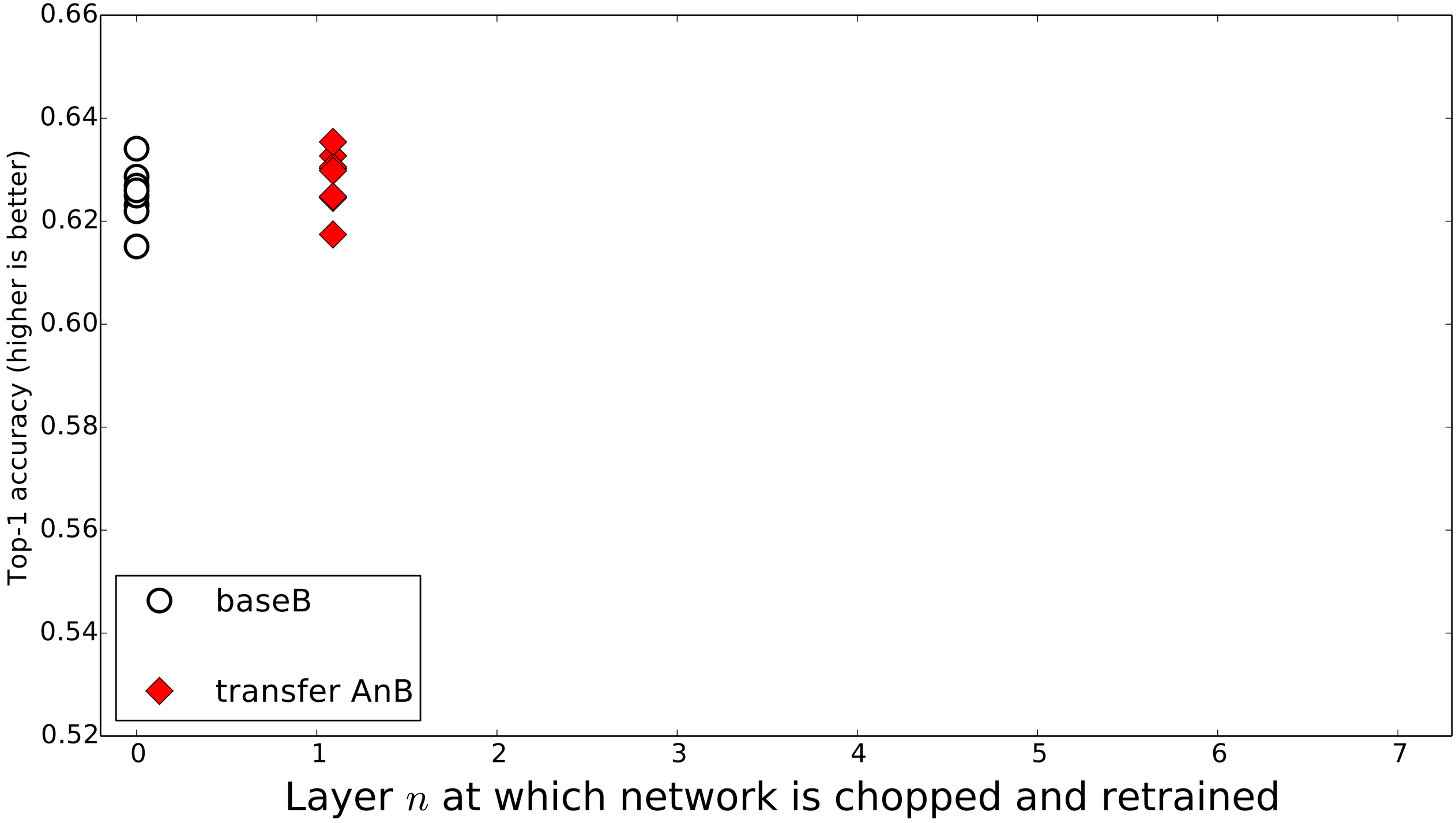
Layer n at which network is chopped and retrained
baseB
transfer AnB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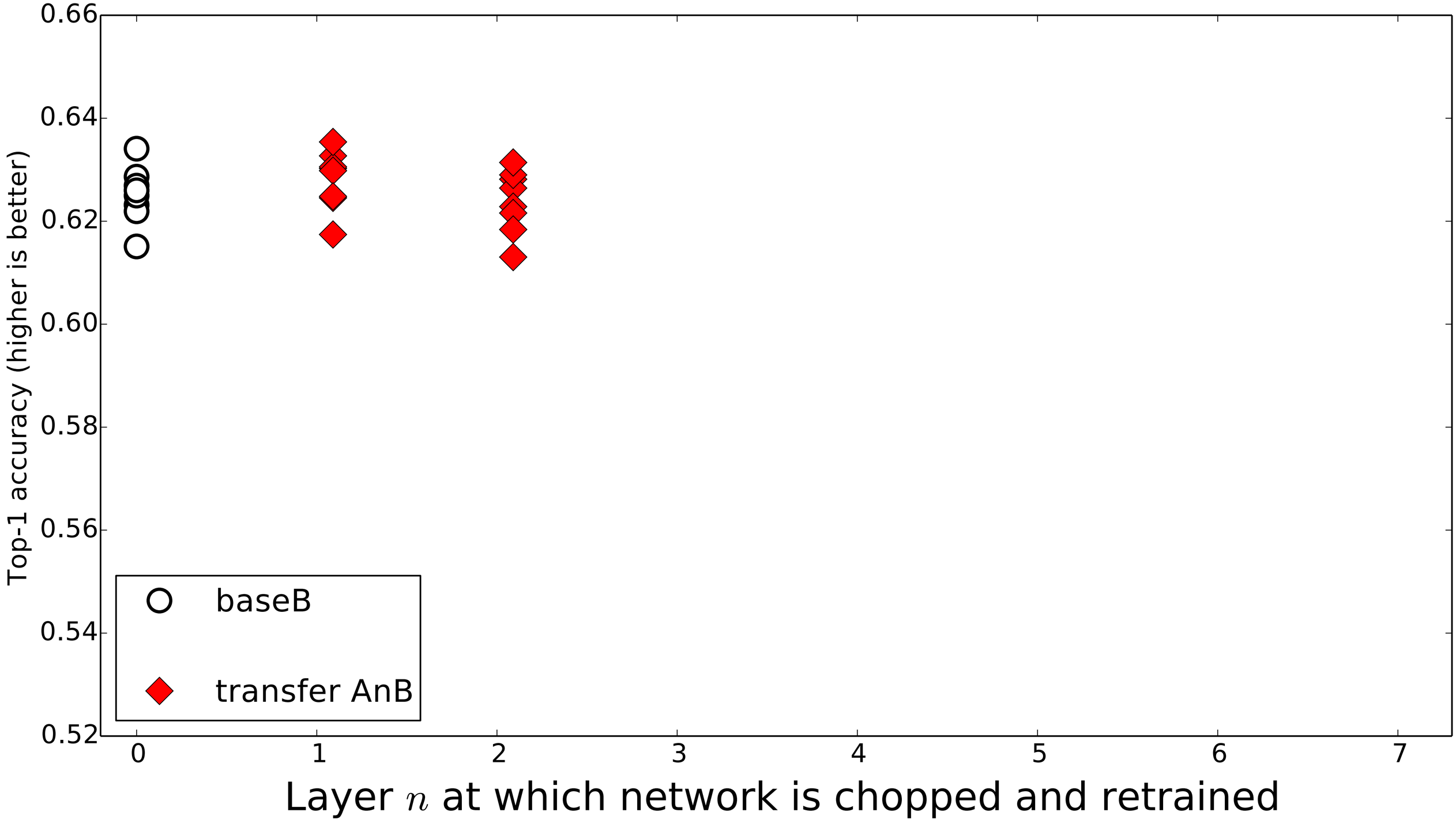
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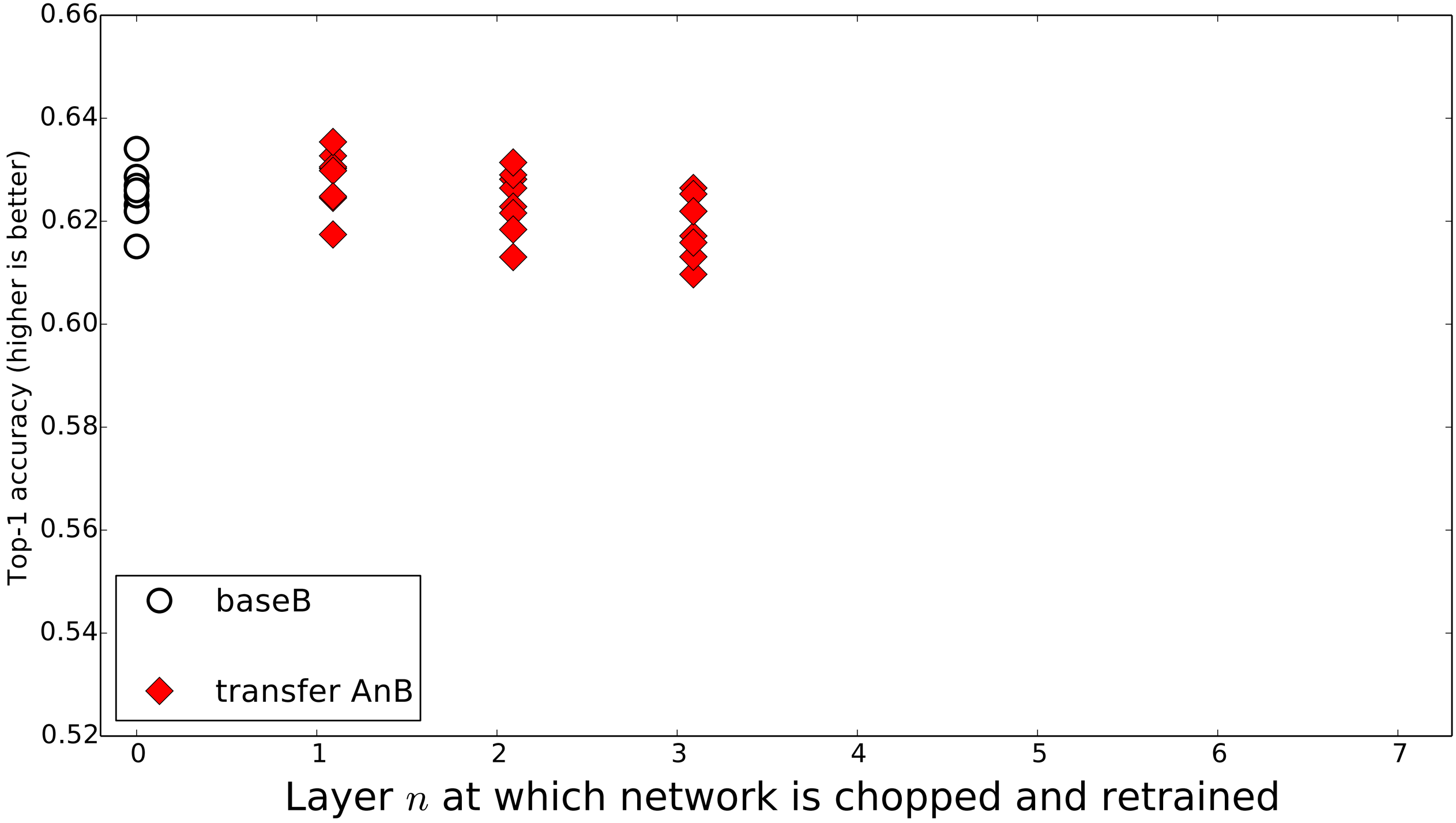
