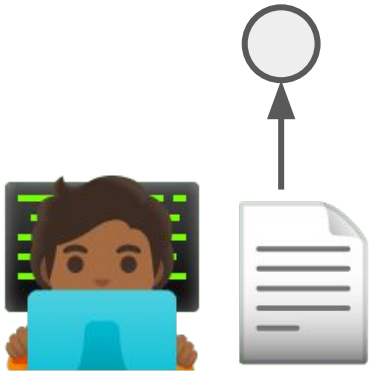
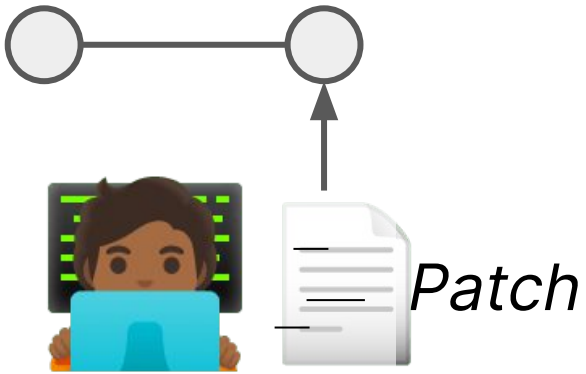
Infrastructure and Progress Towards the First Community-Built and Continually-Improved Model

Colin Raffel

Collaborative, Communal, Continual {CCC} ML

- Where are we in terms of making CCCML possible?
- We can build a useful VCS for CCCML now.
- We’re building a `git`-based VCS for CCCML.
- We’re building a CCC model to test it out.

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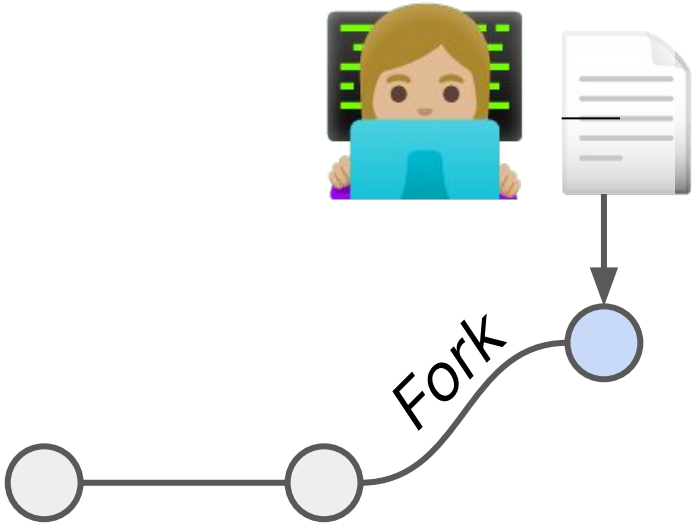
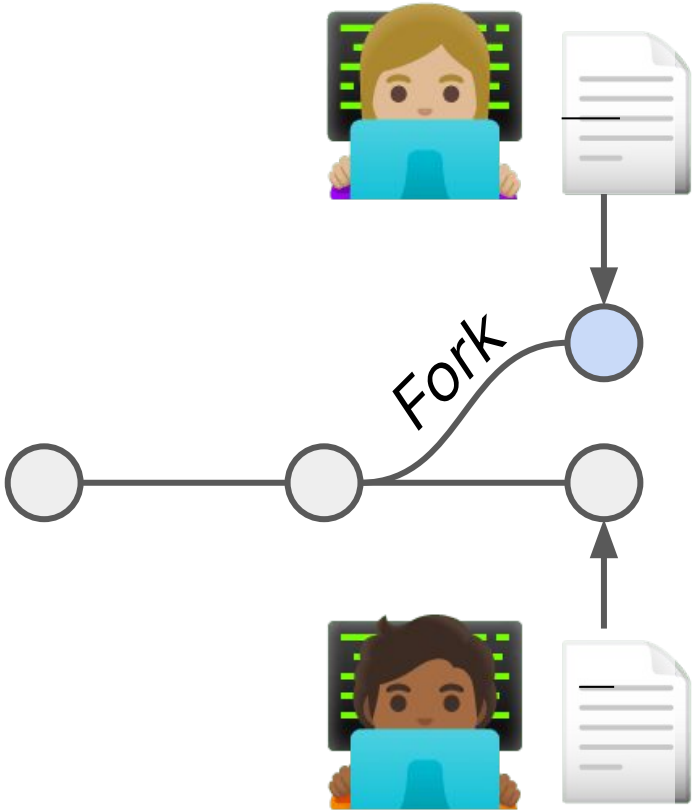

Fork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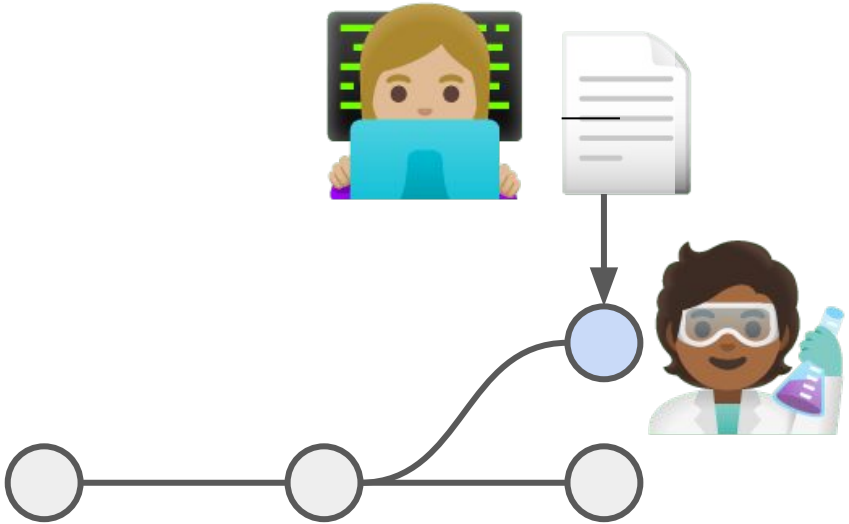
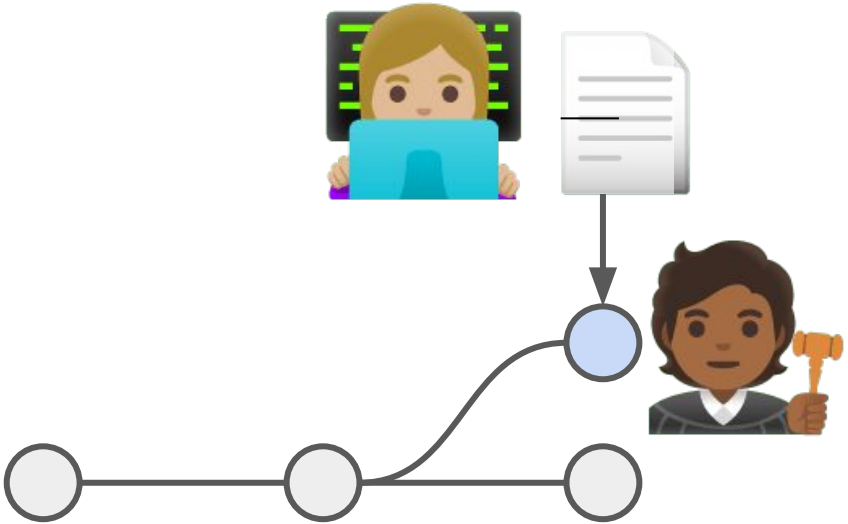
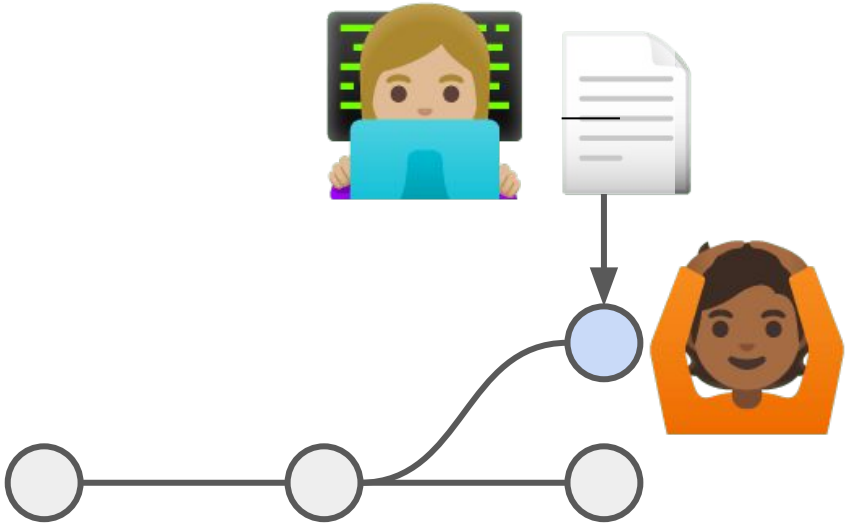
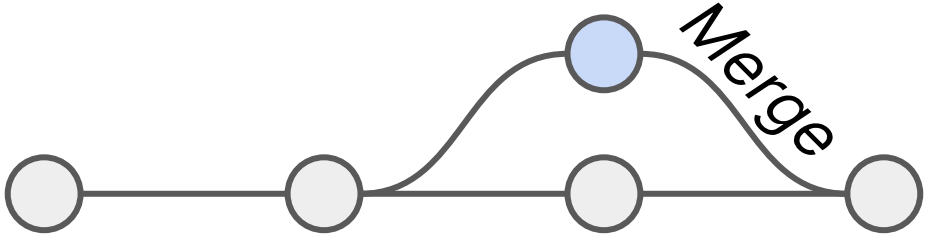
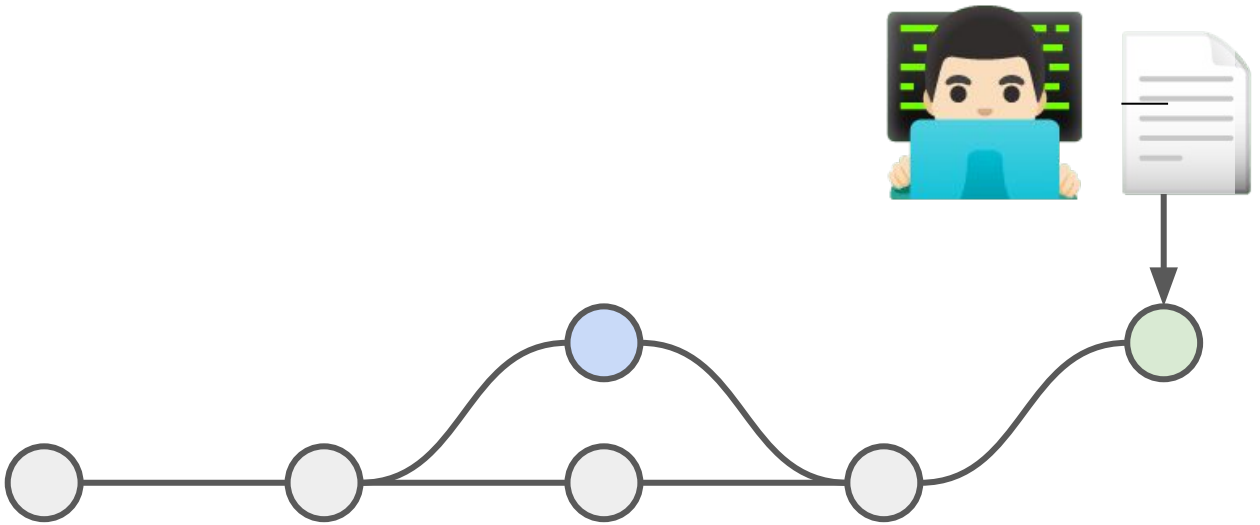
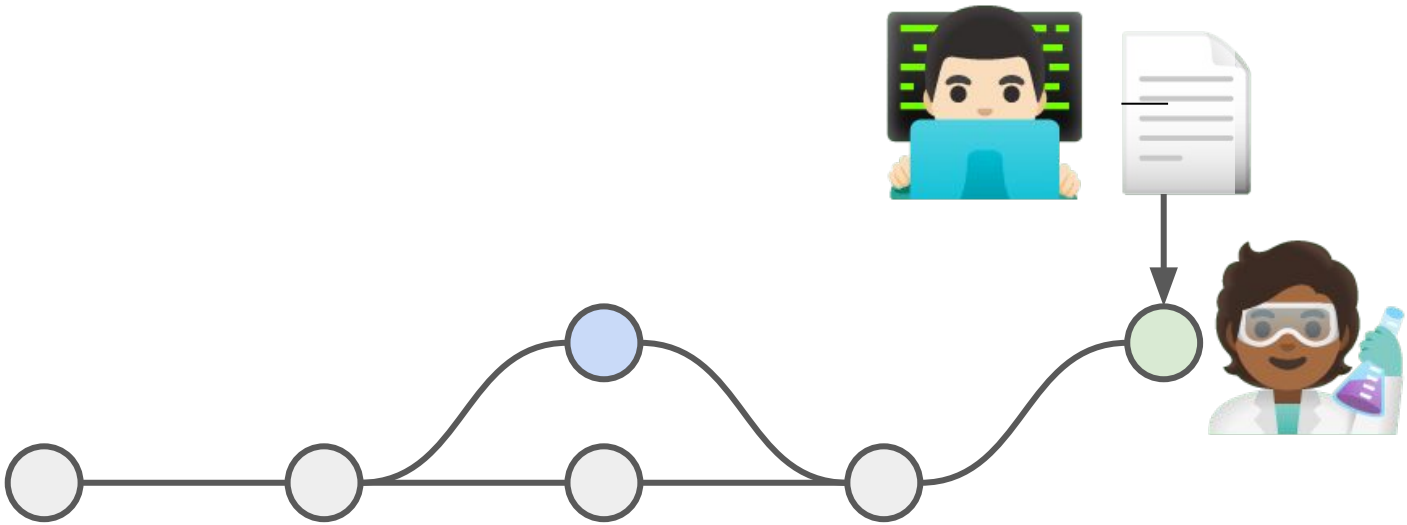