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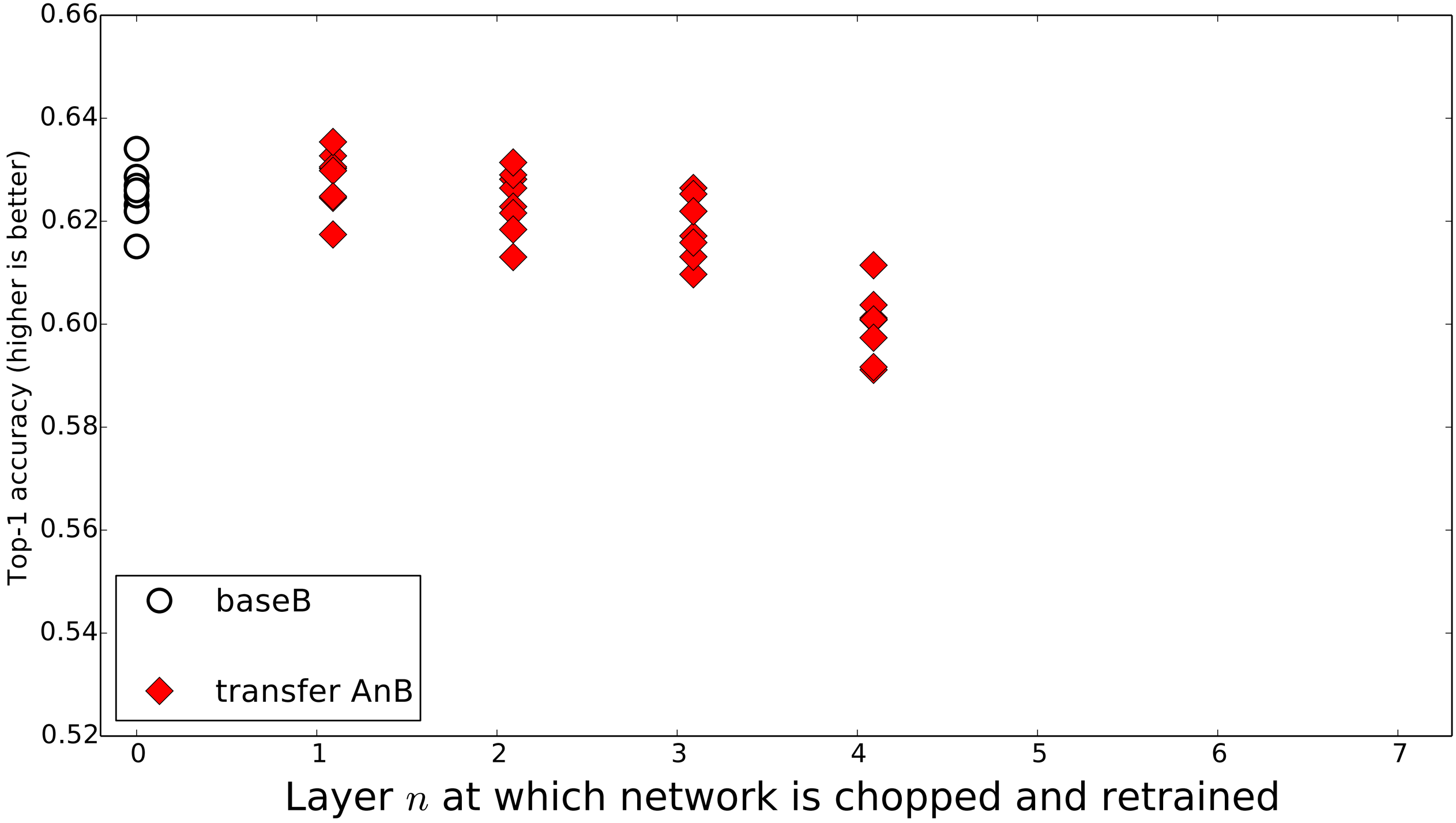
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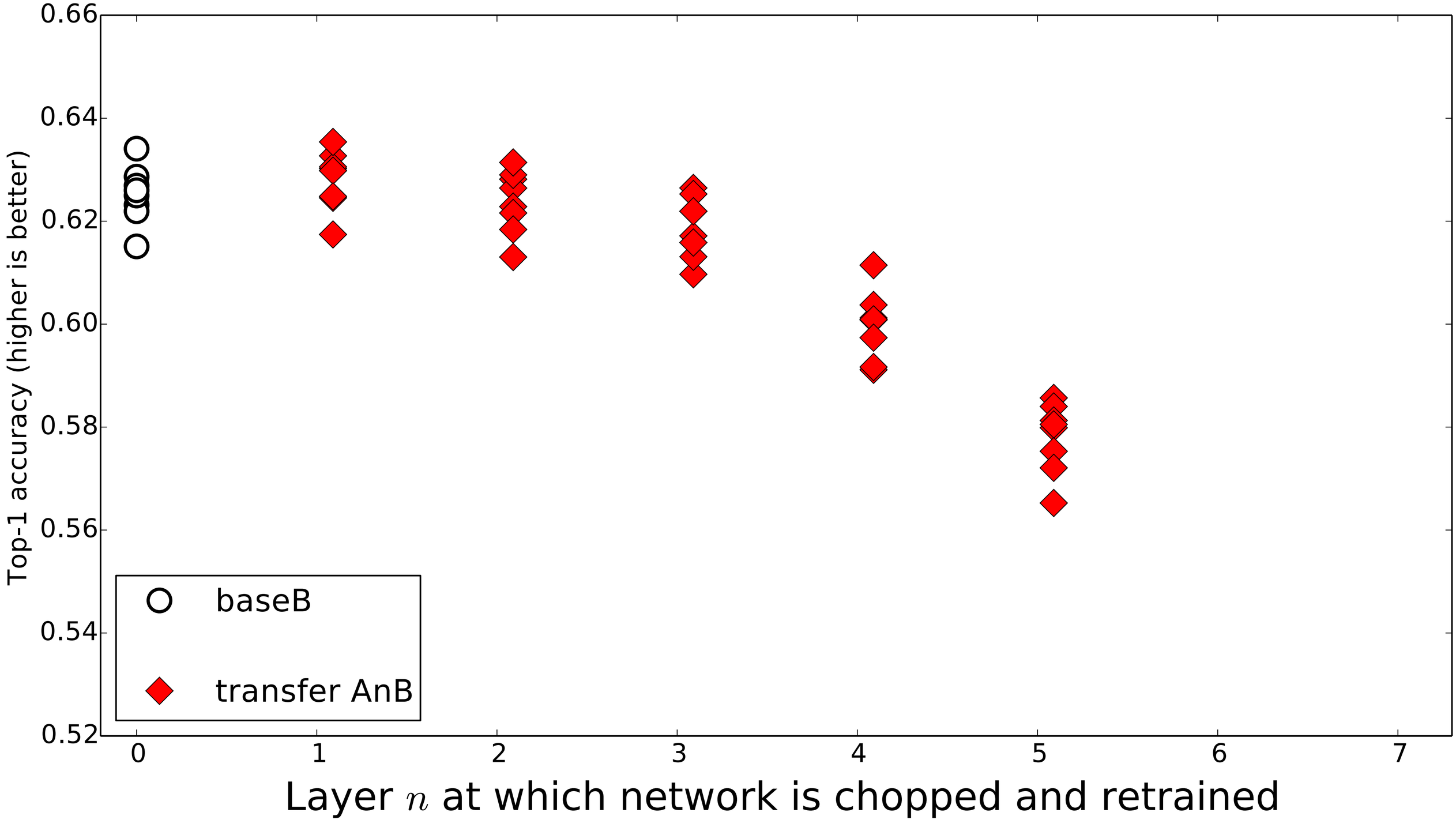
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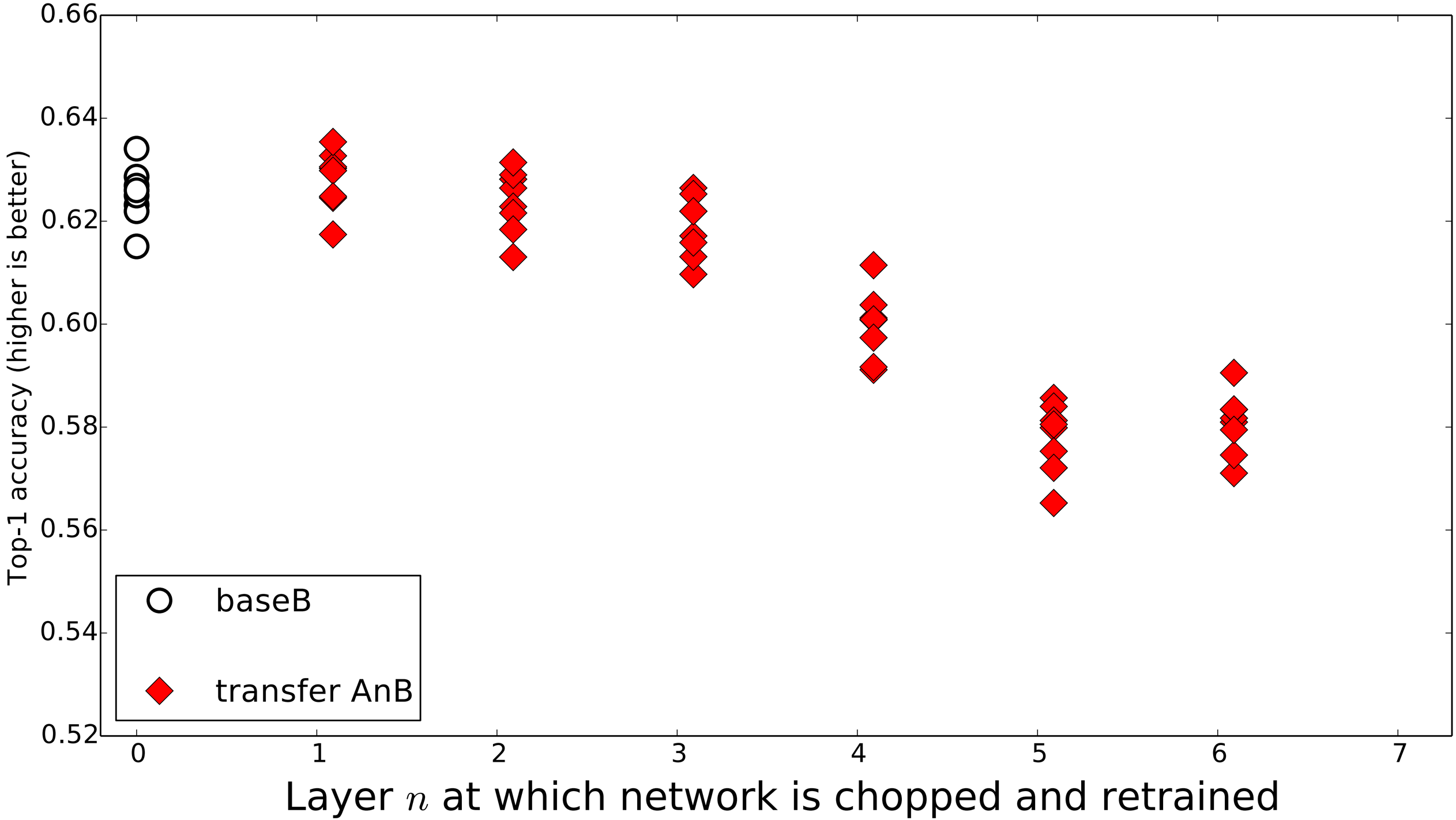
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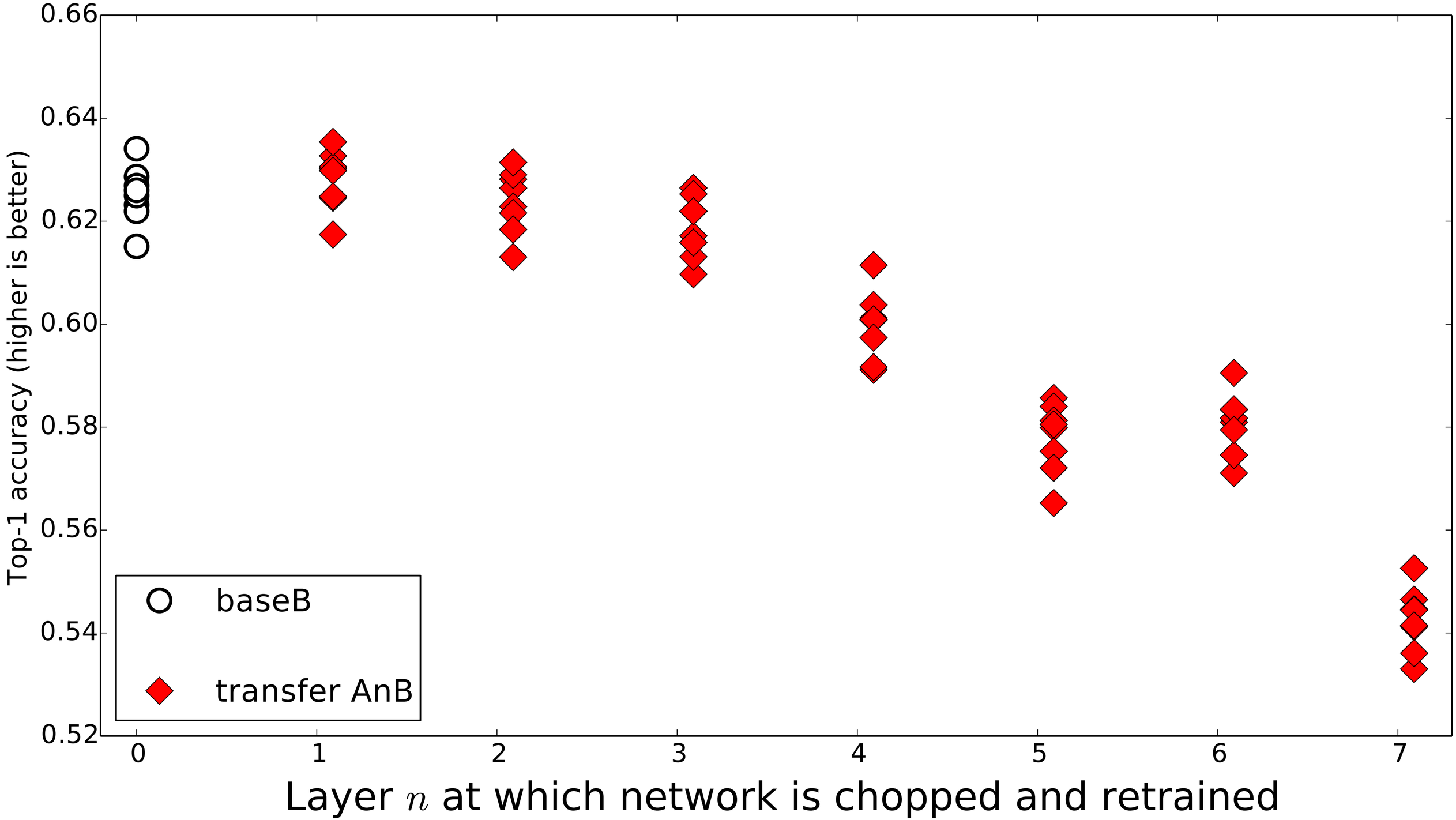