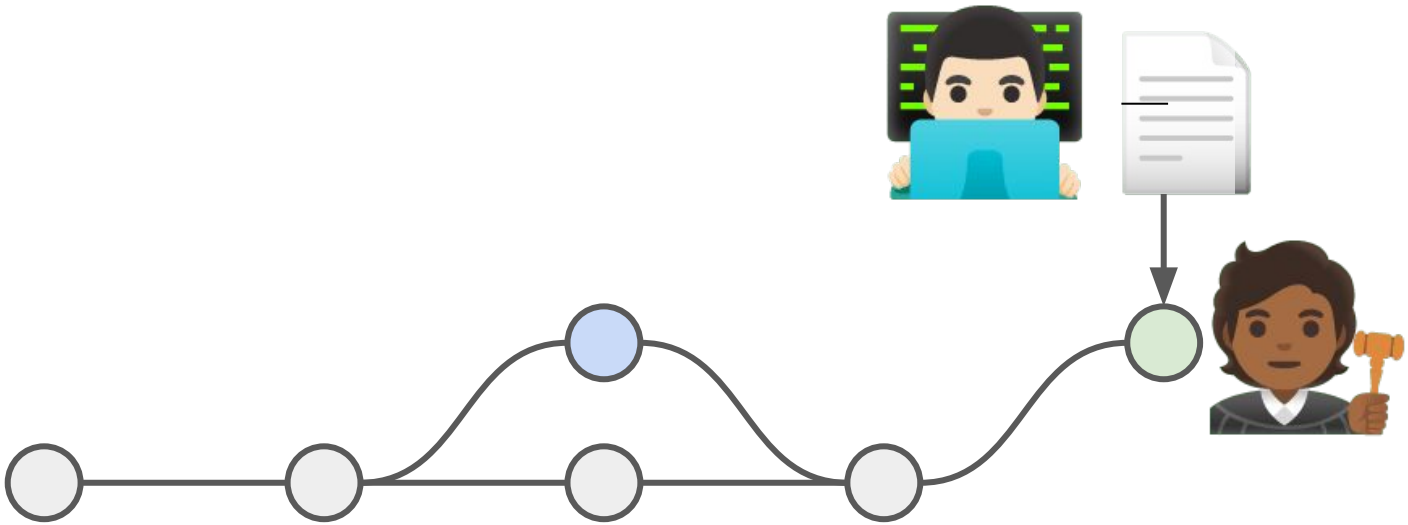


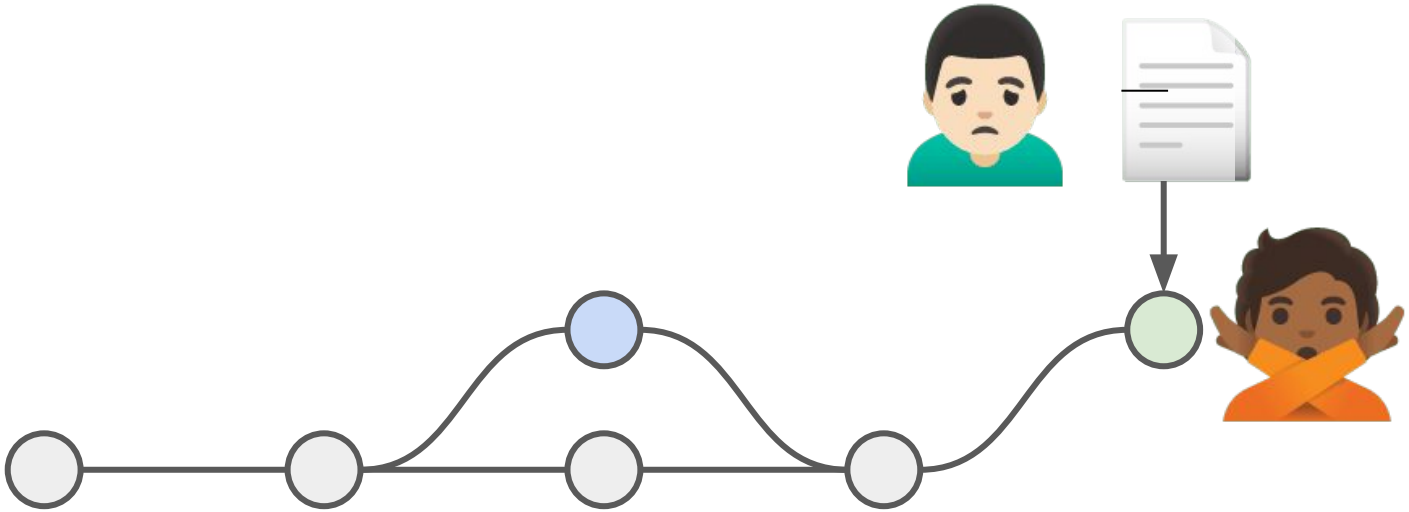


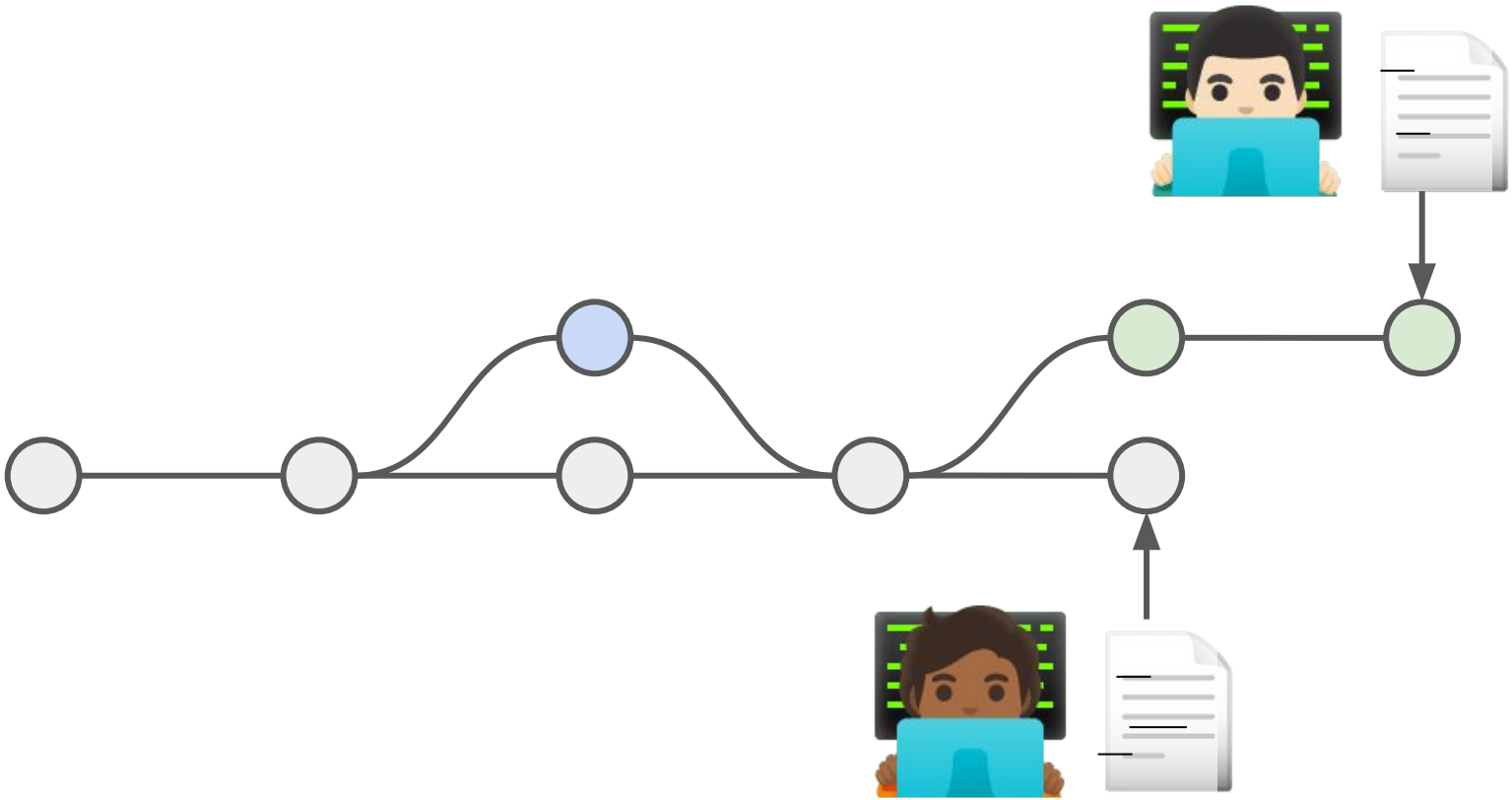

Merge

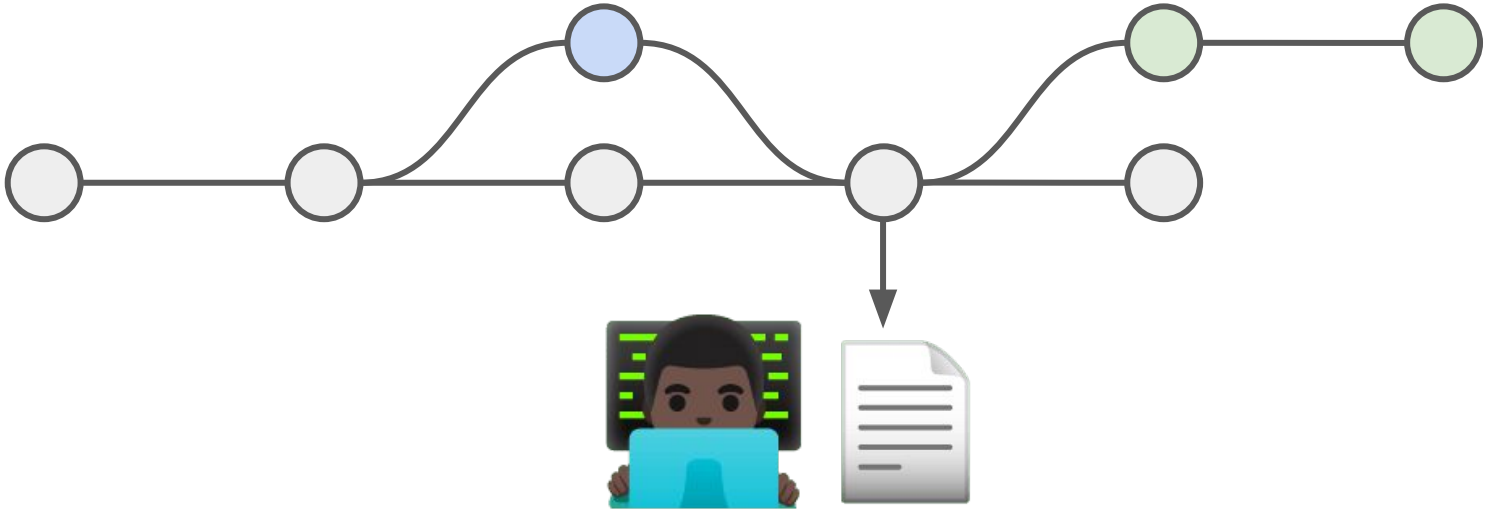








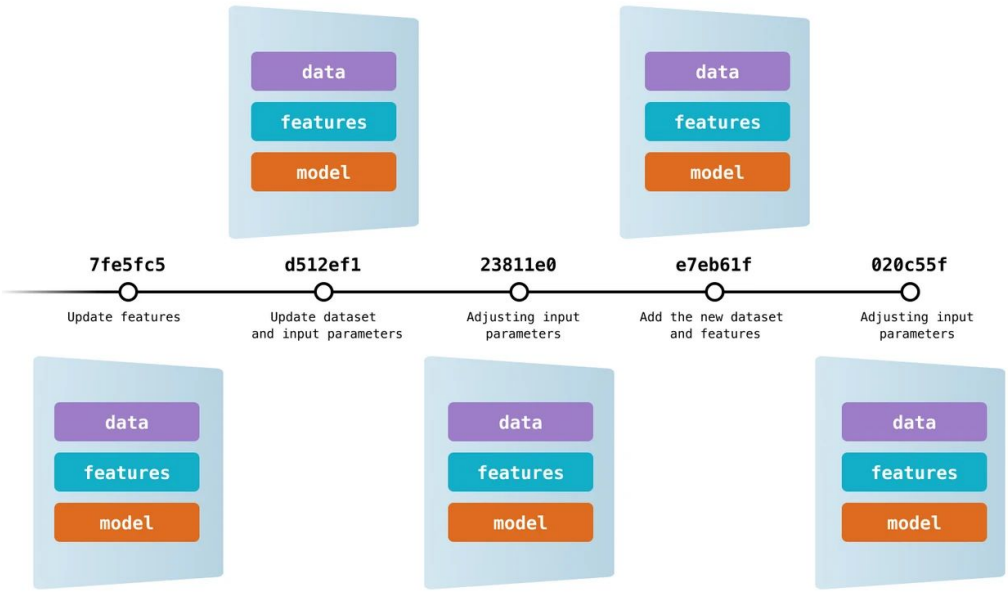


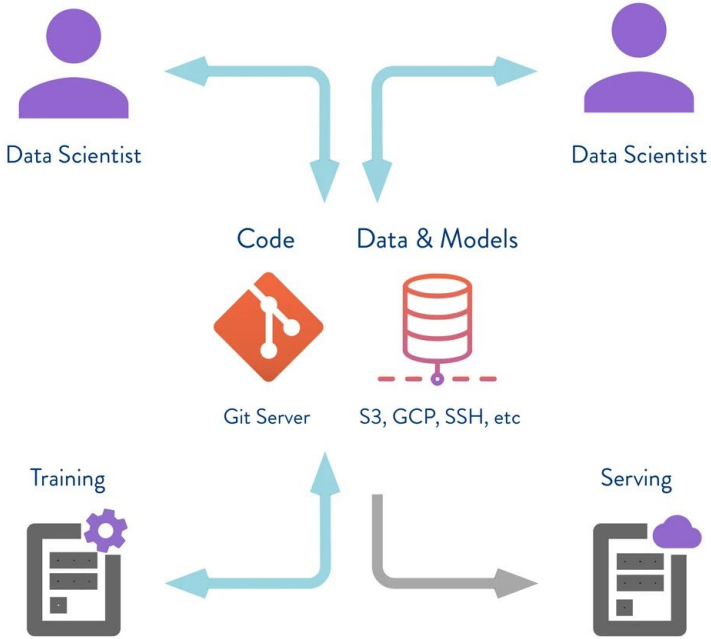


W&B

HUGGING FACE

comet





from https://dvc.org/

How can we enable collaborative and continual development of machine learning models?

We need to be able to cheaply communicate **patches** and **merge** updates from different contributors.

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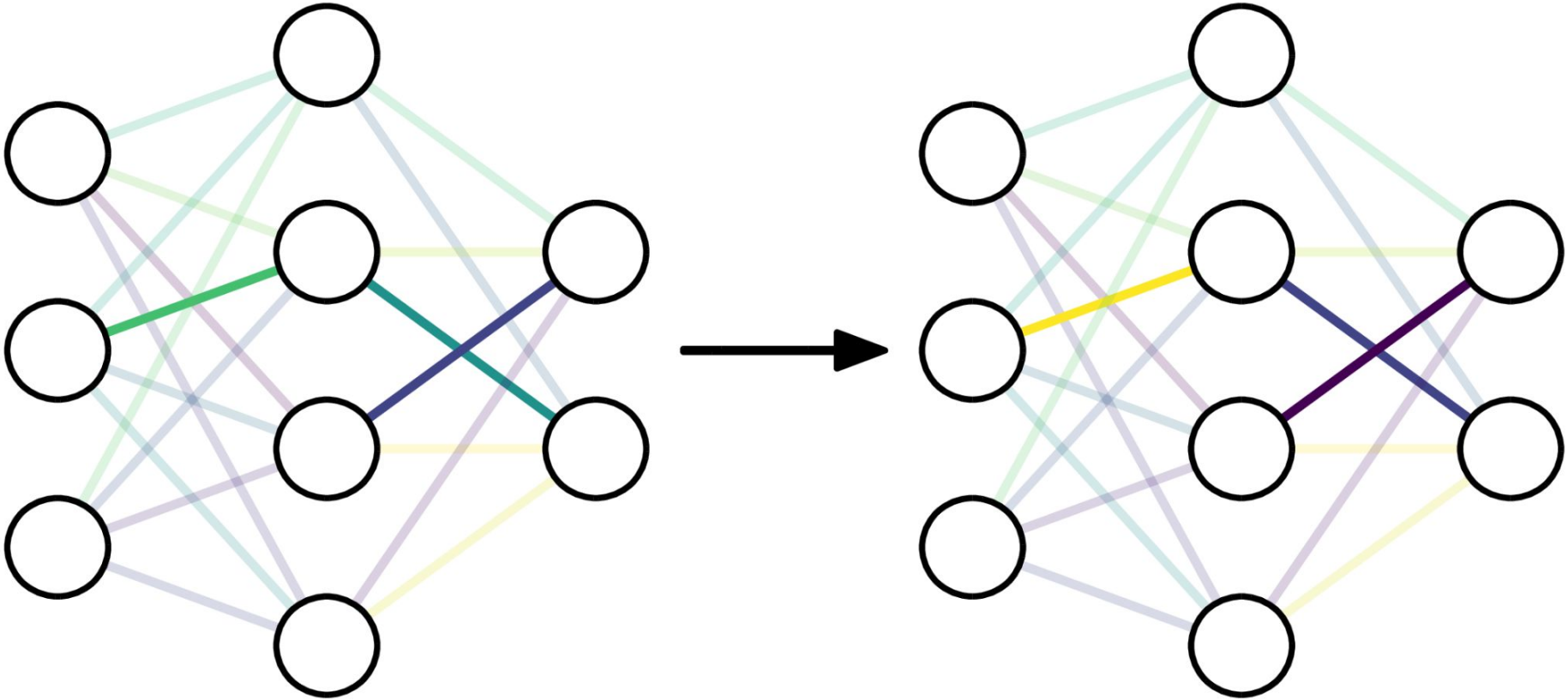
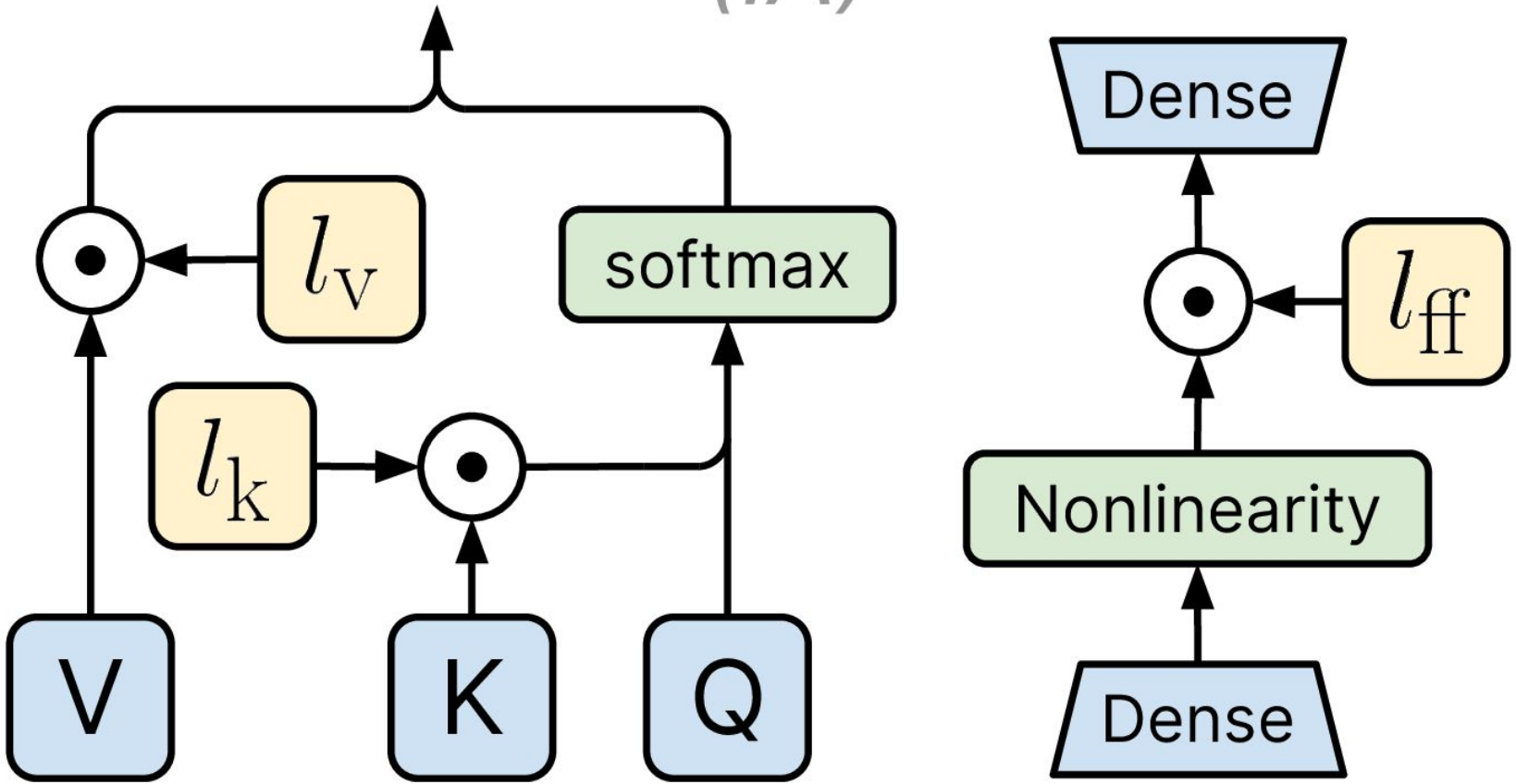