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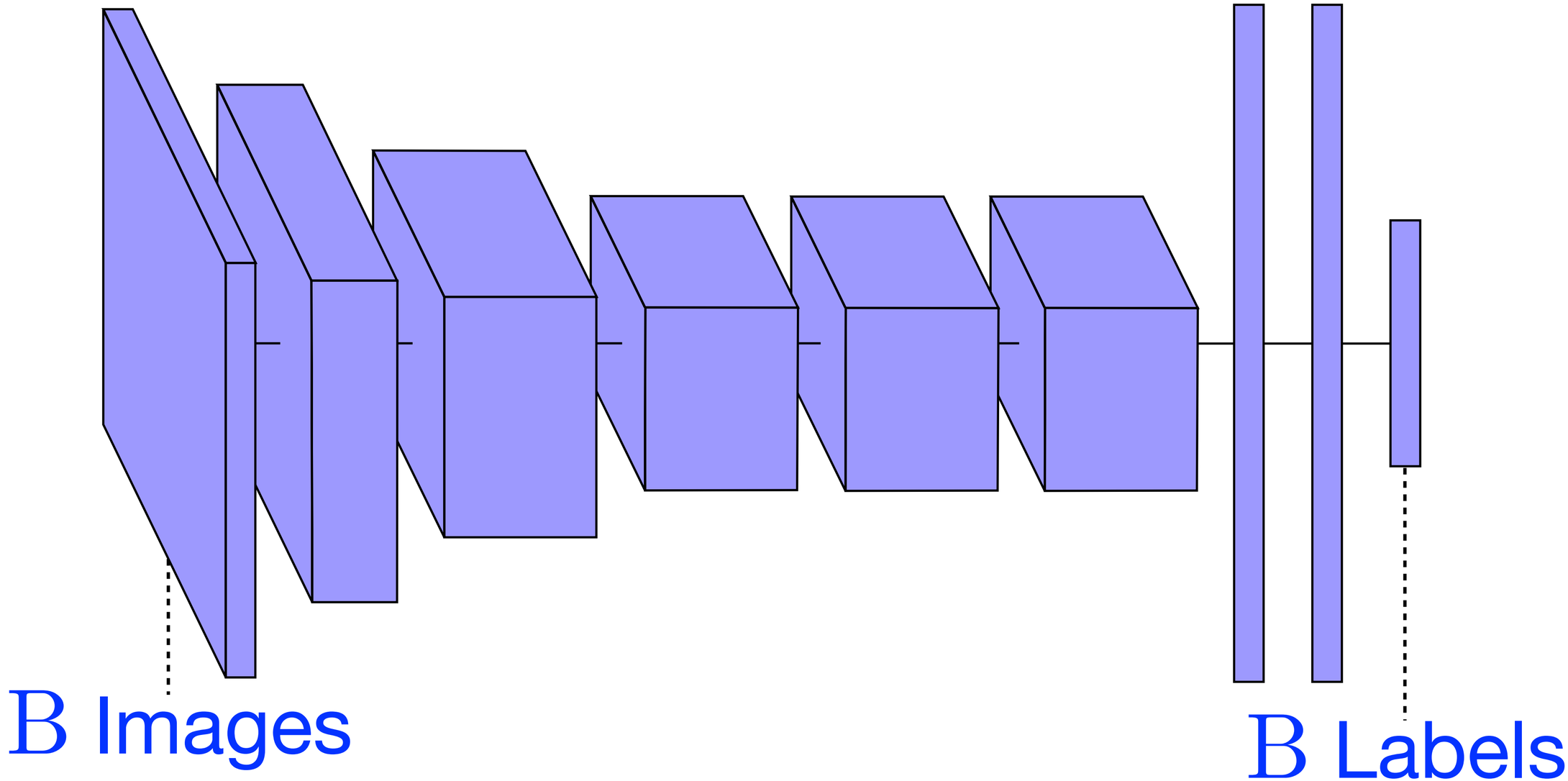
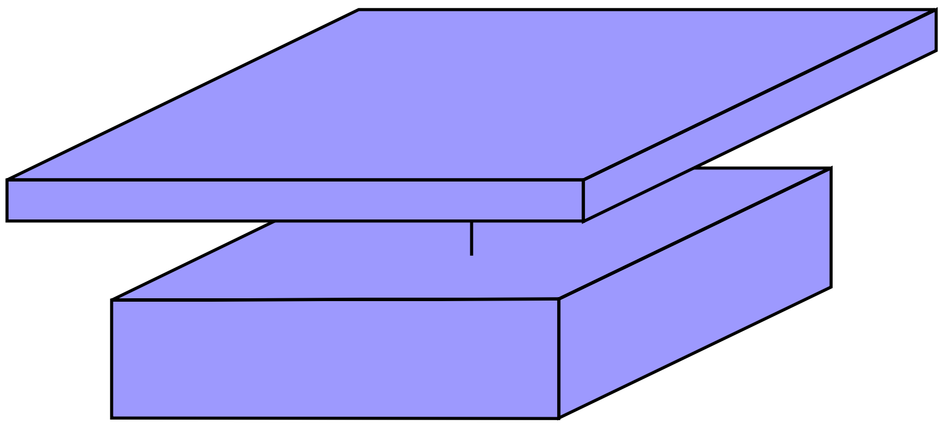
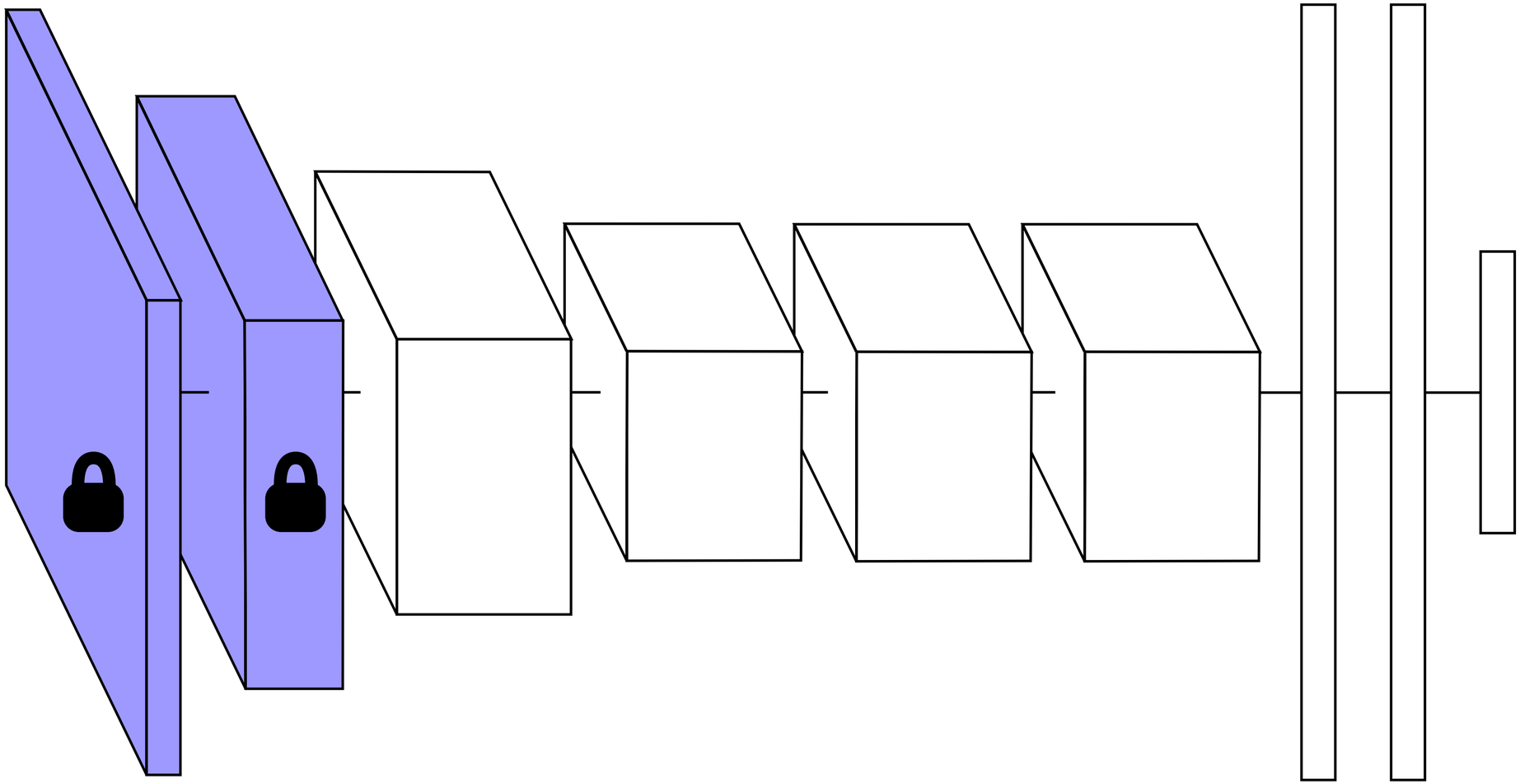
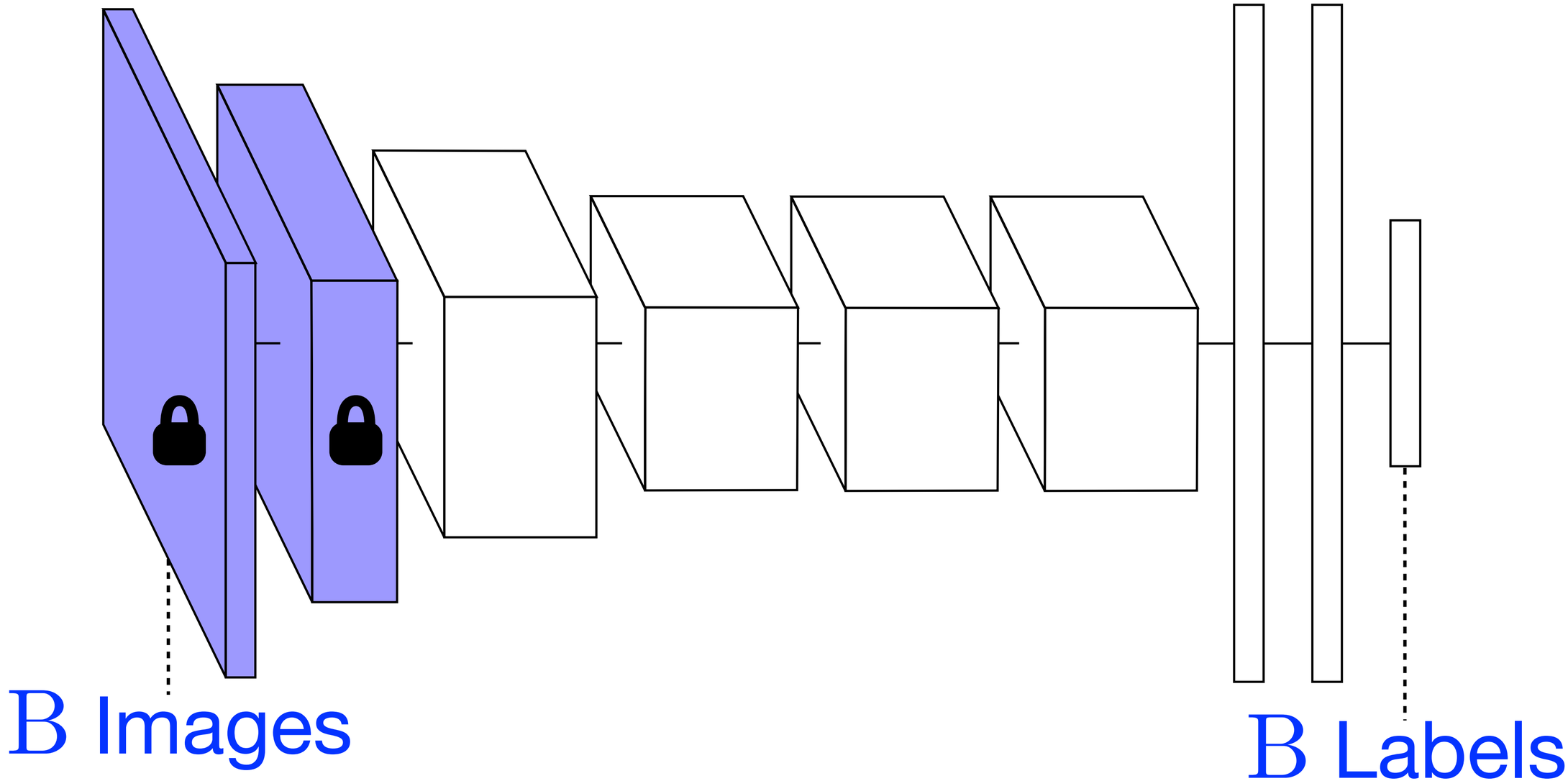
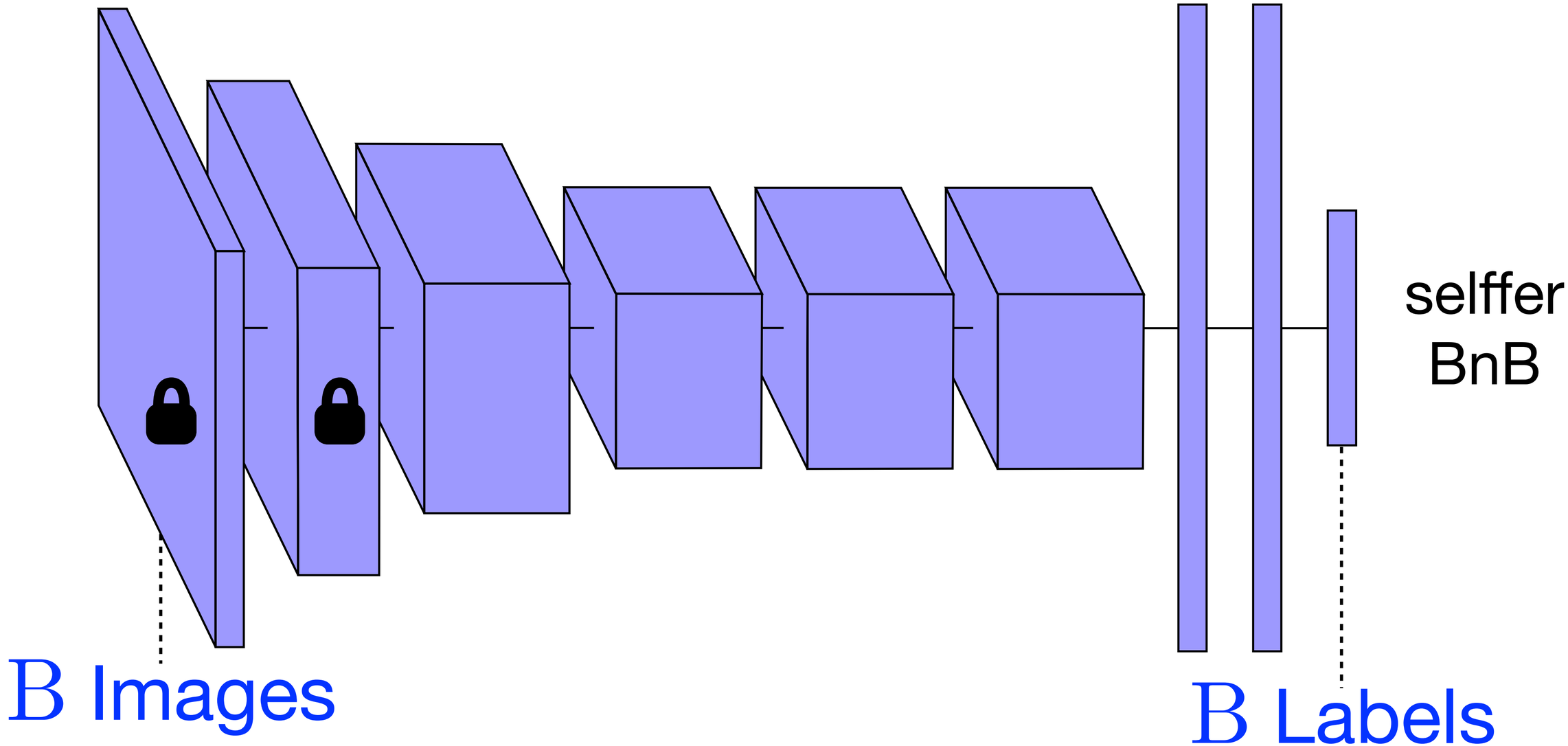
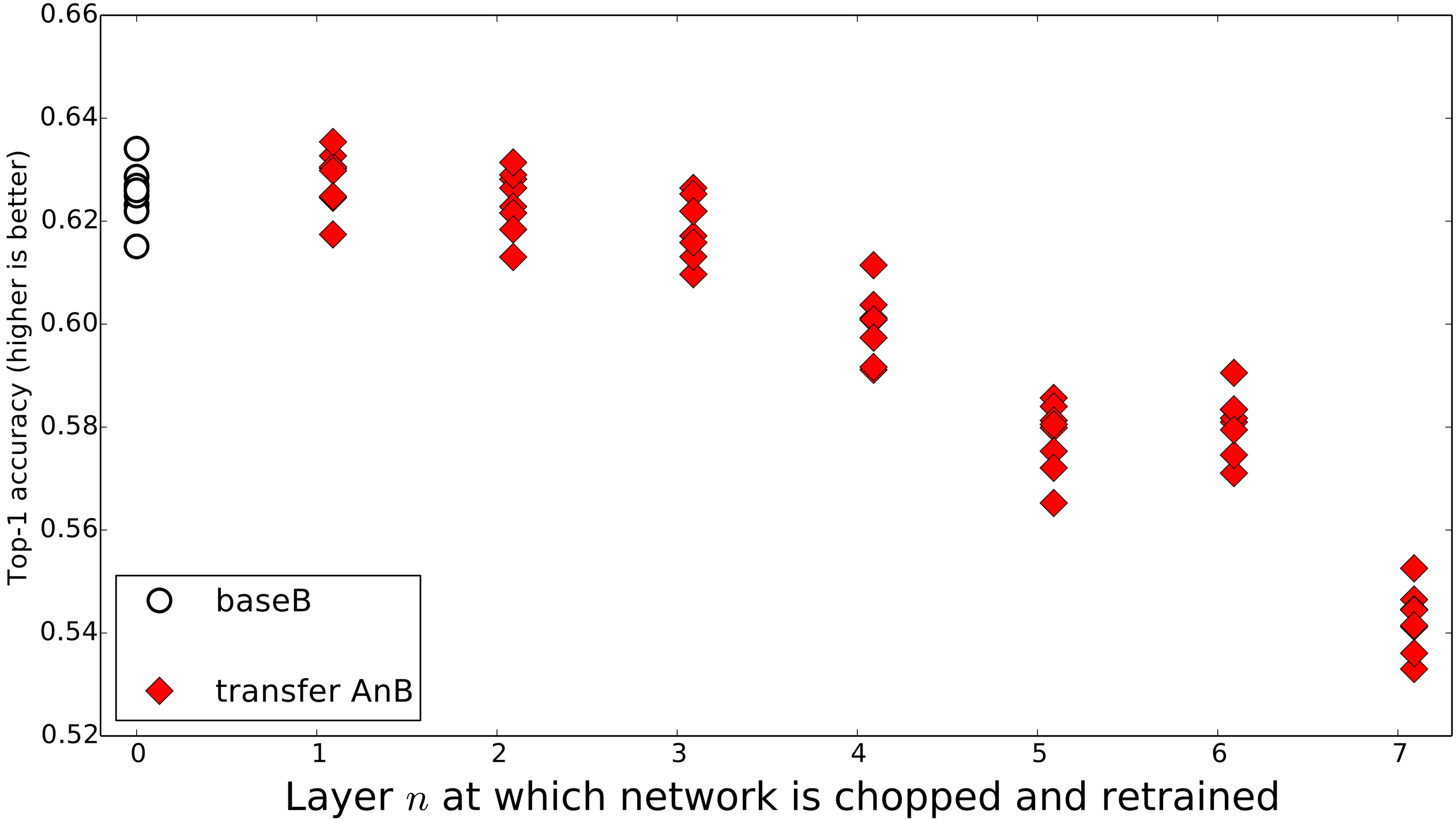