From *Training Neural Networks with Fixed Sparse Masks* by Sung et al.

$(IA)^3$



From *Few-Shot Parameter-Efficient Fine-Tuning is Better and Cheaper than In-Context Learning* by Liu et al.

$$\mathbf{h}_2^\ell = \text{Dropout}\left(\mathbf{W}_{m_1}^\ell \cdot \mathbf{h}_1^\ell + \mathbf{b}_{m_1}^\ell\right) \quad (1)$$

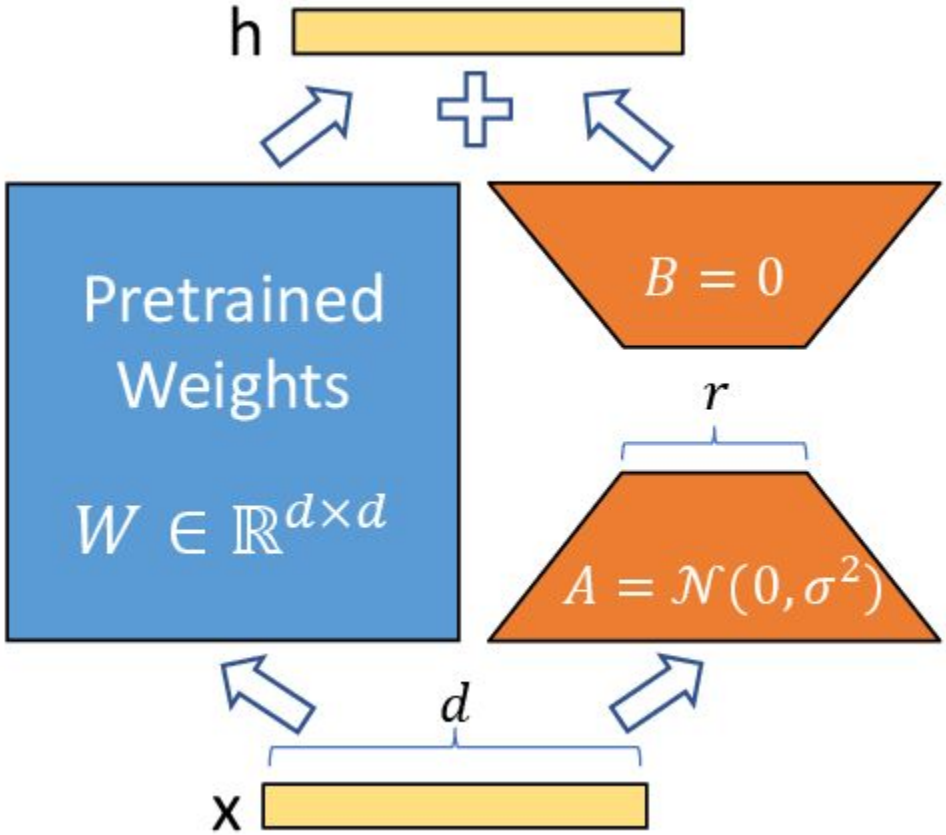
$$\mathbf{h}_3^\ell = \mathbf{g}_{LN_1}^\ell \odot \frac{(\mathbf{h}_2^\ell + \mathbf{x}) - \mu}{\sigma} + \mathbf{b}_{LN_1}^\ell \quad (2)$$

$$\mathbf{h}_4^\ell = \text{GELU}\left(\mathbf{W}_{m_2}^\ell \cdot \mathbf{h}_3^\ell + \mathbf{b}_{m_2}^\ell\right) \quad (3)$$

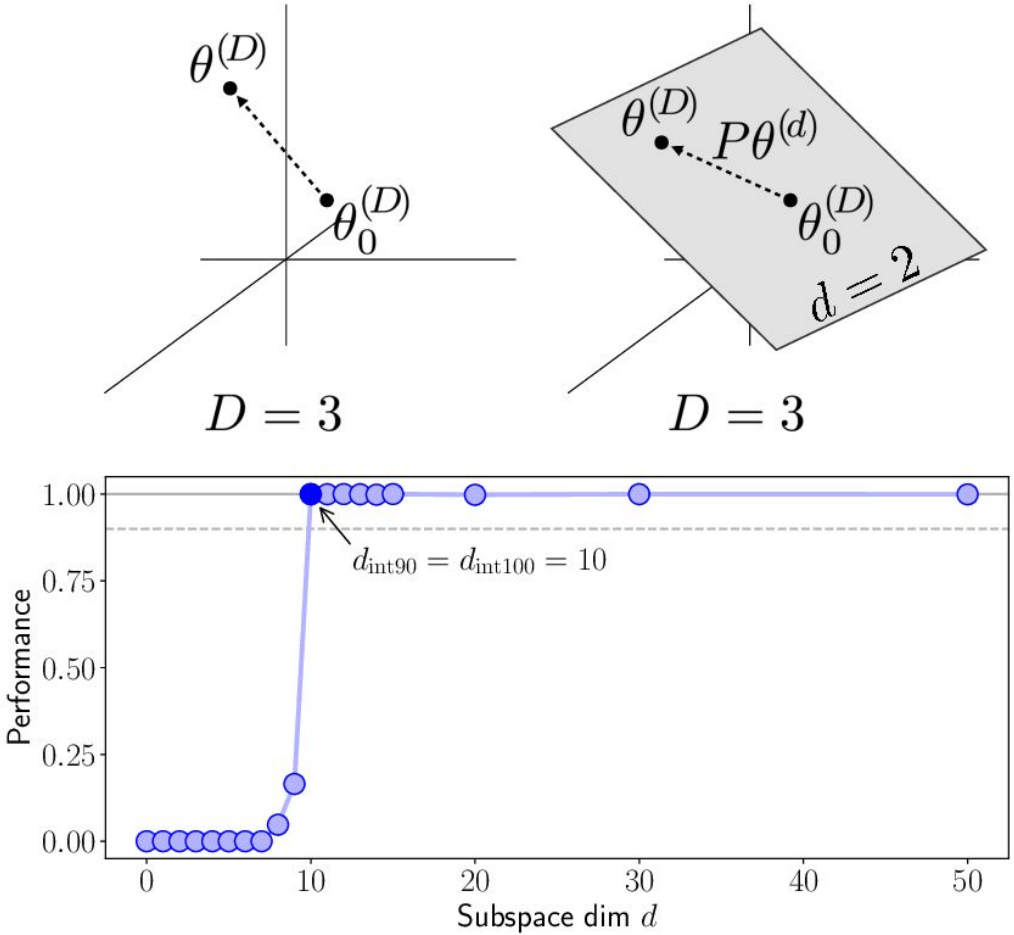
$$\mathbf{h}_5^\ell = \text{Dropout}\left(\mathbf{W}_{m_3}^\ell \cdot \mathbf{h}_4^\ell + \mathbf{b}_{m_3}^\ell\right) \quad (4)$$

$$\text{out}^\ell = \mathbf{g}_{LN_2}^\ell \odot \frac{(\mathbf{h}_5^\ell + \mathbf{h}_3^\ell) - \mu}{\sigma} + \mathbf{b}_{LN_2}^\ell \quad (5)$$

From *BitFit: Simple Parameter-efficient Fine-tuning for Transformer-based Masked Language-models* by Ben Zaken et al.



From *LoRA: Low-Rank Adaptation of Large Language Models* by Hu et al.



From *Measuring the Intrinsic Dimension of Objective Landscapes* by Li et al.

Algorithm 1: Sparse Ternary Compression (STC)

input: flattened tensor $T \in \mathbb{R}^n$, sparsity p

output: sparse ternary tensor $T^* \in \{-\mu, 0, \mu\}^n$

- $k \leftarrow \max(np, 1)$
- $v \leftarrow \text{top}_k(|T|)$
- $\text{mask} \leftarrow (|T| \geq v) \in \{0, 1\}^n$
- $T^{masked} \leftarrow \text{mask} \odot T$
- $\mu \leftarrow \frac{1}{k} \sum_{i=1}^{n} |T_i^{masked}|$

return $T^* \leftarrow \mu \times \text{sign}(T^{masked})$

From *Robust and Communication-Efficient Federated Learning from Non-IID Data* by Sattler et al.

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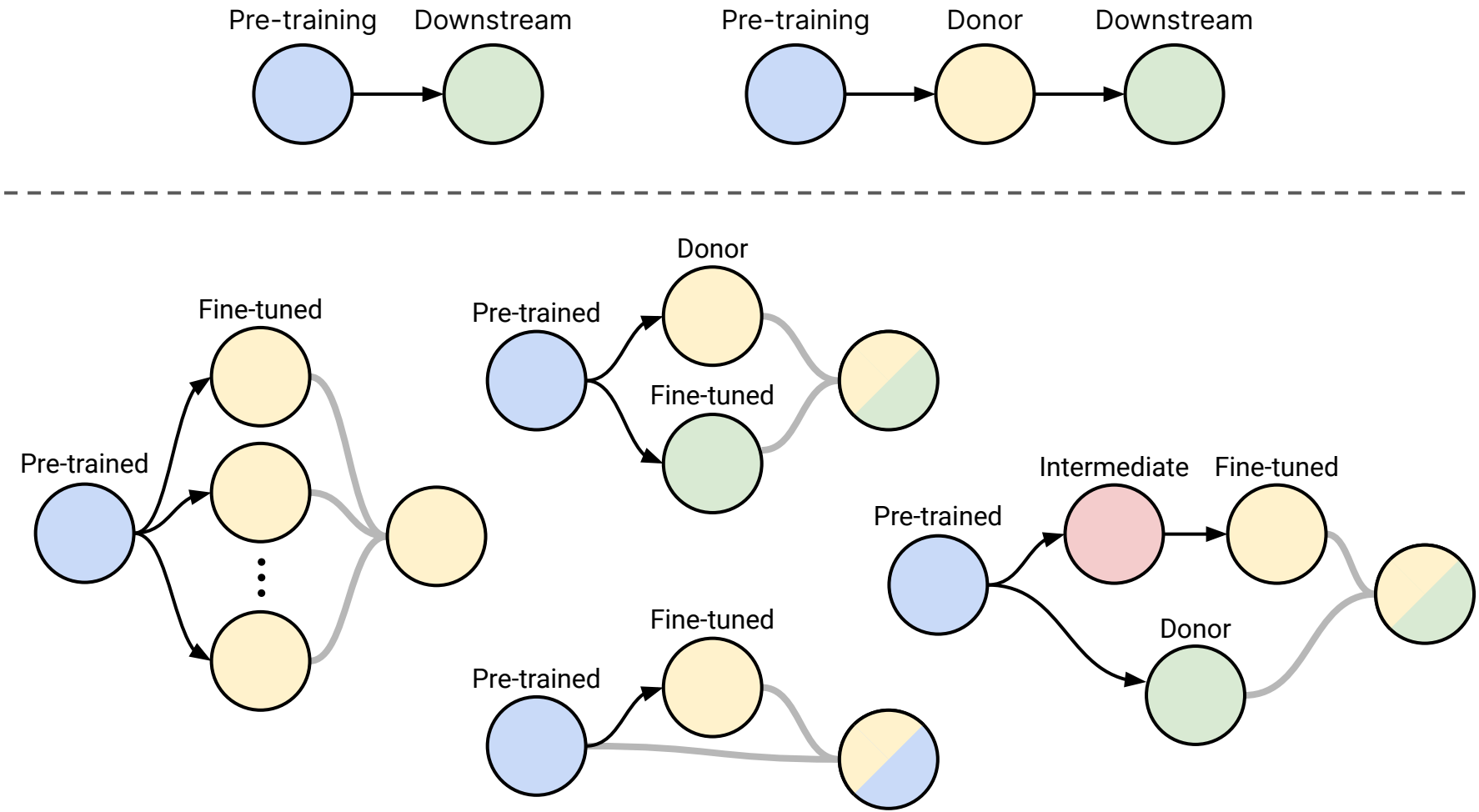
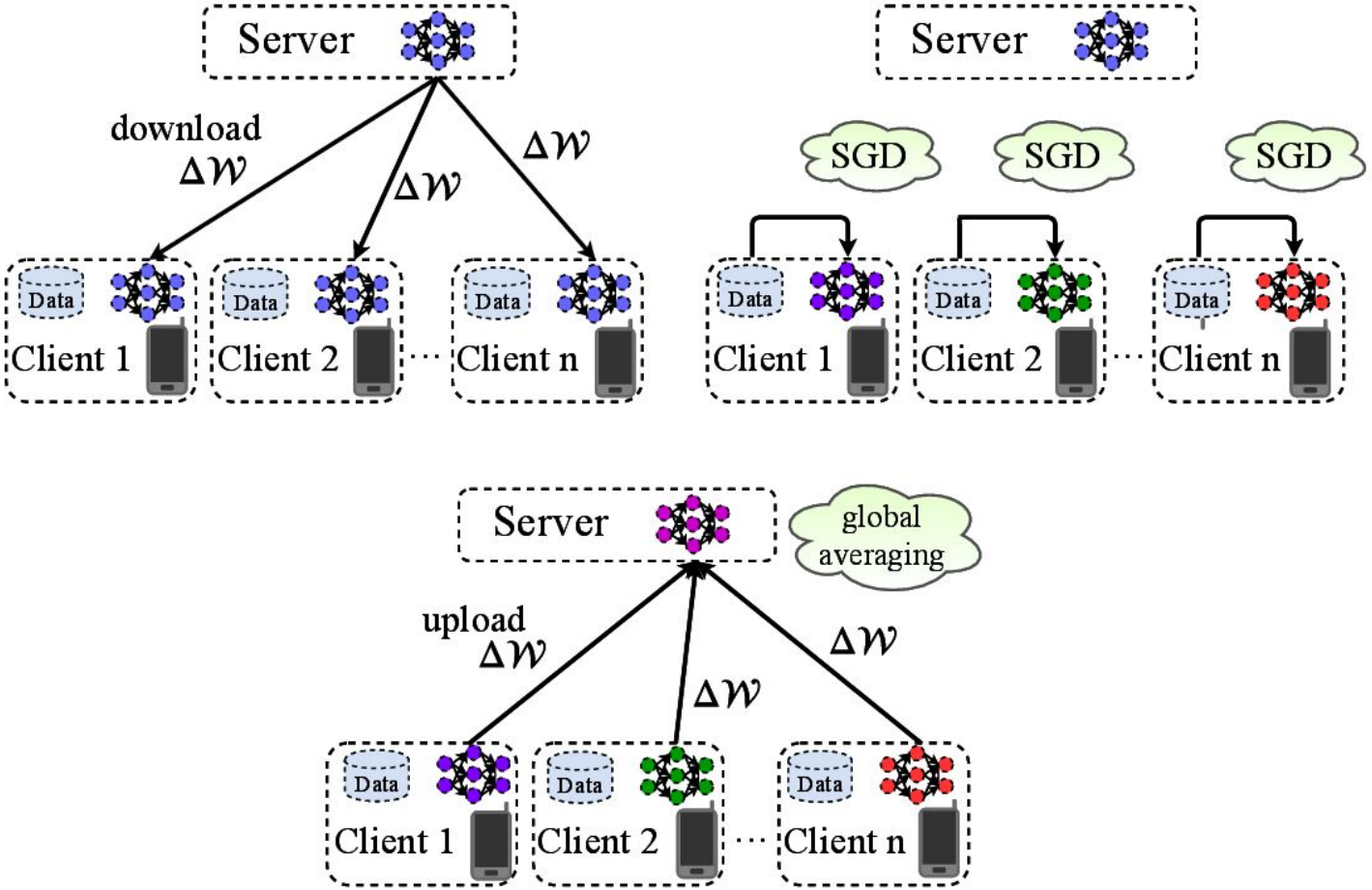