B Images
B Labels






B Images
B Labels


selffer
BnB
B Images
B Labels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Top-1 accuracy (higher is better)
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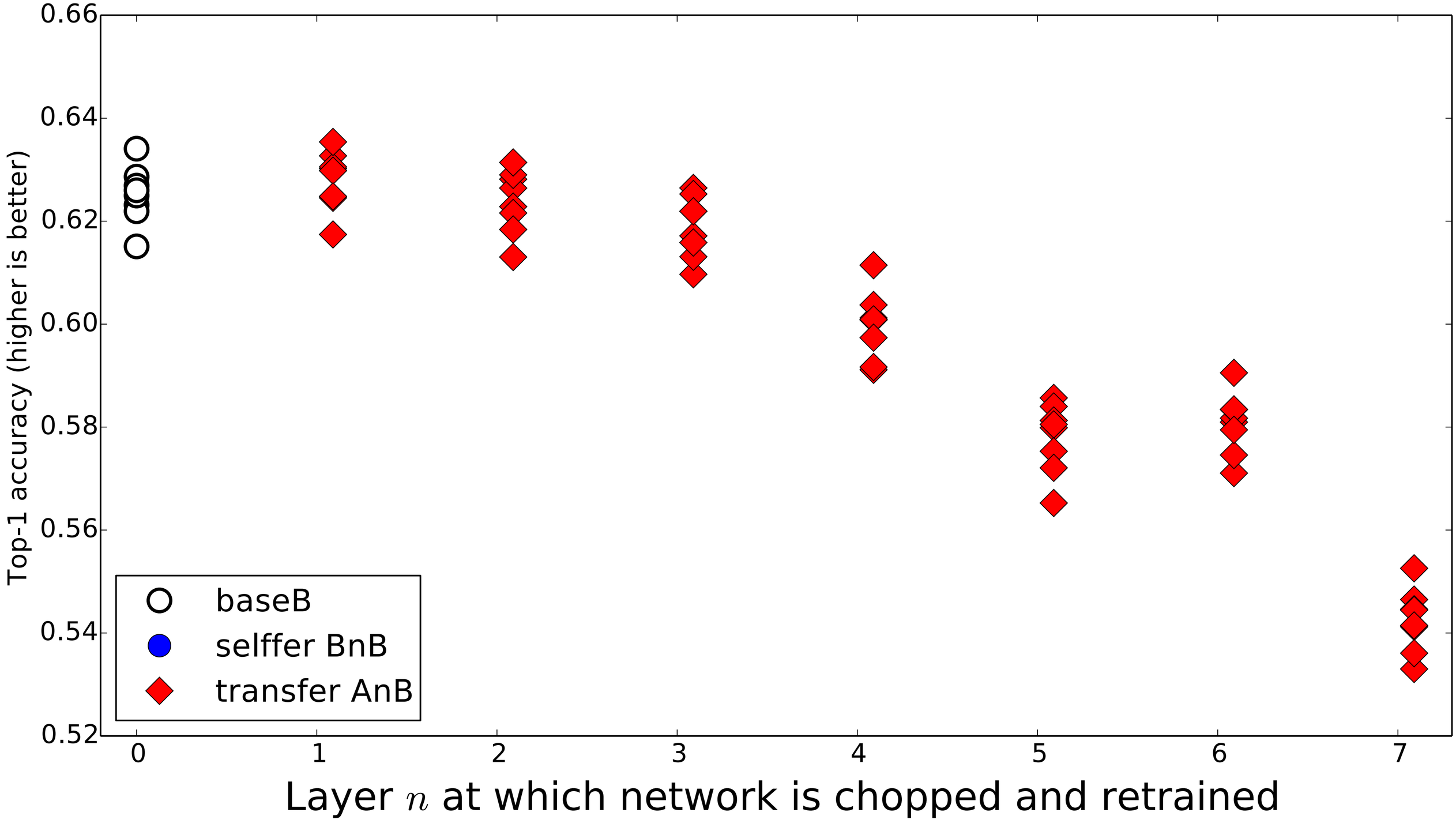
Layer n at which network is chopped and retrained
baseB
transfer AnB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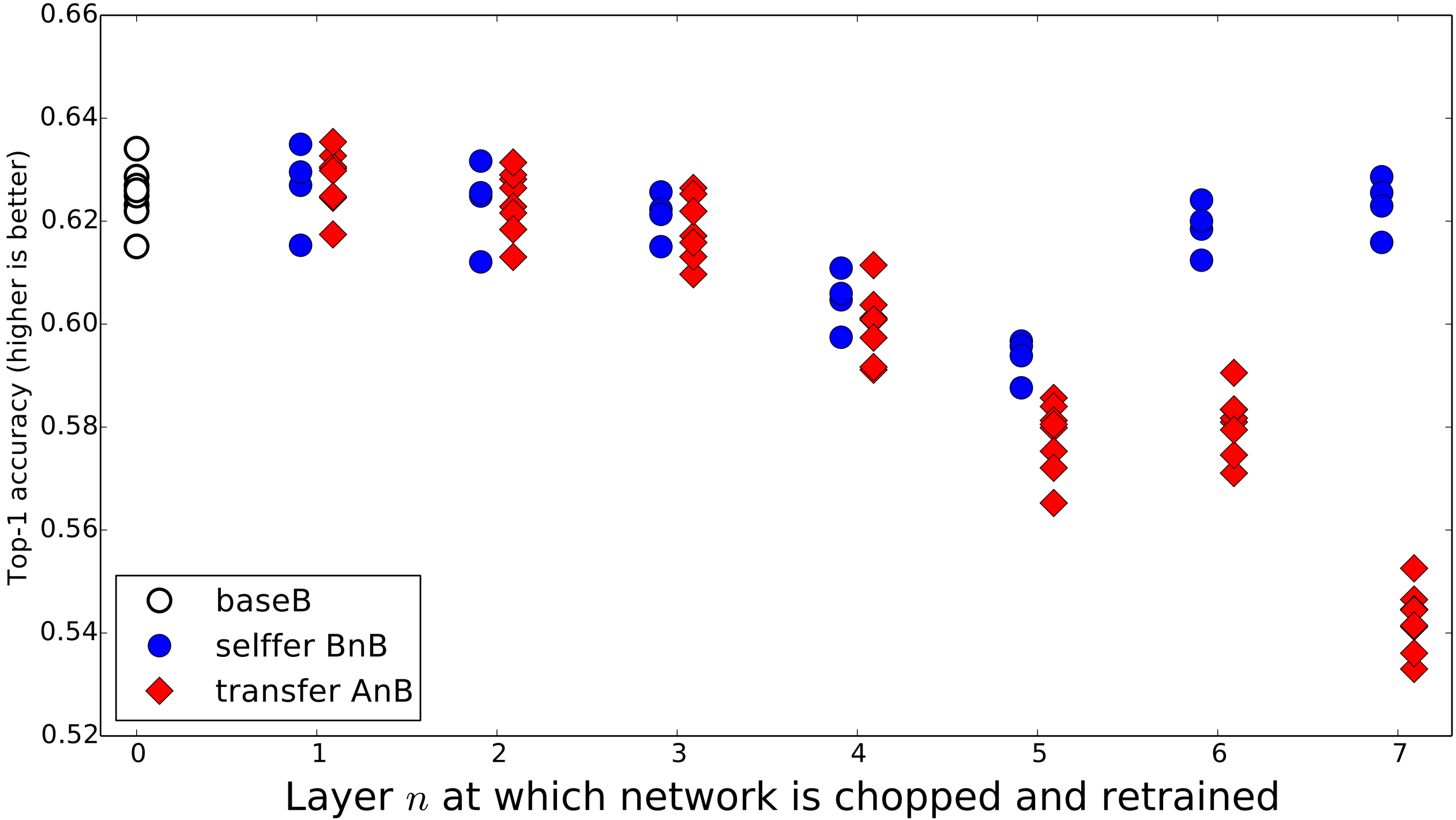
transfer AnB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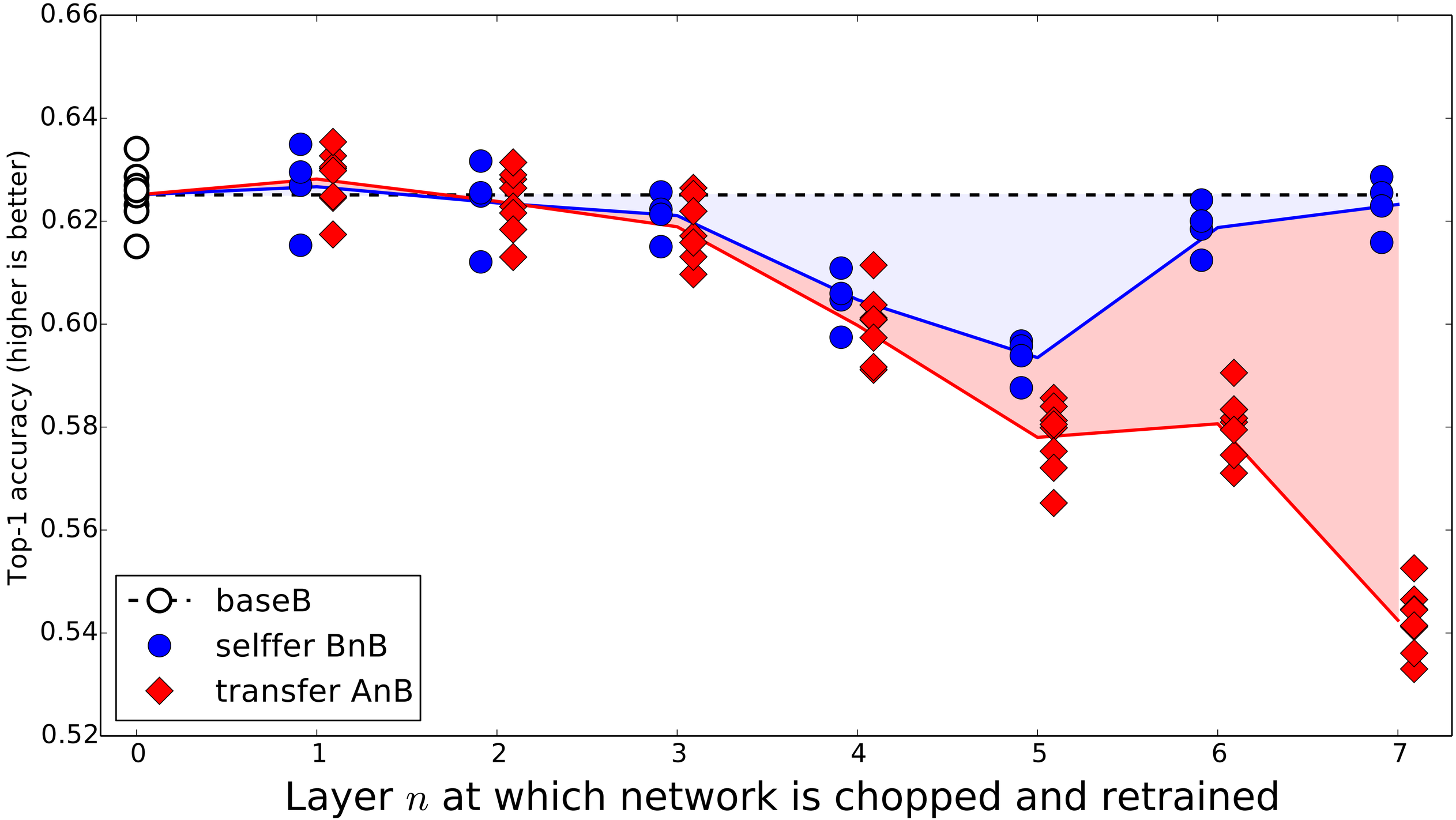
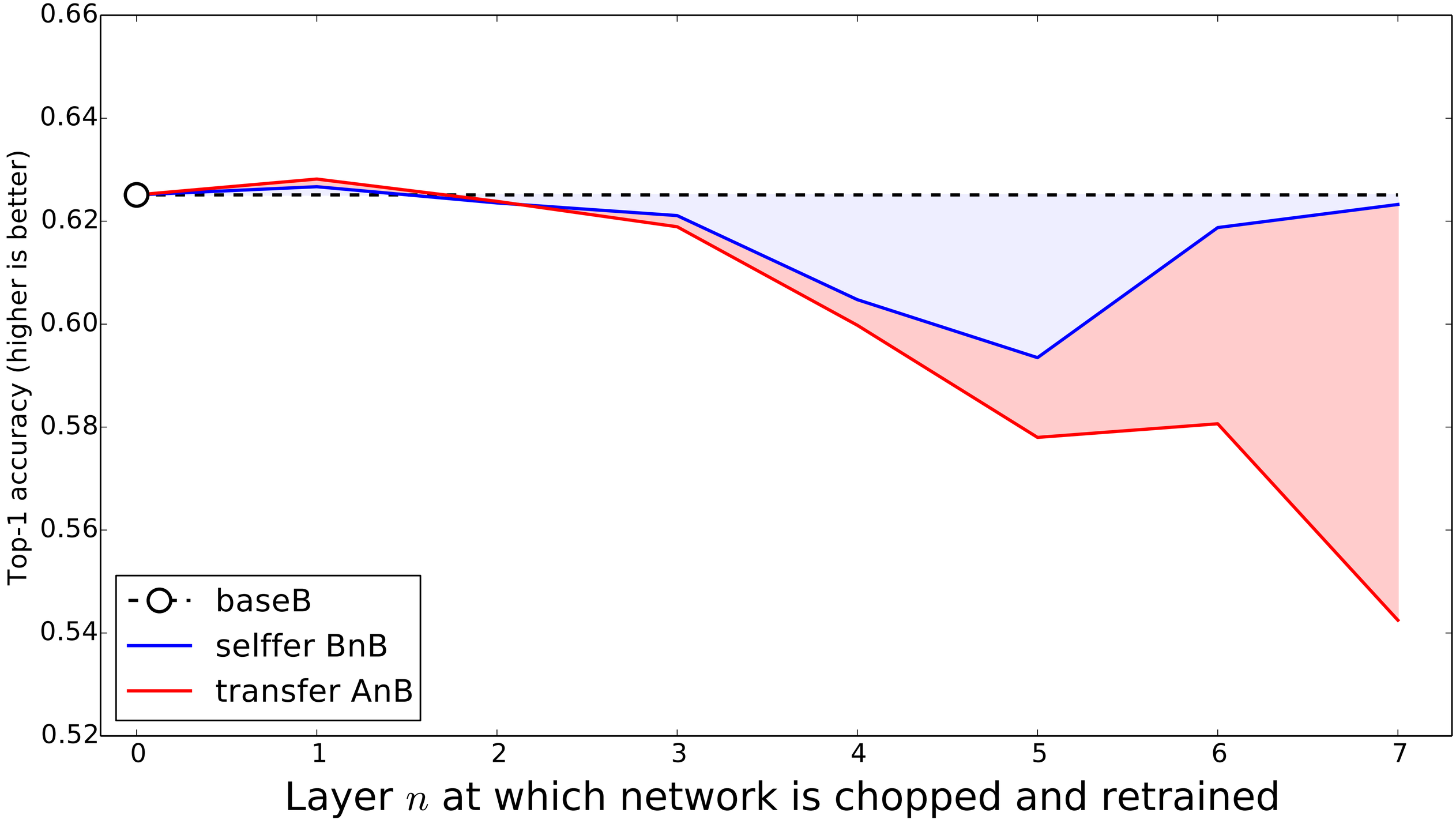
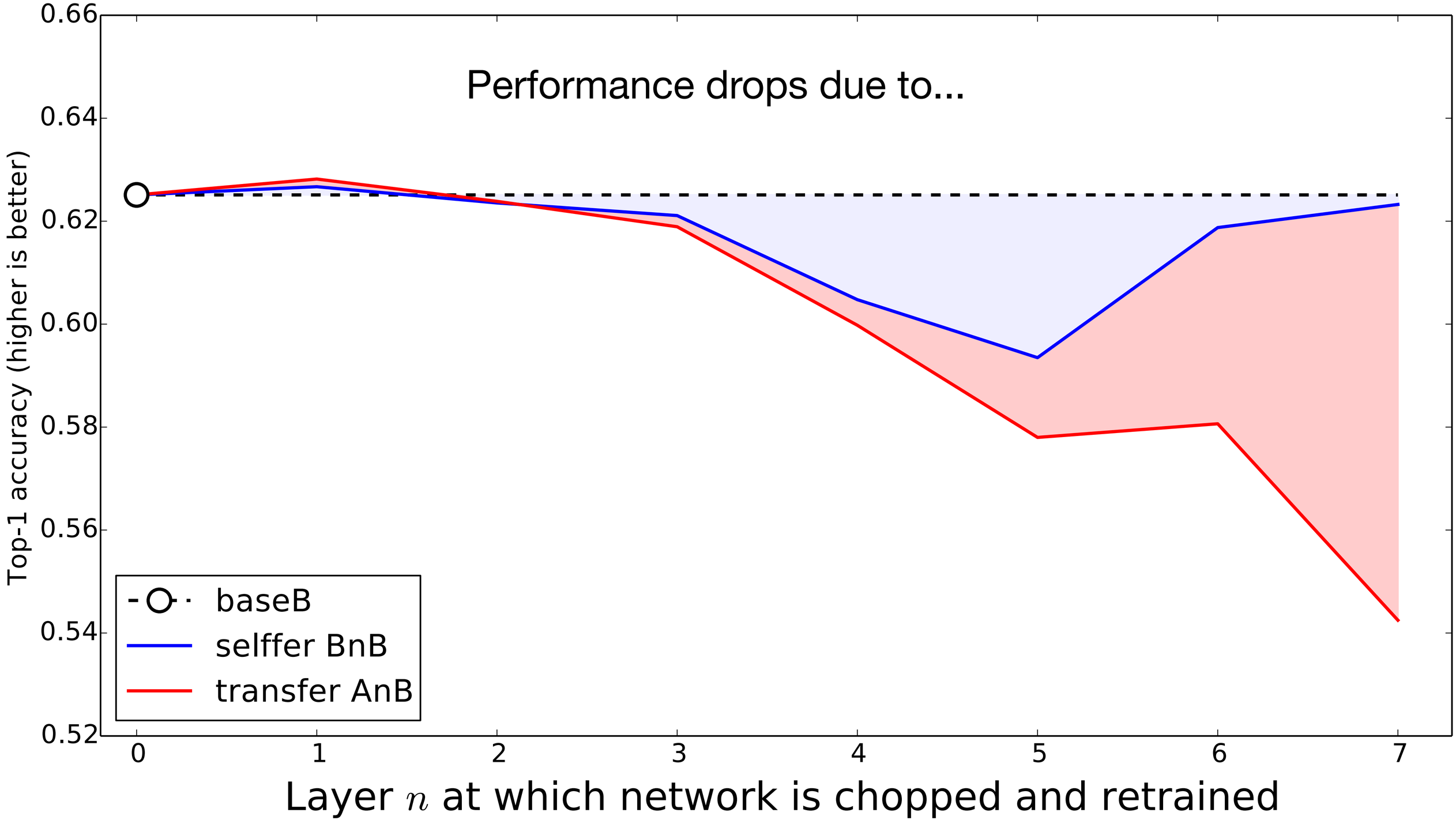
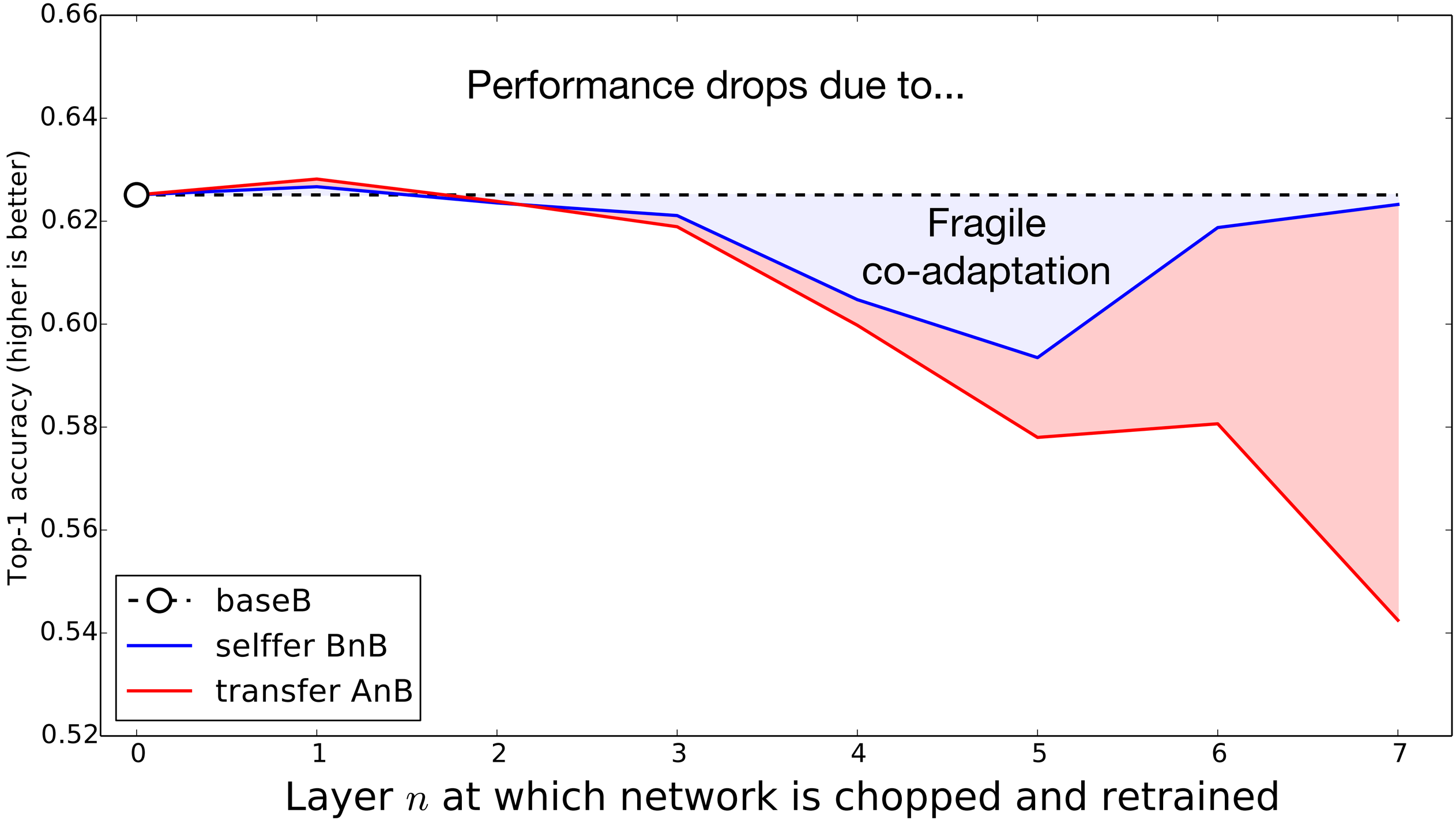
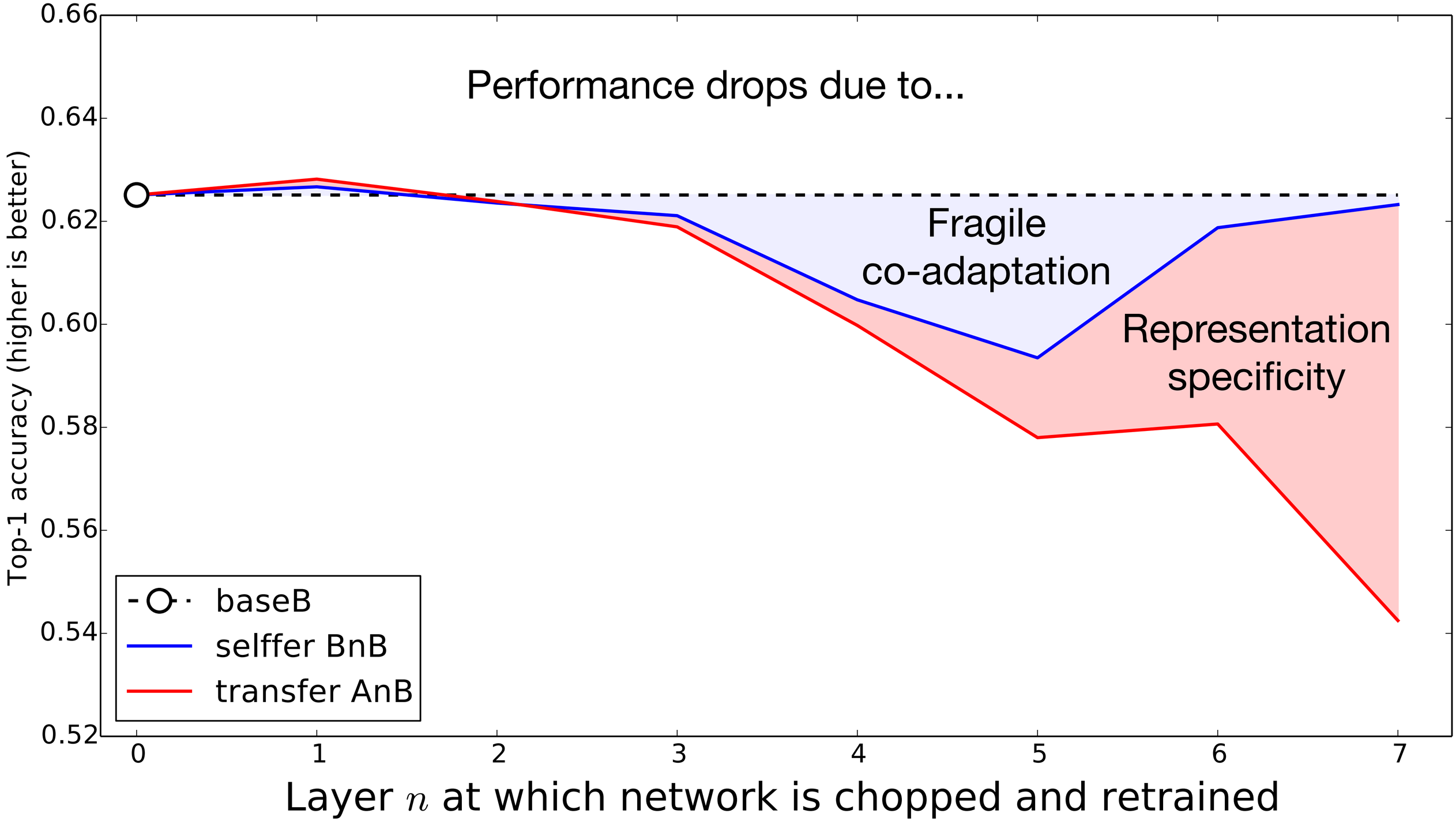
selffer BnB
transfer AnB