From *Merging Models with Fisher-Weighted Averaging* by Matena and Raffel



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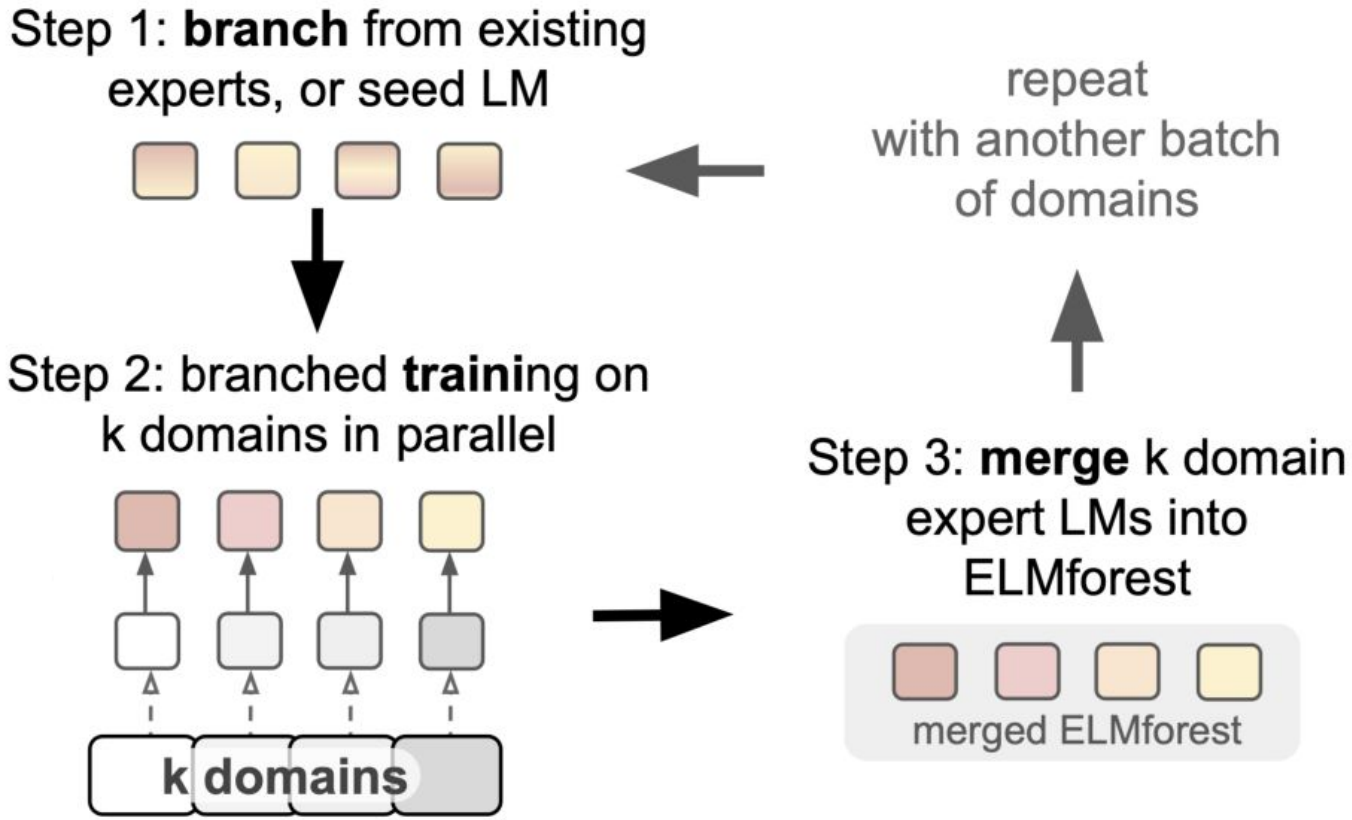
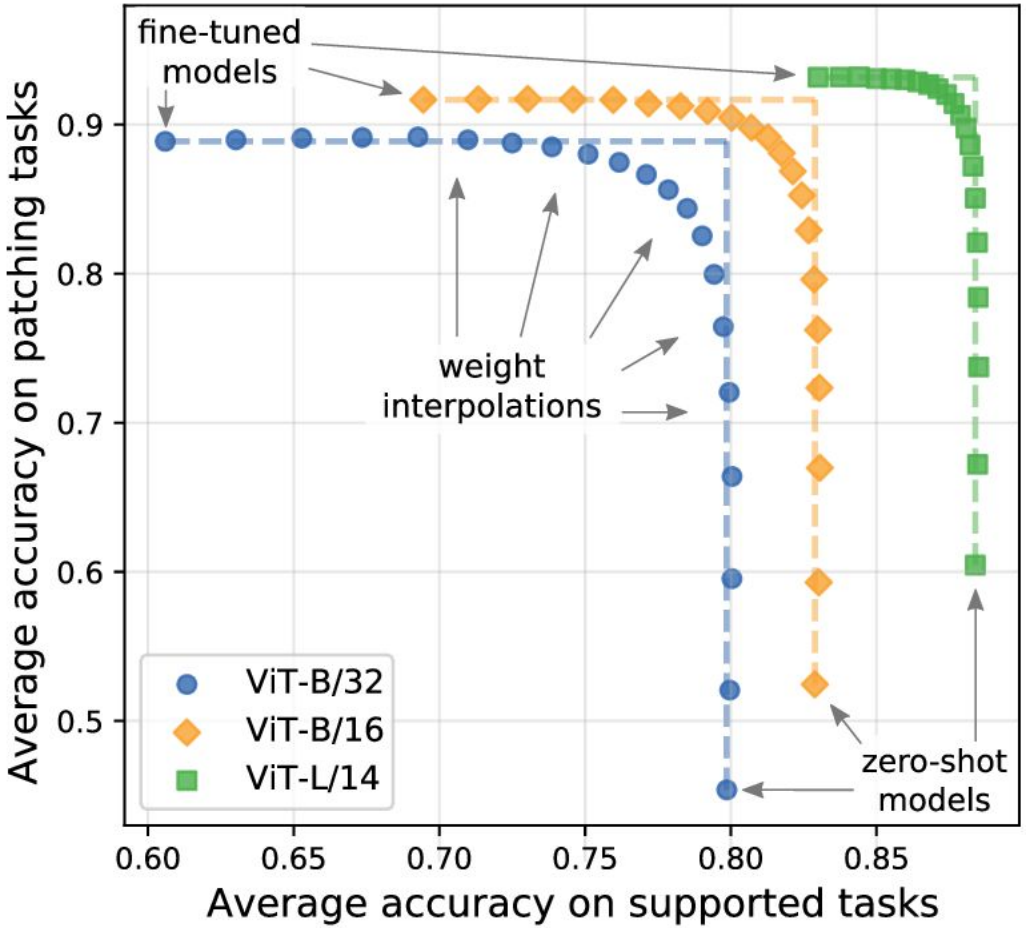
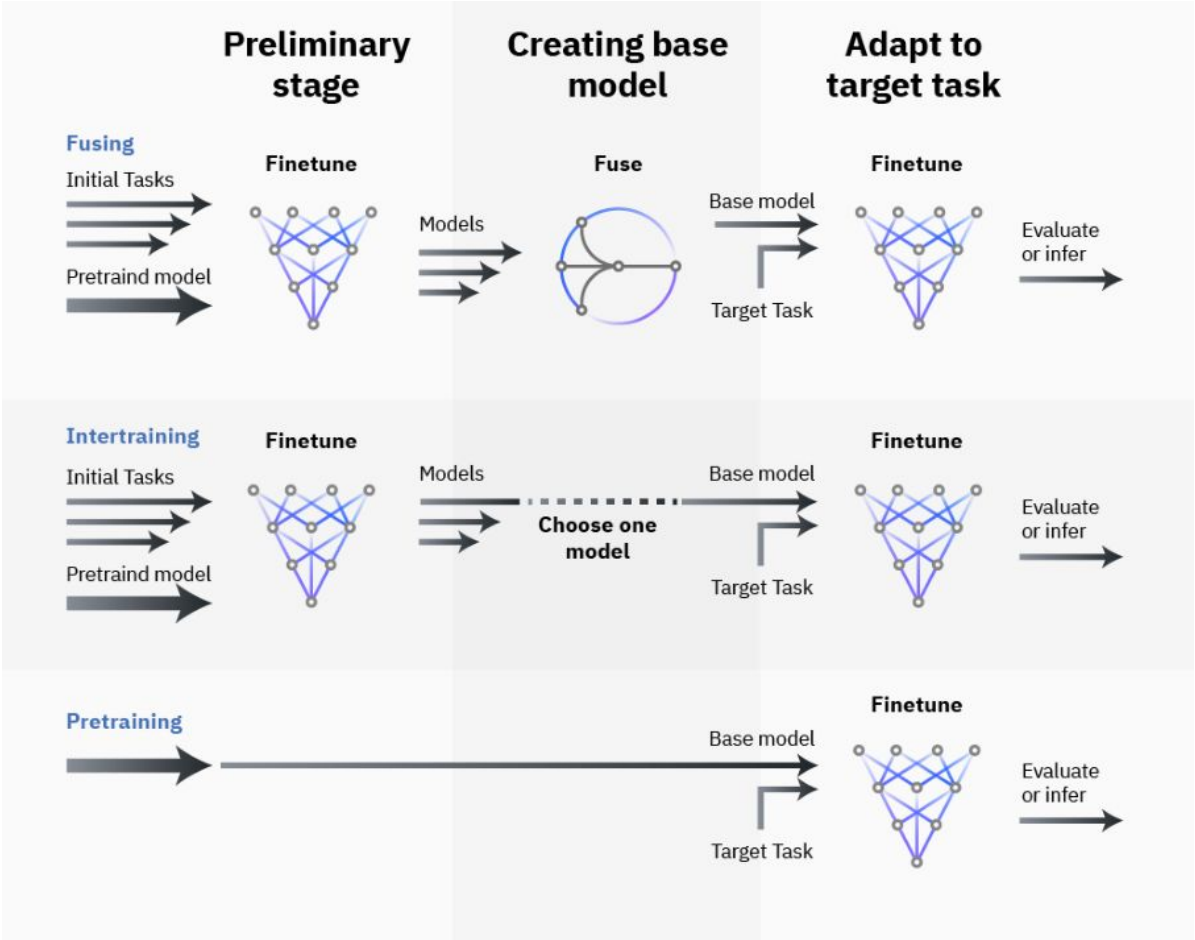


From *Branch-Train-Merge: Embarrassingly Parallel Training of Expert Language Models* by Li et al.



From *Patching open-vocabulary models by interpolating weights* by Ilharco et al.



From *Fusing finetuned models for better pretraining* by Choshen et al.

$$\arg\max_{\theta} \sum_{i=1}^{M} \lambda_i \log \mathcal{N}(\theta | \theta_i, \hat{F}_i^{-1})$$

$$\theta^{*(j)} = \frac{\sum_{i=1}^{M} \lambda_i \hat{F}_i^{(j)} \theta_i^{(j)}}{\sum_{i=1}^{M} \lambda_i \hat{F}_i^{(j)}}$$

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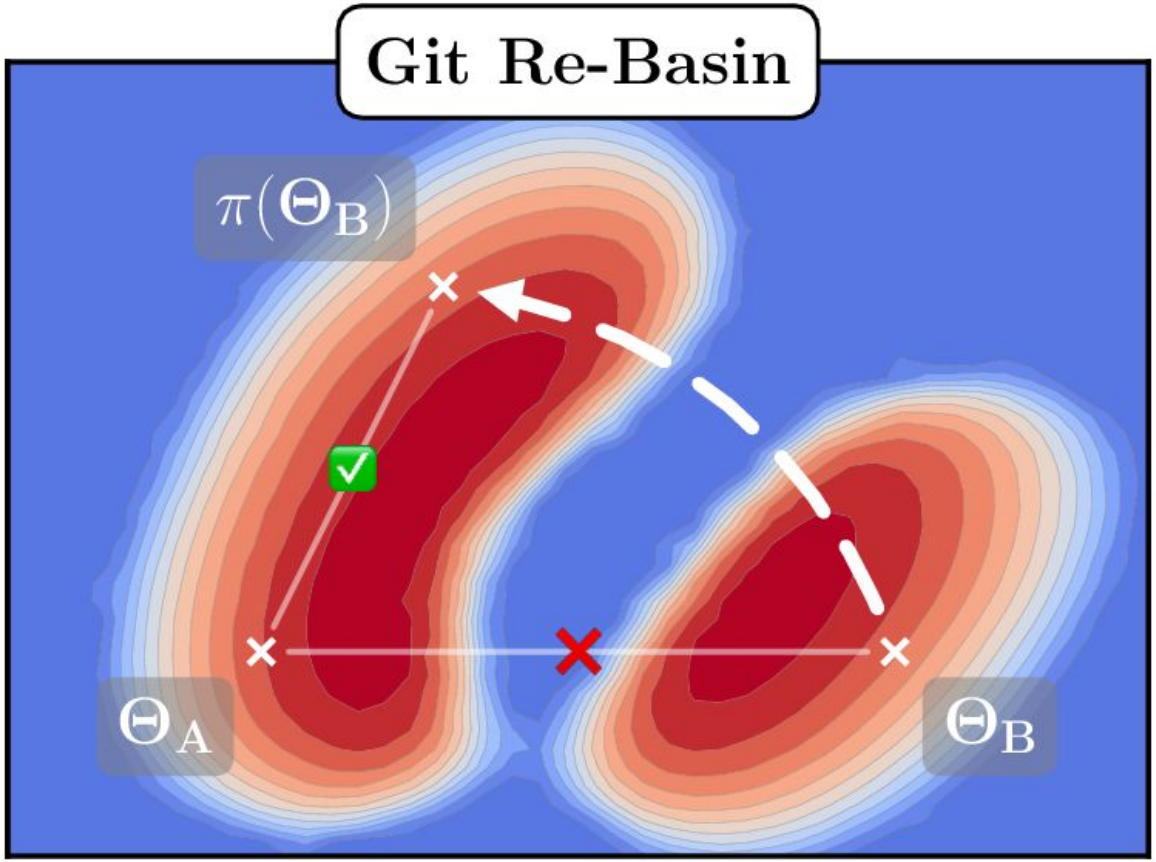
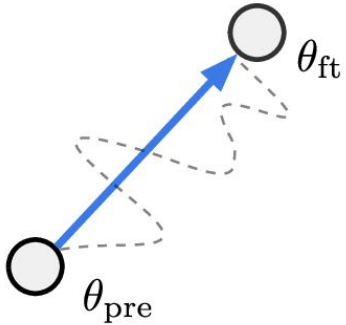