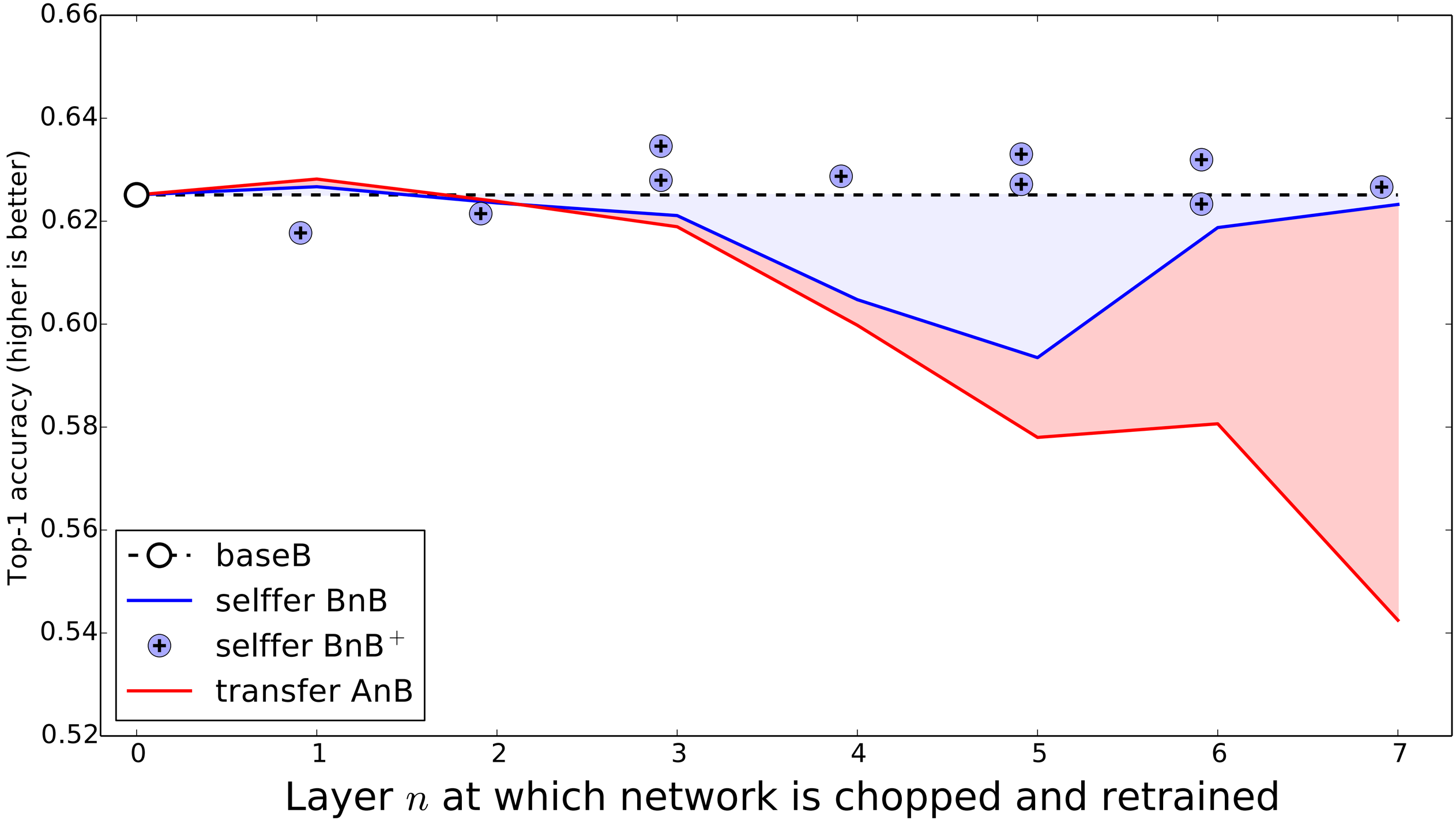

0.66
0.64
0.62
0.60
0.58
0.56
0.54
0.52
Top-1 accuracy (higher is better)
0
1
2
3
4
5
6
7
Layer n at which network is chopped and retrained
baseB
selffer BnB
transfer AnB

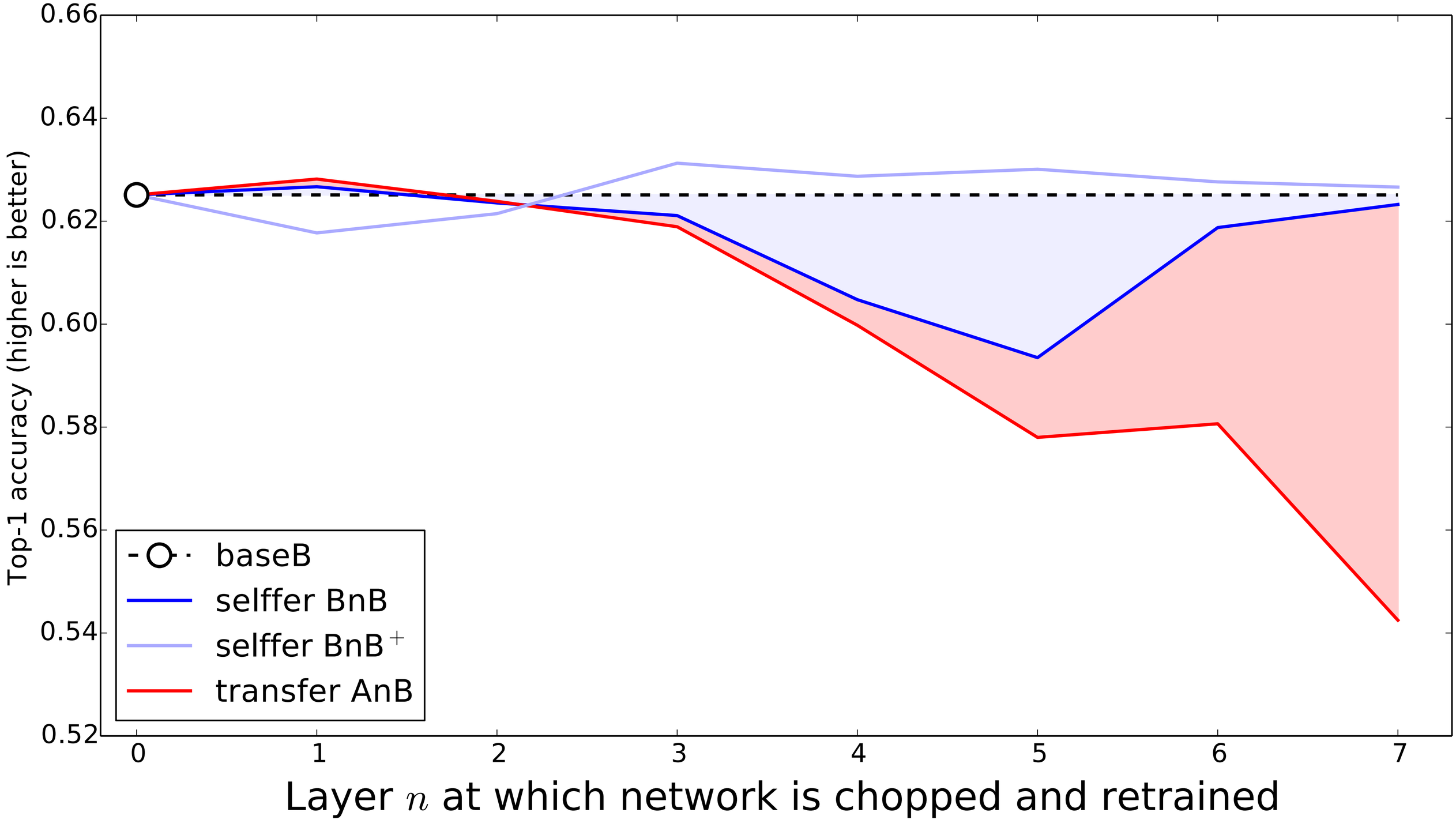

0.66
0.64
0.62
0.60
0.58
0.56
0.54
0.52
Top-1 accuracy (higher is better)
0
1
2
3
4
5
6
7
Layer n at which network is chopped and retrained
baseB
selffer BnB
transfer AnB

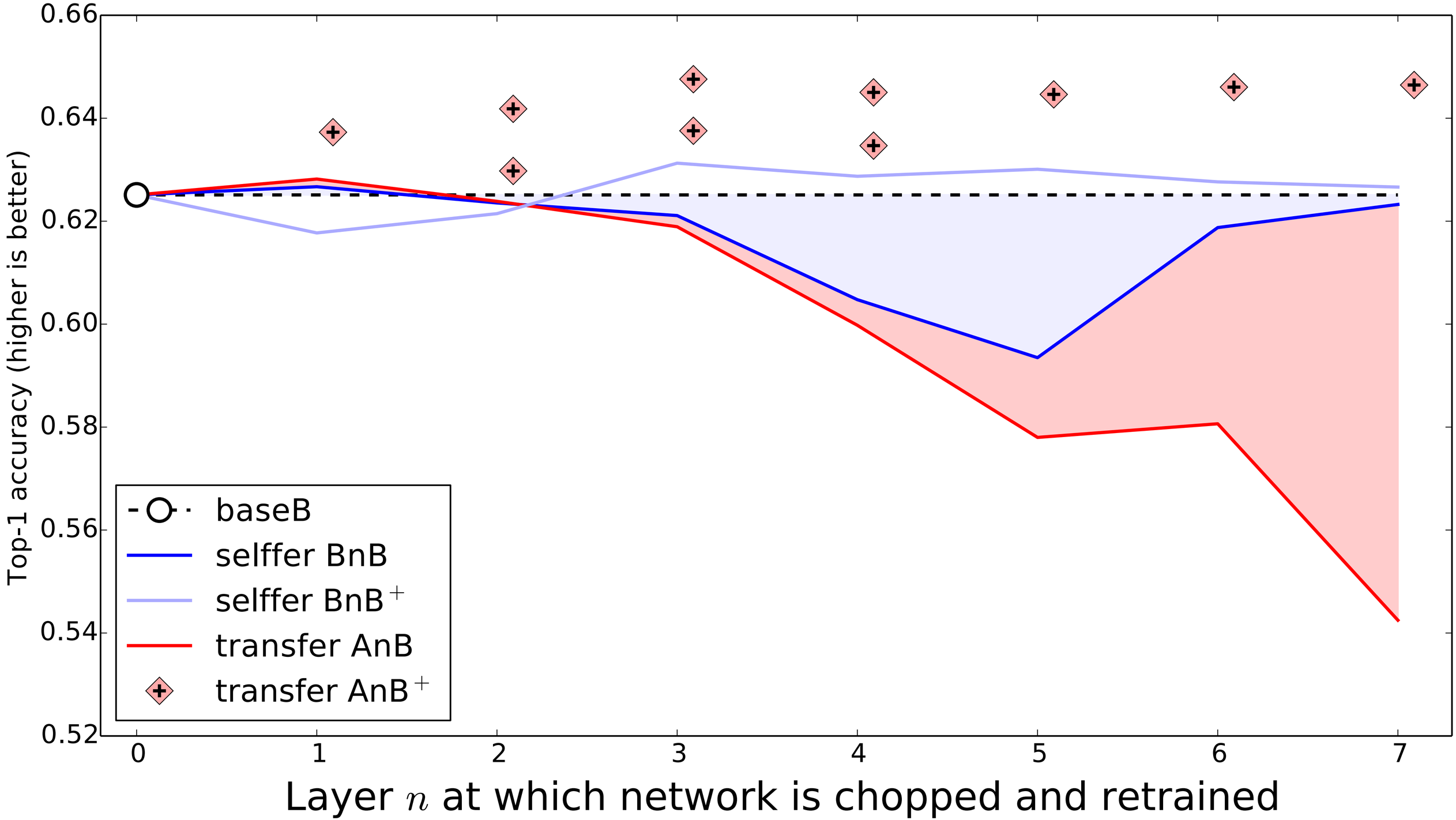

Performance drops due to...
Top-1 accuracy (higher is better)
0.66
0.64
0.62
0.60
0.58
0.56
0.54
0.52
0
1
2
3
4
5
6
7
Layer n at which network is chopped and retrained
baseB
selffer BnB
transfer AnB

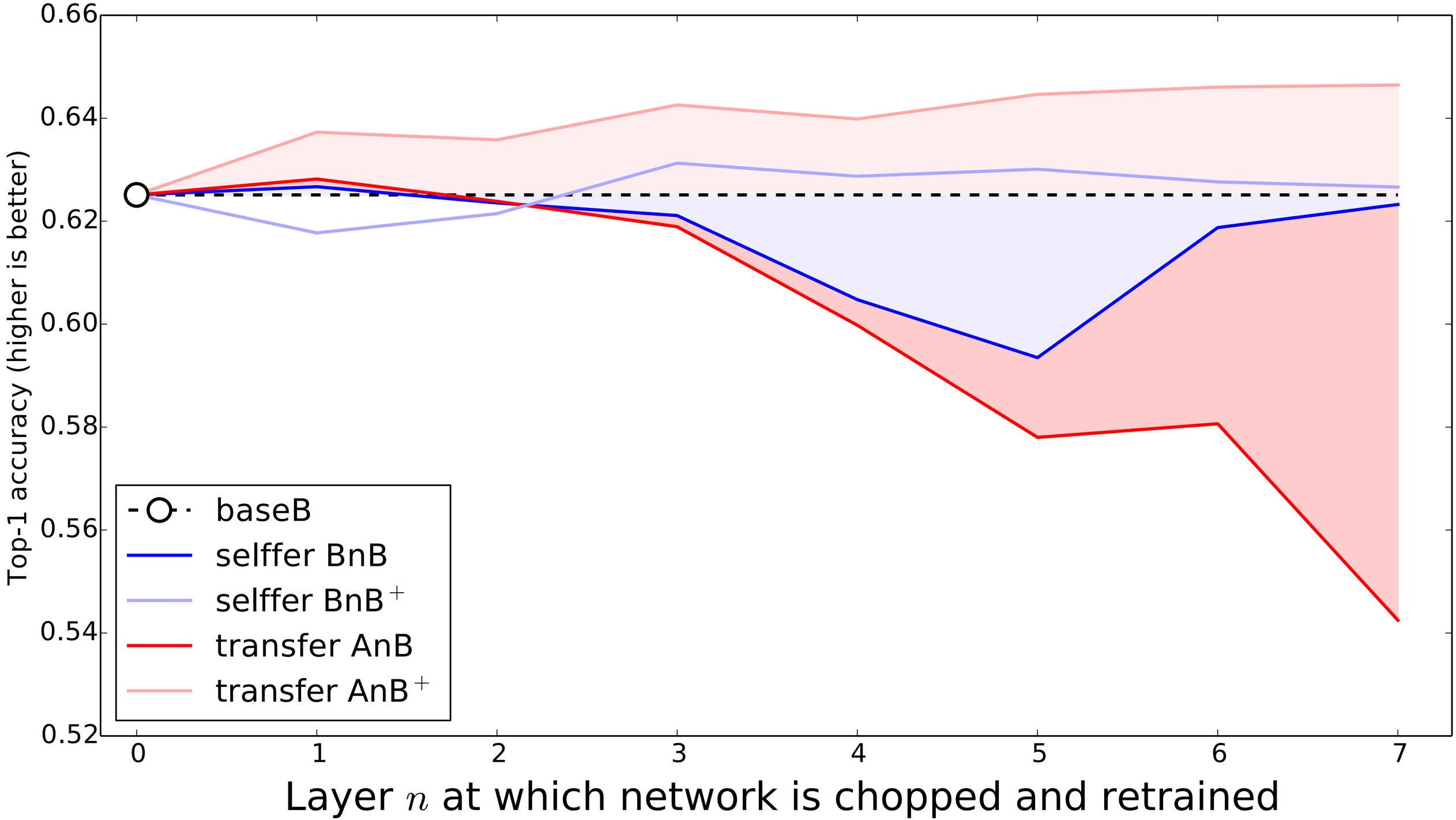

Performance drops due to...
Fragile
co-adaptation
Top-1 accuracy (higher is better)
0.66
0.64
0.62
0.60
0.58
0.56
0.54
0.52
0
1
2
3
4
5
6
7
Layer n at which network is chopped and retrained
baseB
selffer BnB
transfer AnB