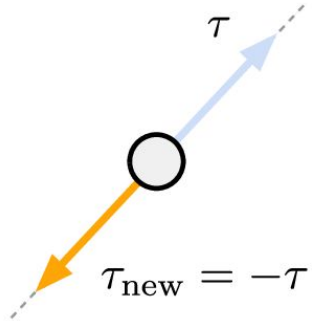
From *Git Re-Basin: Merging Models modulo Permutation Symmetries* by Ainsworth et al.

a) Task vectors



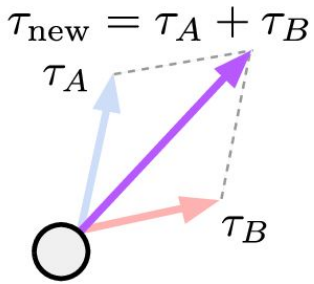
$$\tau = \theta_{\text{ft}} - \theta_{\text{pre}}$$

b) Forgetting via negation



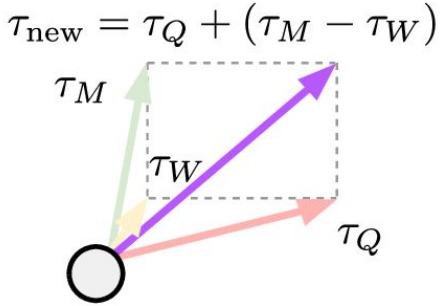
Example: making a language model produce less toxic content

c) Learning via addition



Example: building a multi-task model

d) Task analogies



Example: learning about kings with data from queens, man and woman

From *Editing Models with Task Arithmetic* by Ilharco et al.

How can we enable collaborative and continual development of machine learning models?

We need a system to **track changes and manage contributions** to a model.

What we need(ed)

- **Track changes to a checkpoint.** There are many ways to modify a checkpoint, e.g. updating all parameters, updating a subset of parameters, adding/removing parameters, etc. The system should support all of these operations.

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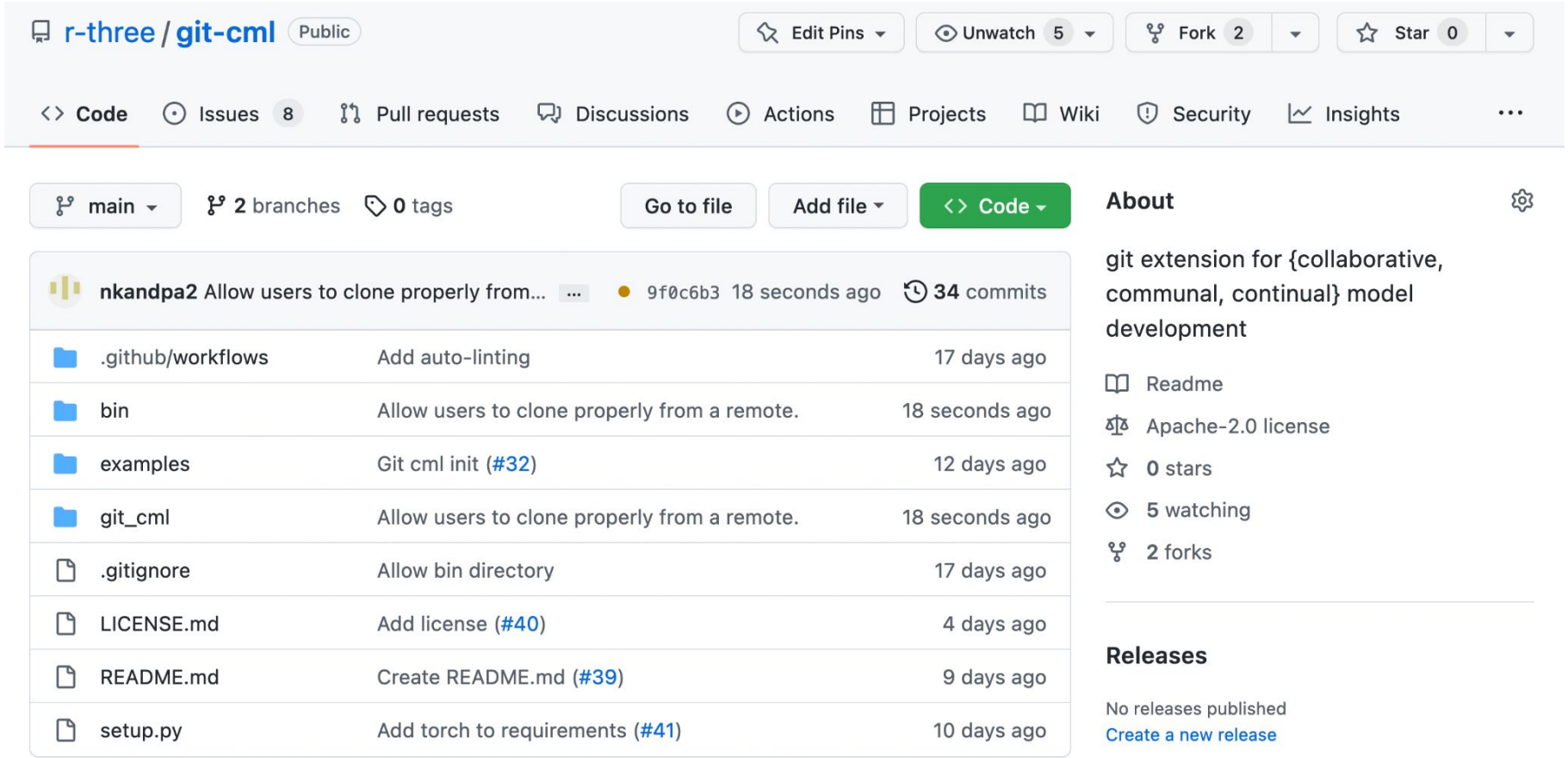
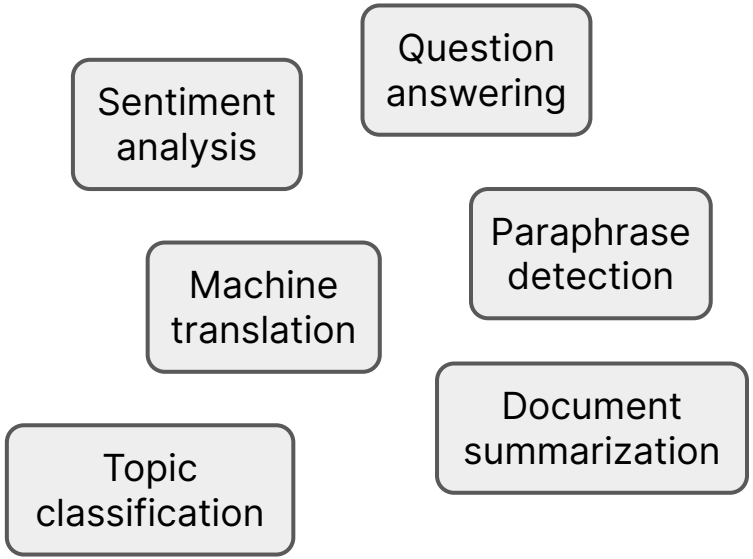
- **Easy to go from training → version control system.** We don't expect contributors to directly create patches; we expect them to use version control-aware training code that needs to interact with the system to create patches, etc.


r-three / git-cml
Public
Edit Pins
Unwatch 5
Fork 2
Star 0
Code
Issues 8
Pull requests
Discussions
Actions
Projects
Wiki
Security
Insights
main
2 branches
0 tags
Go to file
Add file
Code
nkandpa2 Allow users to clone properly from...
9f0c6b3 18 seconds ago
34 commits
.github/workflows
Add auto-linting
17 days ago
bin
Allow users to clone properly from a remote.
18 seconds ago
examples
Git cml init (#32)
12 days ago
git_cml
Allow users to clone properly from a remote.
18 seconds ago
.gitignore
Allow bin directory
17 days ago
LICENSE.md
Add license (#40)
4 days ago
README.md
Create README.md (#39)
9 days ago
setup.py
Add torch to requirements (#41)
10 days ago
About
git extension for {collaborative, communal, continual} model development
Readme
Apache-2.0 license
0 stars
5 watching
2 forks
Releases
No releases published
Create a new release

How can we enable collaborative and continual development of machine learning models?

Let’s try it by focusing on a specific architecture.