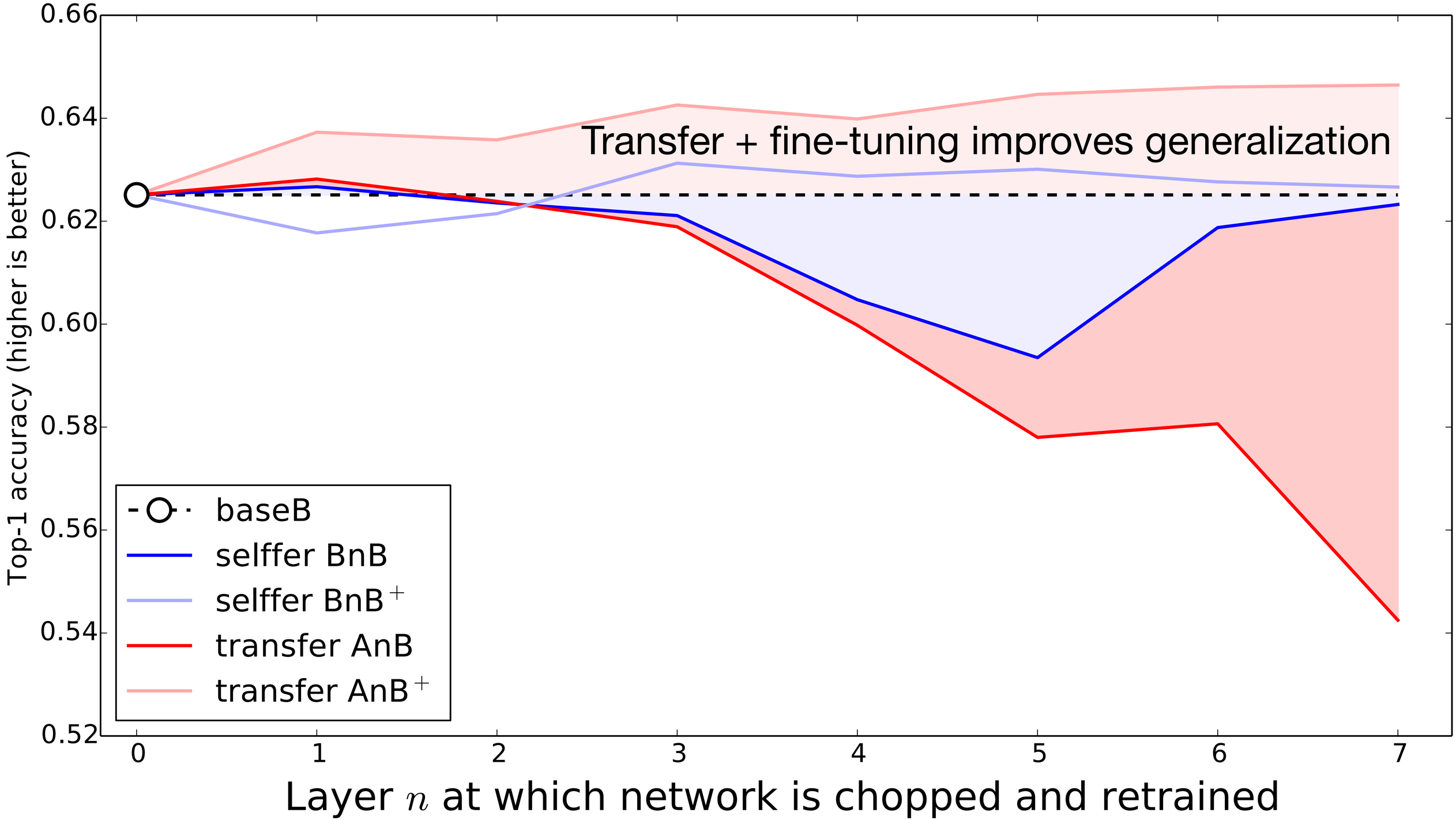

Performance drops due to...
Fragile
co-adaptation
Representation
specificity
baseB
selffer BnB
transfer AnB
Top-1 accuracy (higher is better)
0.66
0.64
0.62
0.60
0.58
0.56
0.54
0.52
0
1
2
3
4
5
6
7
Layer n at which network is chopped and retrained


0.66
0.64
0.62
0.60
0.58
0.56
0.54
0.52
Top-1 accuracy (higher is better)
0
1
2
3
4
5
6
7
Layer n at which network is chopped and retrained
baseB
selffer BnB
selffer BnB$^+$
transfer AnB


0.66
0.64
0.62
0.60
0.58
0.56
0.54
0.52
Top-1 accuracy (higher is better)
0
1
2
3
4
5
6
7
Layer n at which network is chopped and retrained
baseB
selffer BnB
selffer BnB$^+$
transfer AnB


0.66
0.64
0.62
0.60
0.58
0.56
0.54
0.52
Top-1 accuracy (higher is better)
0
1
2
3
4
5
6
7
Layer n at which network is chopped and retrained
baseB
selffer BnB
selffer BnB$^+$
transfer AnB
transfer AnB$^+$


0.66
0.64
0.62
0.60
0.58
0.56
0.54
0.52
Top-1 accuracy (higher is better)
0
1
2
3
4
5
6
7
Layer n at which network is chopped and retrained
baseB
selffer BnB
selffer BnB$^+$
transfer AnB
transfer AnB$^+$


Transfer + fine-tuning improves generalization
Top-1 accuracy (higher is better)
0.66
0.64
0.62
0.60
0.58
0.56
0.54
0.52
0
1
2
3
4
5
6
7
Layer n at which network is chopped and retrained
baseB
selffer BnB
selffer BnB$^+$
transfer AnB
transfer AnB$^+$

ImageNet has many related categories...

Dataset A: random

gecko

fire truck

baseball

panther

rabbit

gorilla

Dataset B: random

garbage truck

toucan

radiator

binoculars

lion

bookshop

ImageNet has many related categories...

Dataset A: man-made

garbage truck

fire truck

radiator

baseball

binoculars

bookshop

Dataset B: natural

gorilla

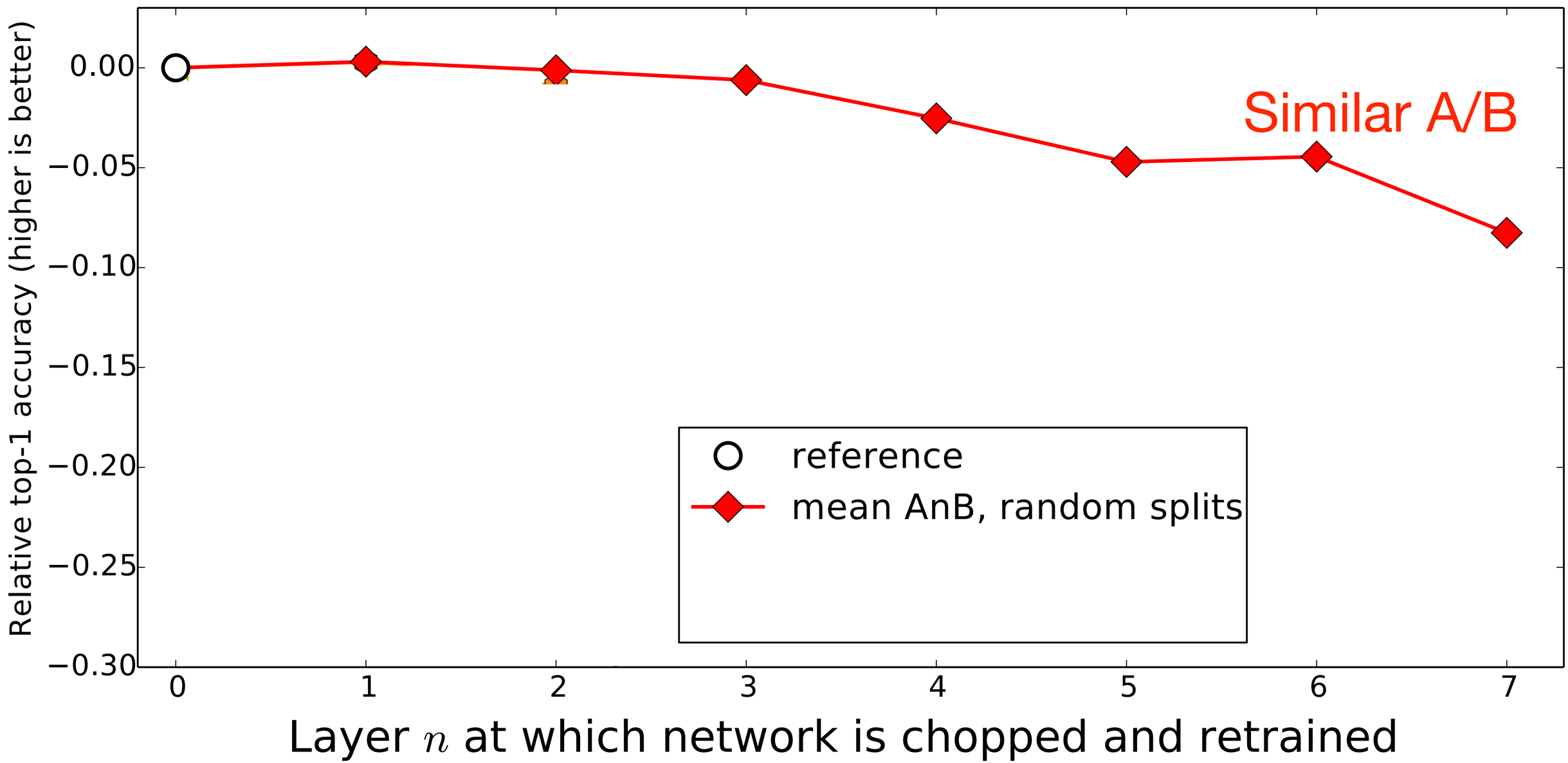
gecko

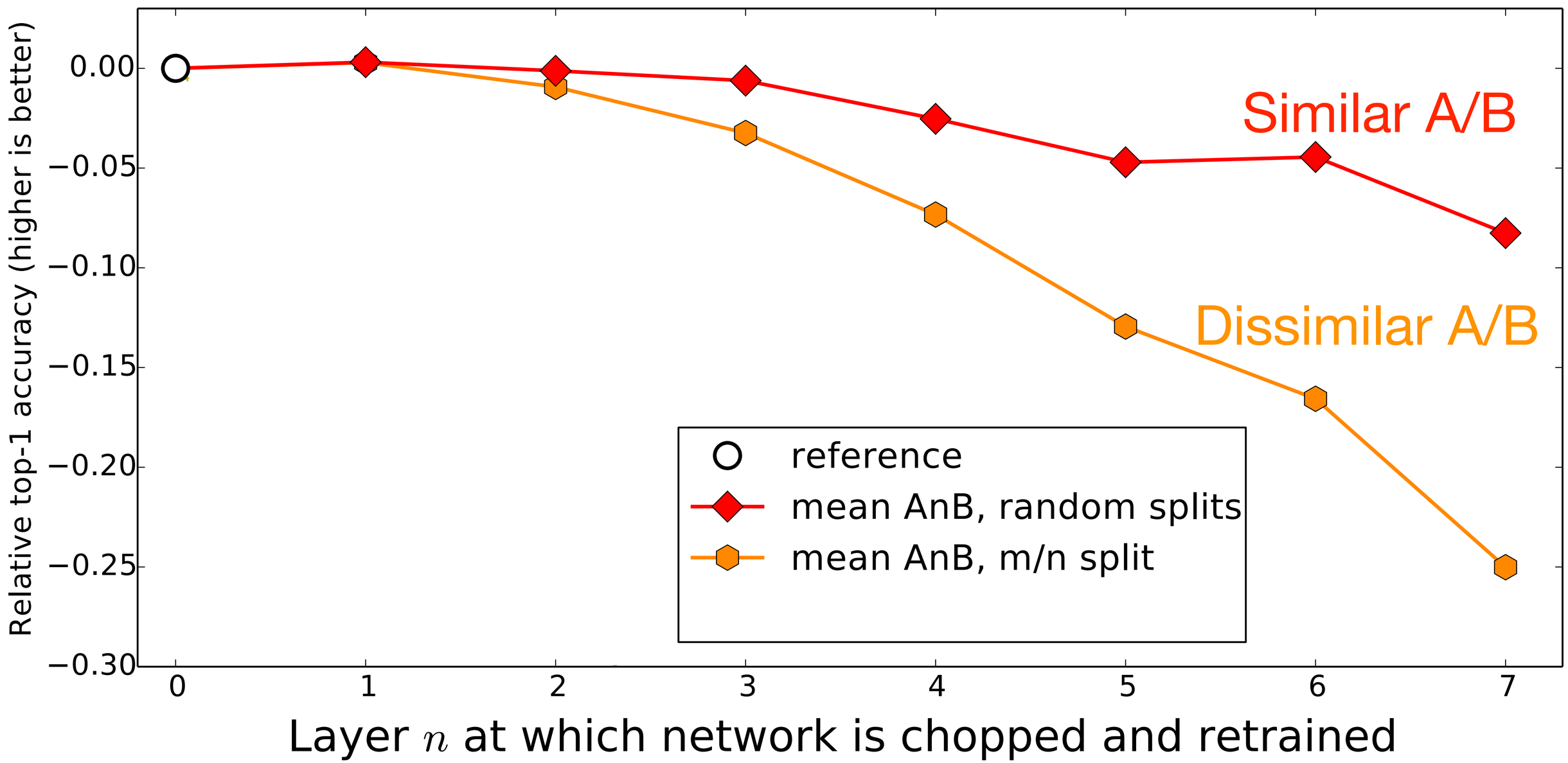
toucan

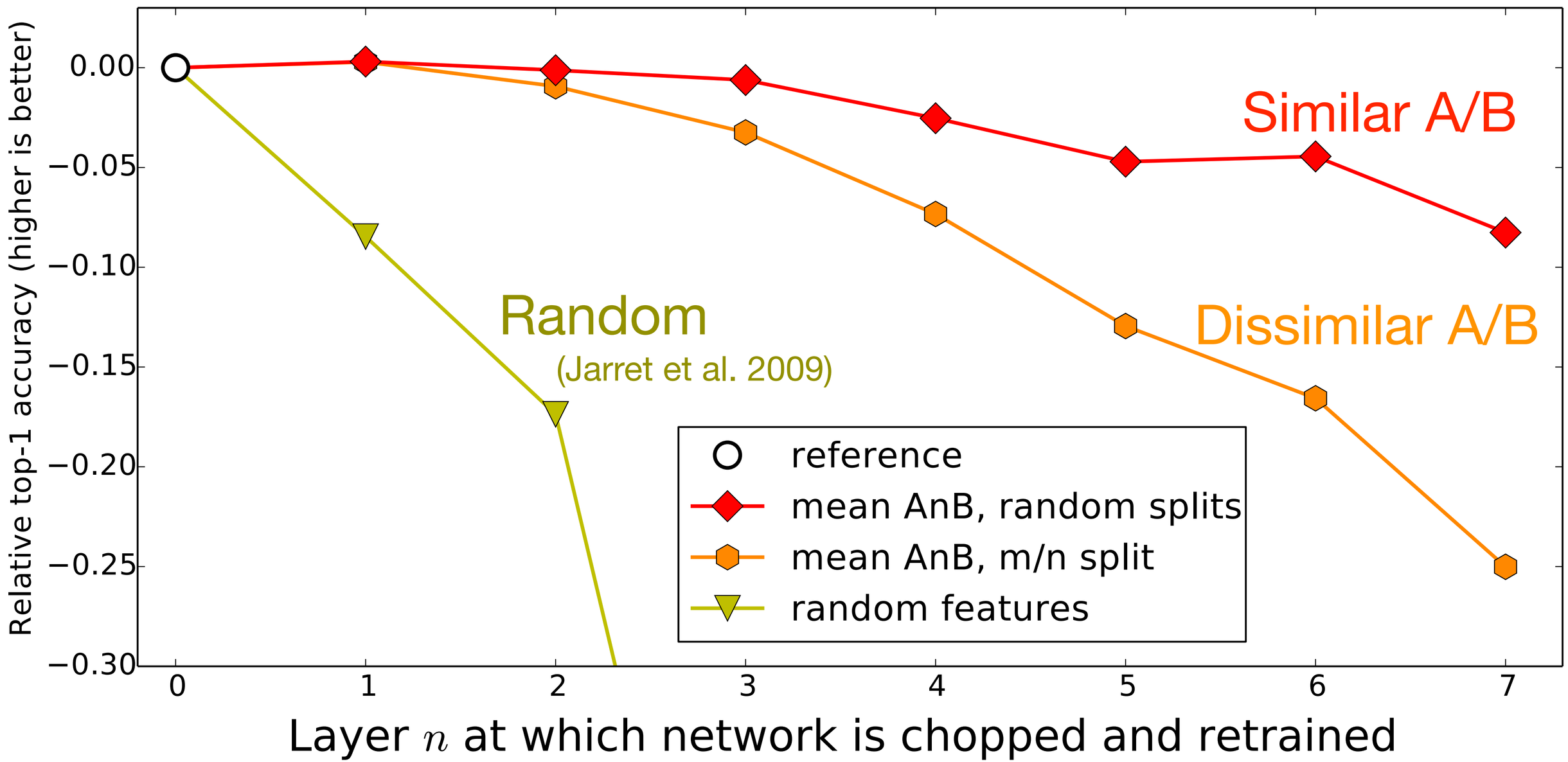
rabbit

panther

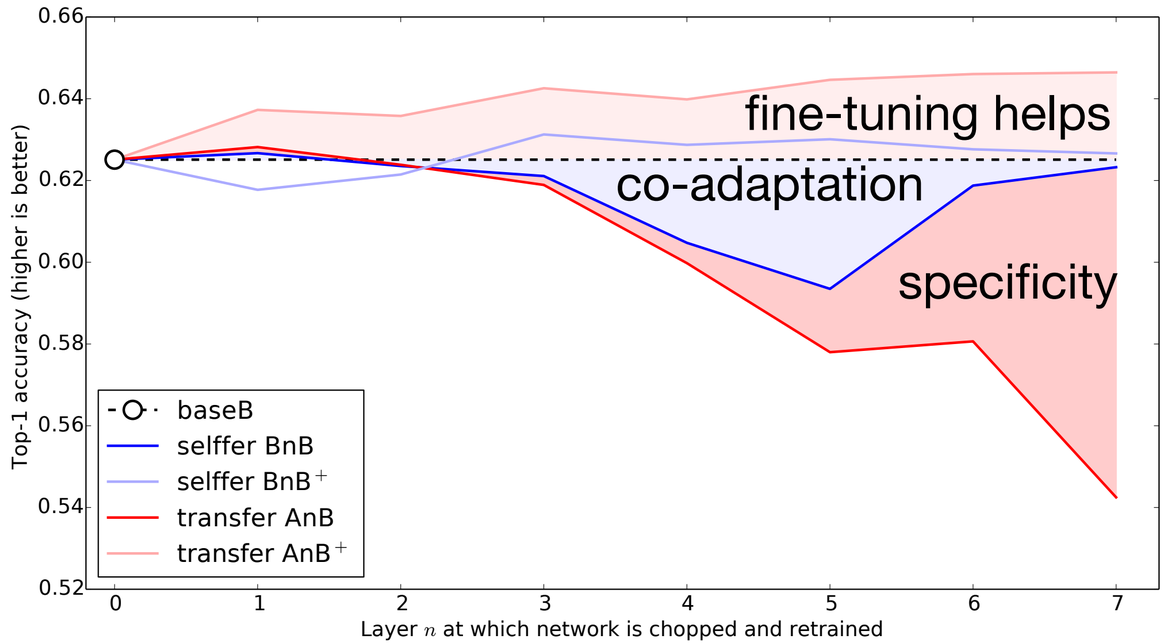
lion

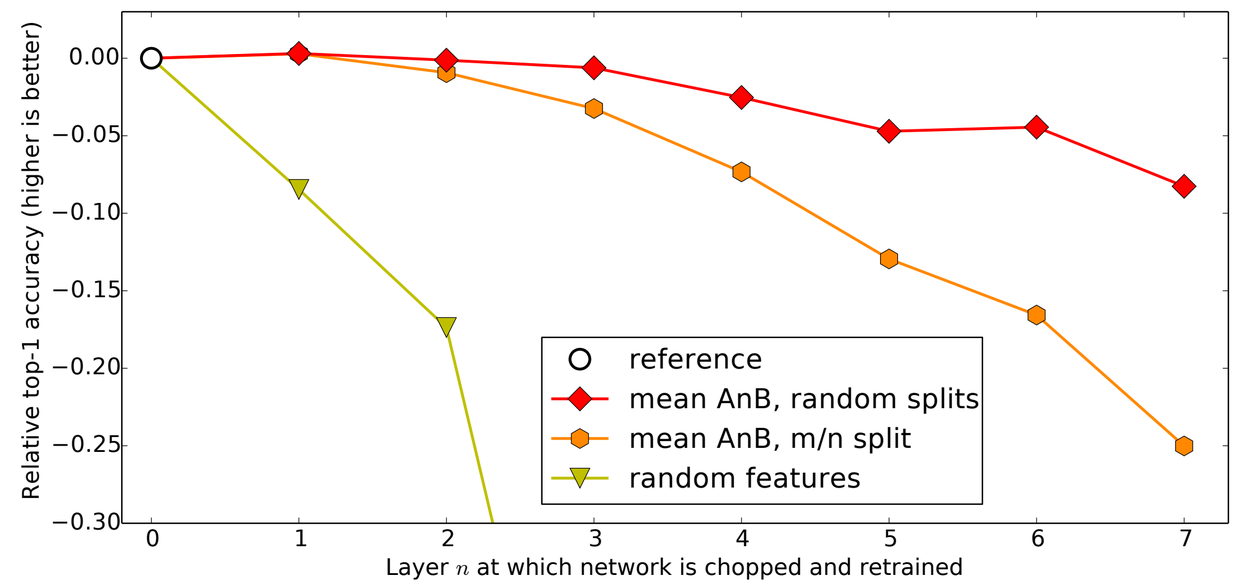

Similar A/B
reference
mean AnB, random splits
Relative top-1 accuracy (higher is better)
0.00
−0.05
−0.10
−0.15
−0.20
−0.25
−0.30
0
1
2
3
4
5
6
7
Layer n at which network is chopped and retrained


Relative top-1 accuracy (higher is better)
0.00
−0.05
−0.10
−0.15
−0.20
−0.25
−0.30
0
1
2
3
4
5
6
7
Layer n at which network is chopped and retrained
Similar A/B
Dissimilar A/B
reference
mean AnB, random splits
mean AnB, m/n split

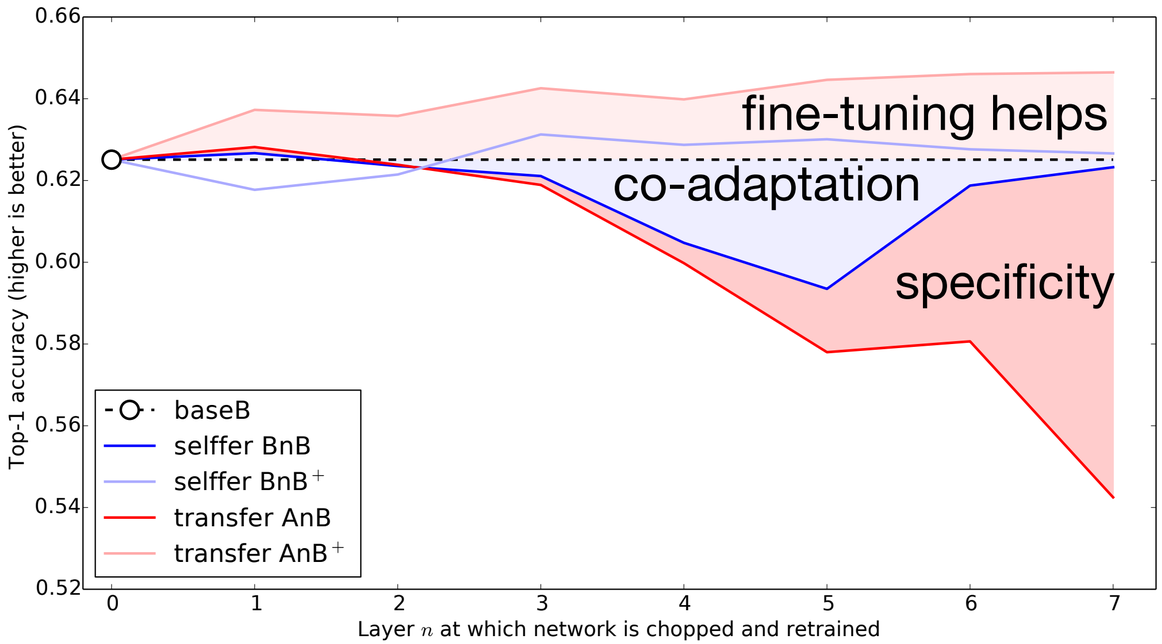

Relative top-1 accuracy (higher is better)
0.00
−0.05
−0.10
−0.15
−0.20
−0.25
−0.30
0
1
2
3
4
5
6
7
Layer n at which network is chopped and retrained
Similar A/B
Dissimilar A/B
Random
(Jarret et al. 2009)
reference
mean AnB, random splits
mean AnB, m/n split
random features

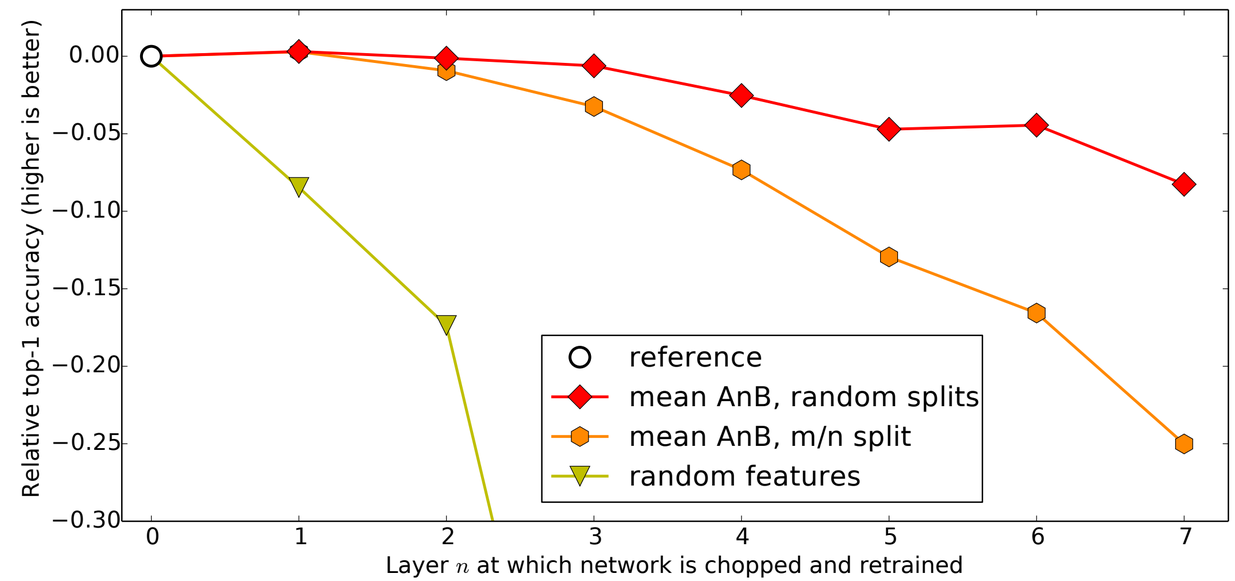
Conclusions





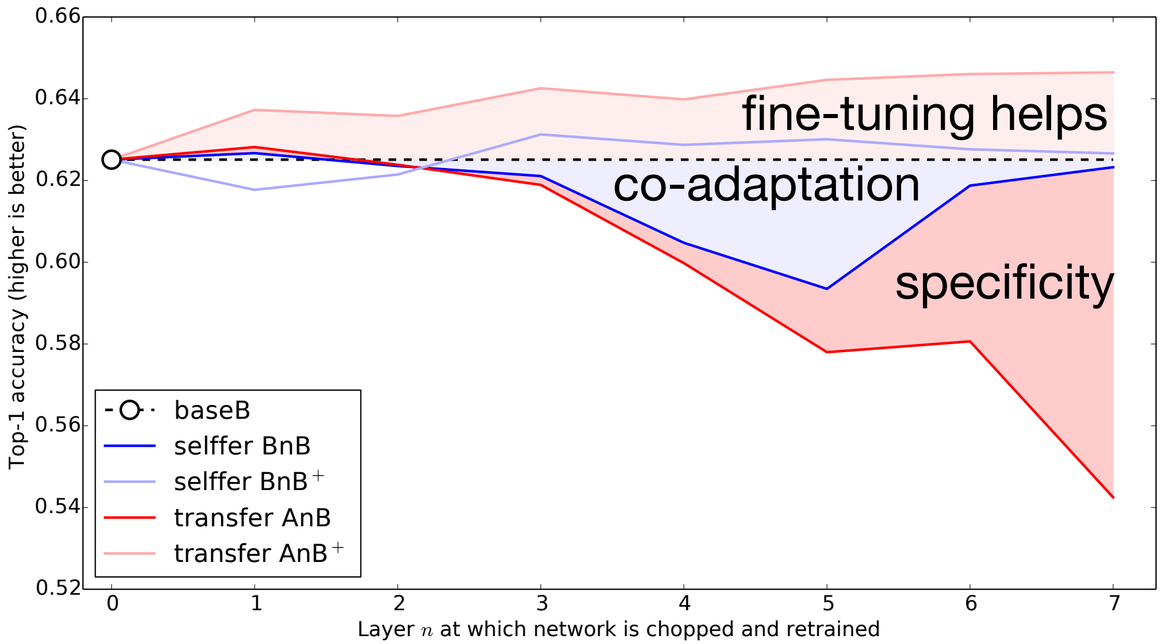
Conclusions

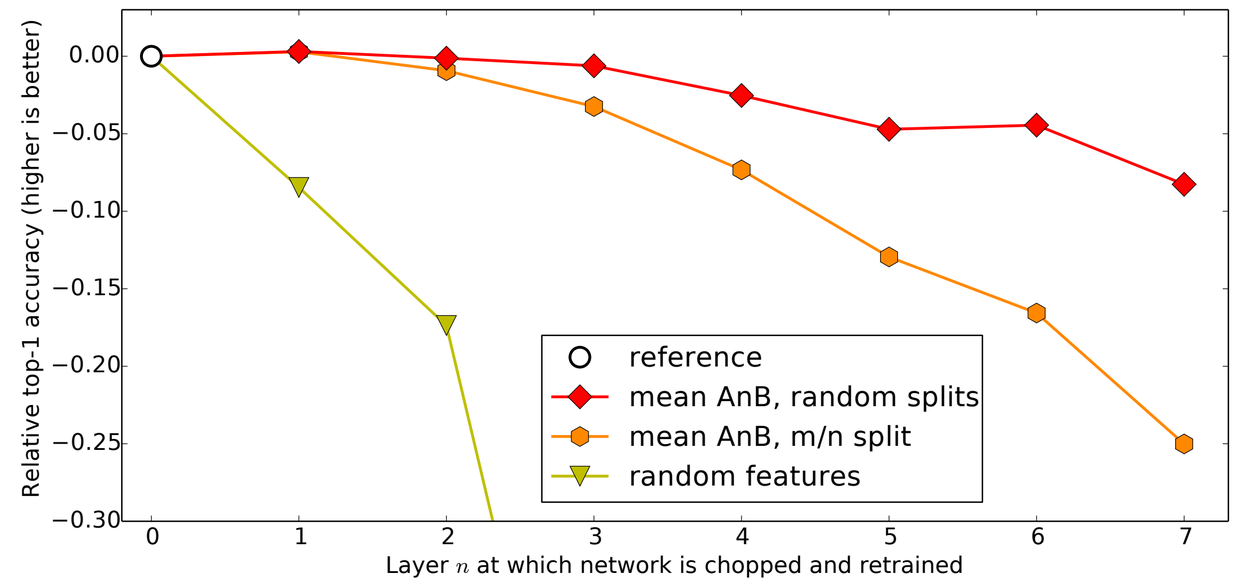




- Measure *general* to *specific* transition layer by layer

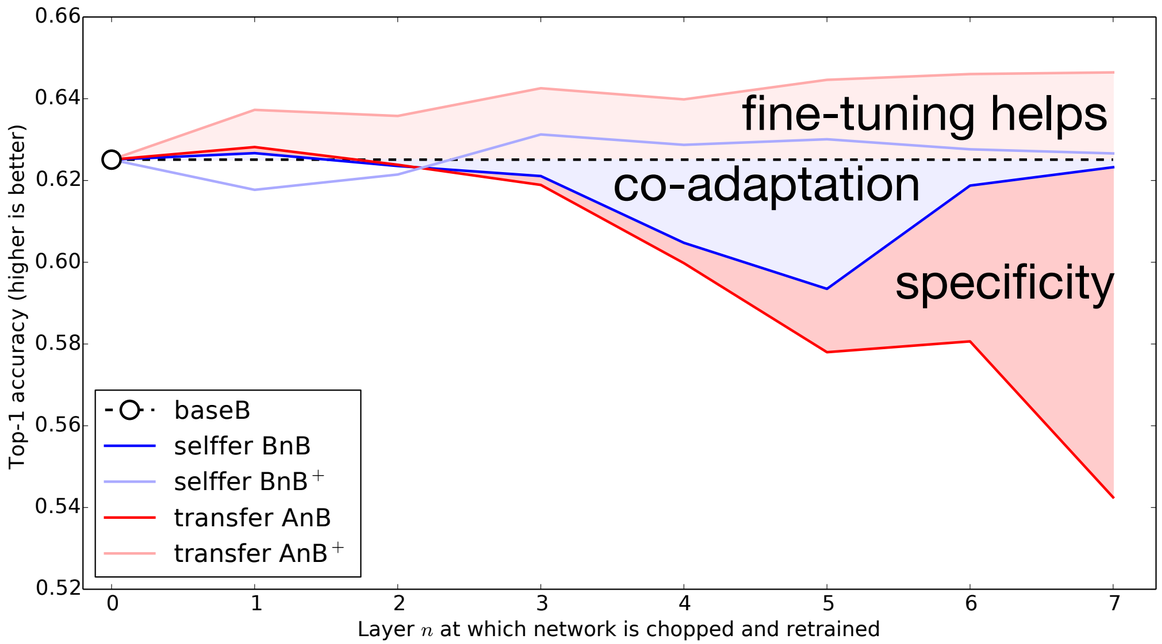
Conclusions

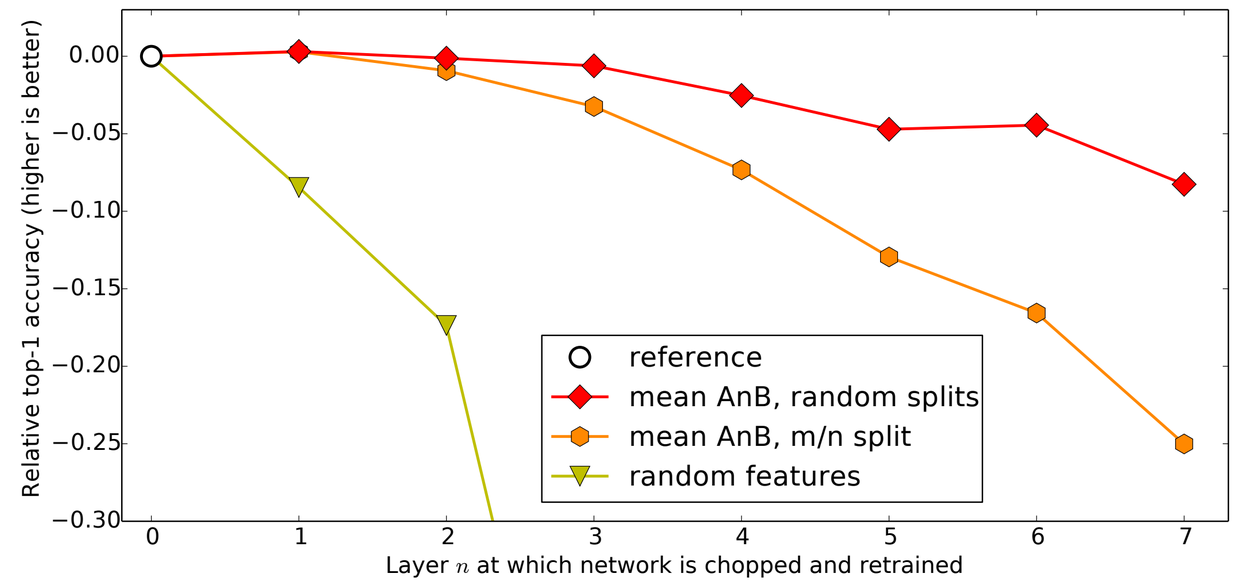




- Measure *general* to *specific* transition layer by layer
- Transferability governed by:

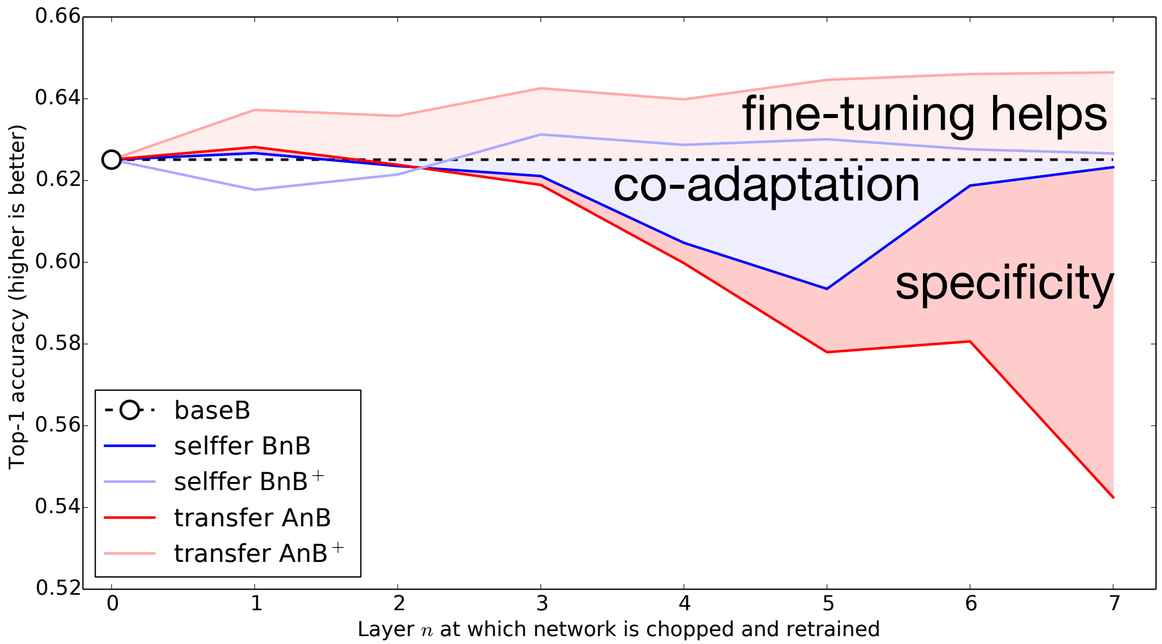
Conclusions

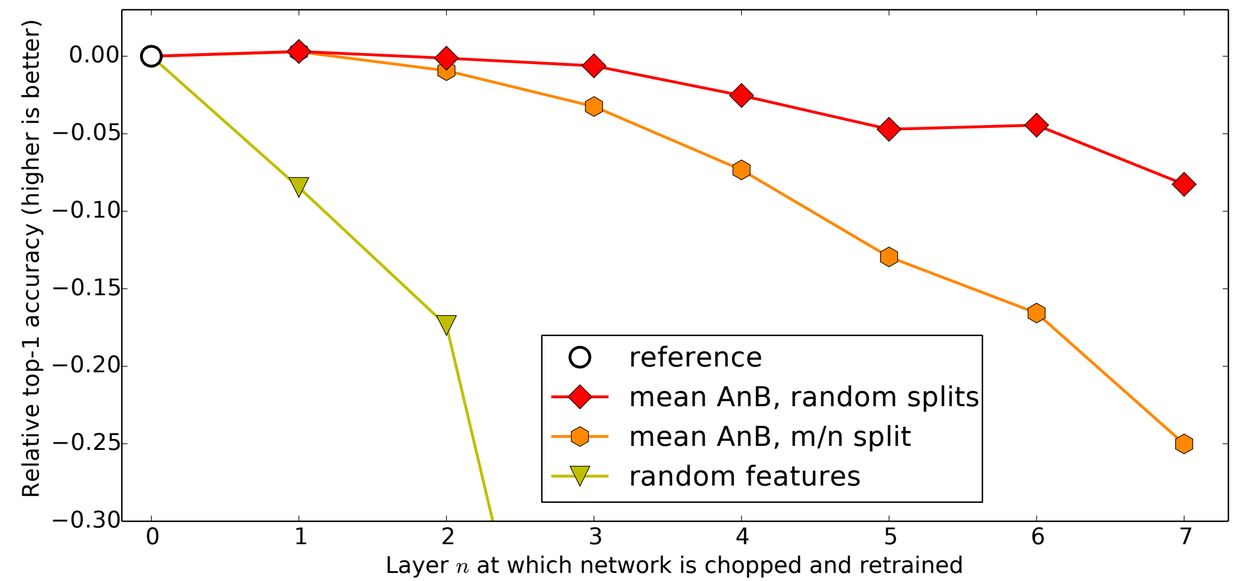




- Measure *general* to *specific* transition layer by layer
- Transferability governed by:
  - lost co-adaptations

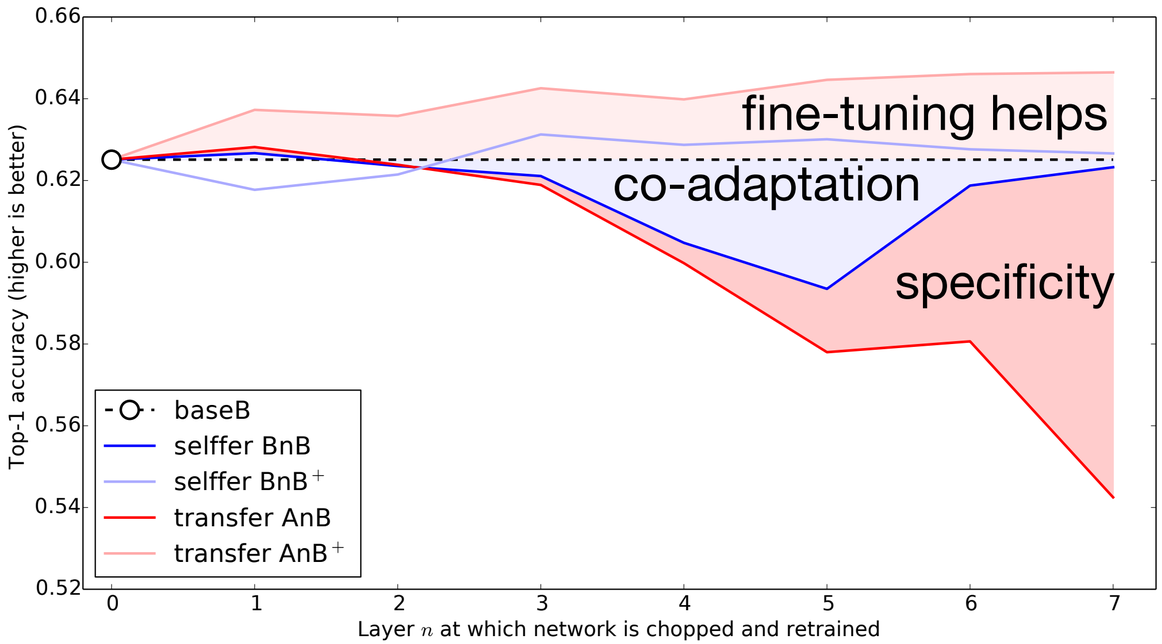
Conclusions

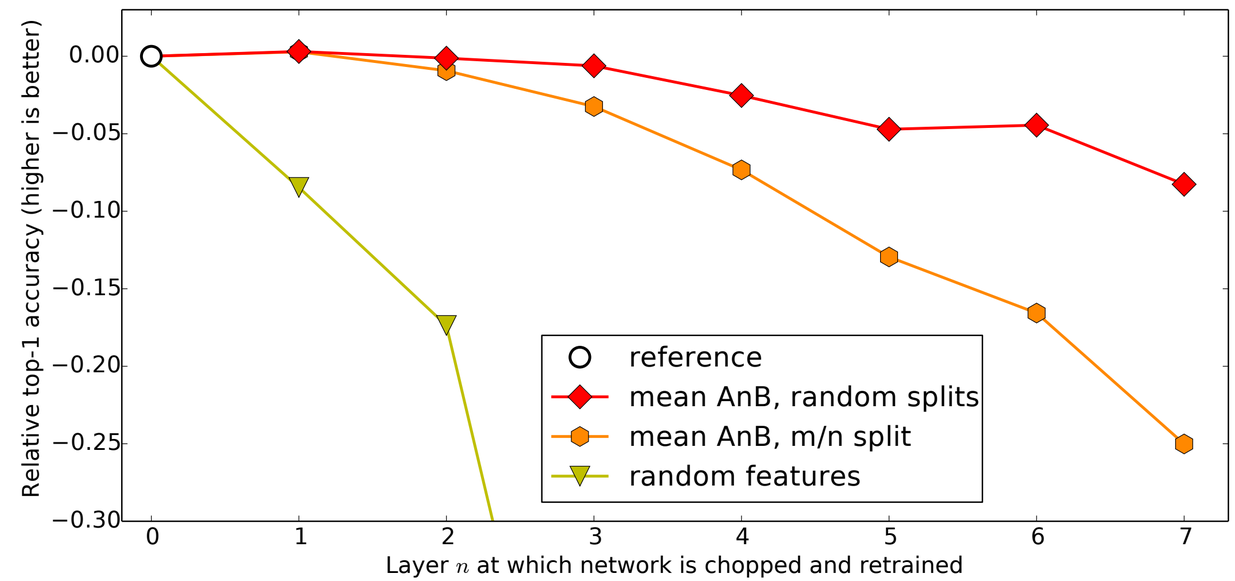




- Measure *general* to *specific* transition layer by layer
- Transferability governed by:
  - lost co-adaptations
  - specificity

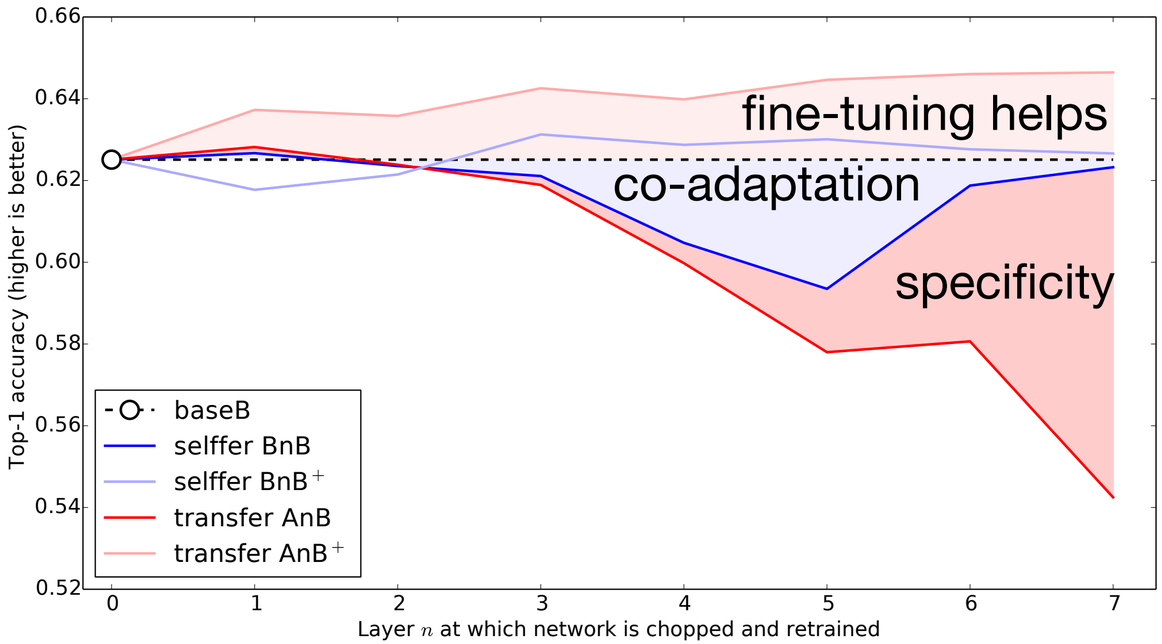
Conclusions

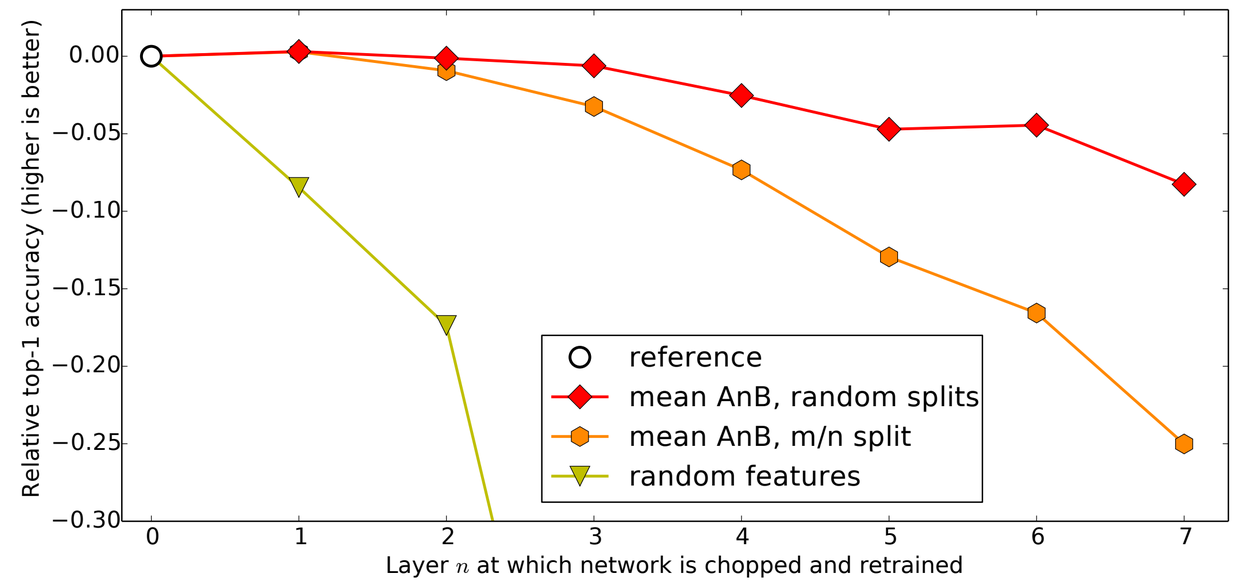




- Measure *general* to *specific* transition layer by layer
- Transferability governed by:
  - lost co-adaptations
  - specificity
  - difference between base and target dataset

Conclusions





- Measure *general* to *specific* transition layer by layer
- Transferability governed by:
  - lost co-adaptations
  - specificity
  - difference between base and target dataset
- Fine-tuning helps even on large target dataset