Question answering
Sentiment analysis
Paraphrase detection
Machine translation
Document summarization
Topic classification

Sentiment analysis

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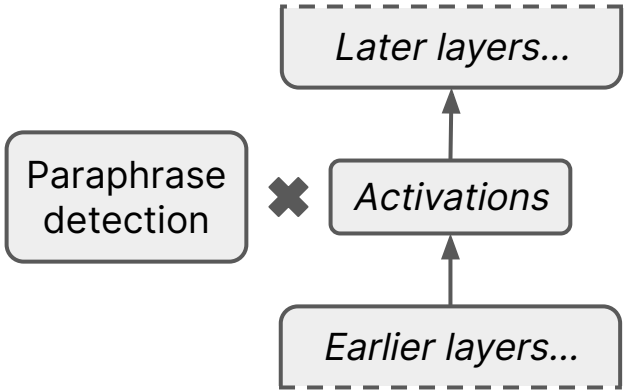

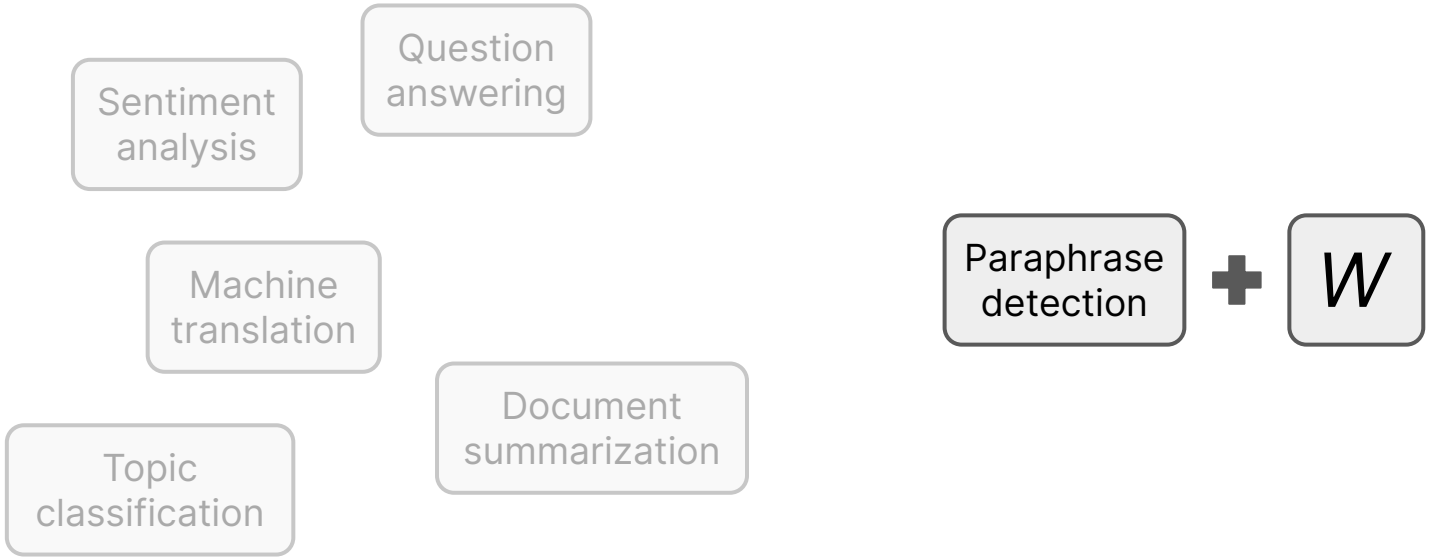
Question answering
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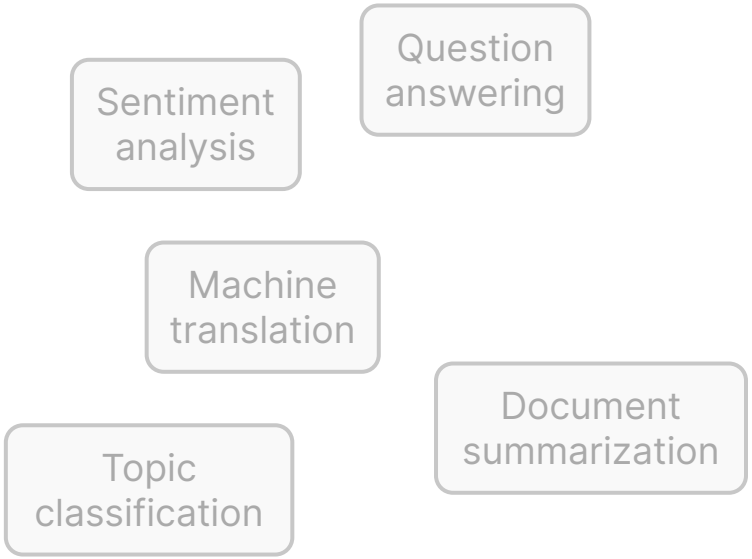
Topic classification
Paraphrase detection
W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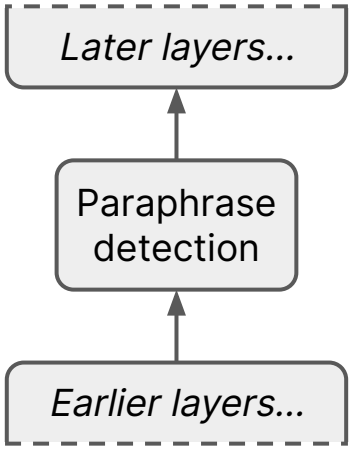
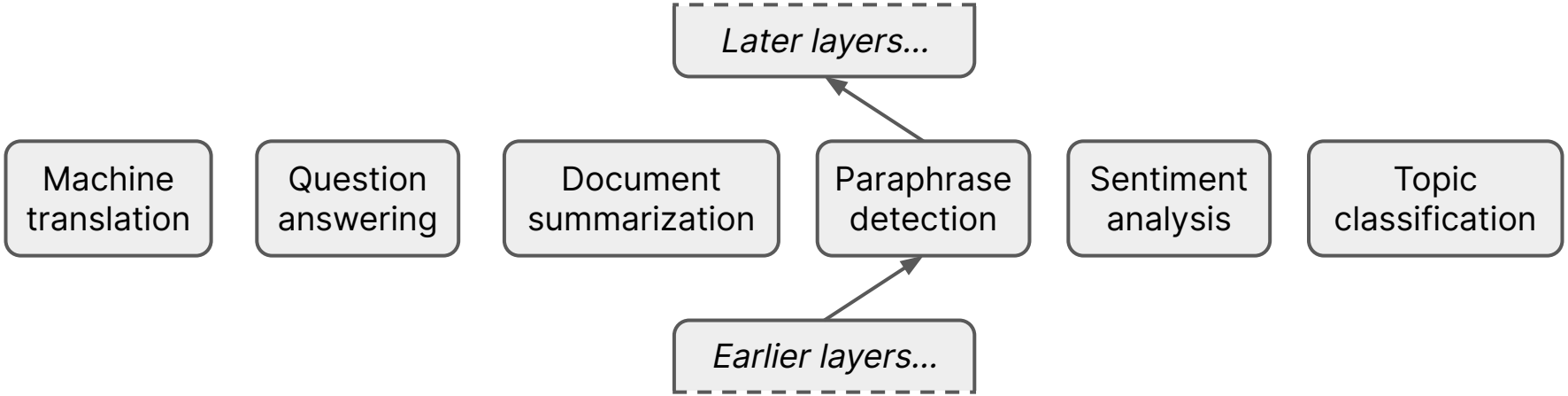
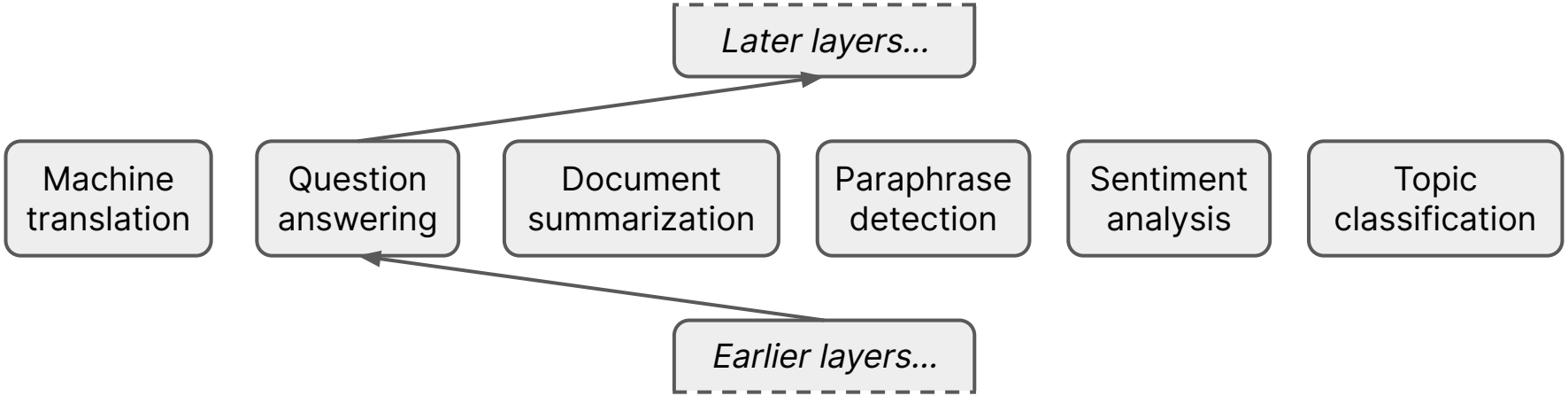

Later layers...
Paraphrase detection
Earlier layers...


Later layers...
Machine translation
Question answering
Document summarization
Paraphrase detection
Sentiment analysis
Topic classification
Earlier layers...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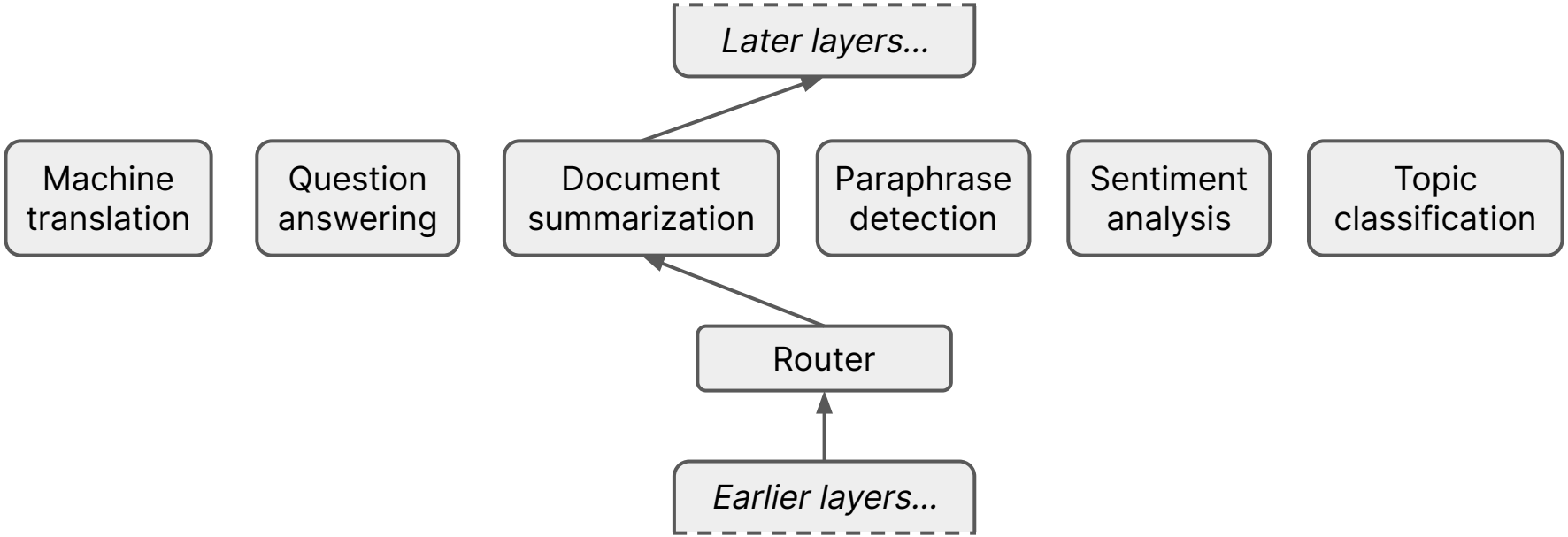
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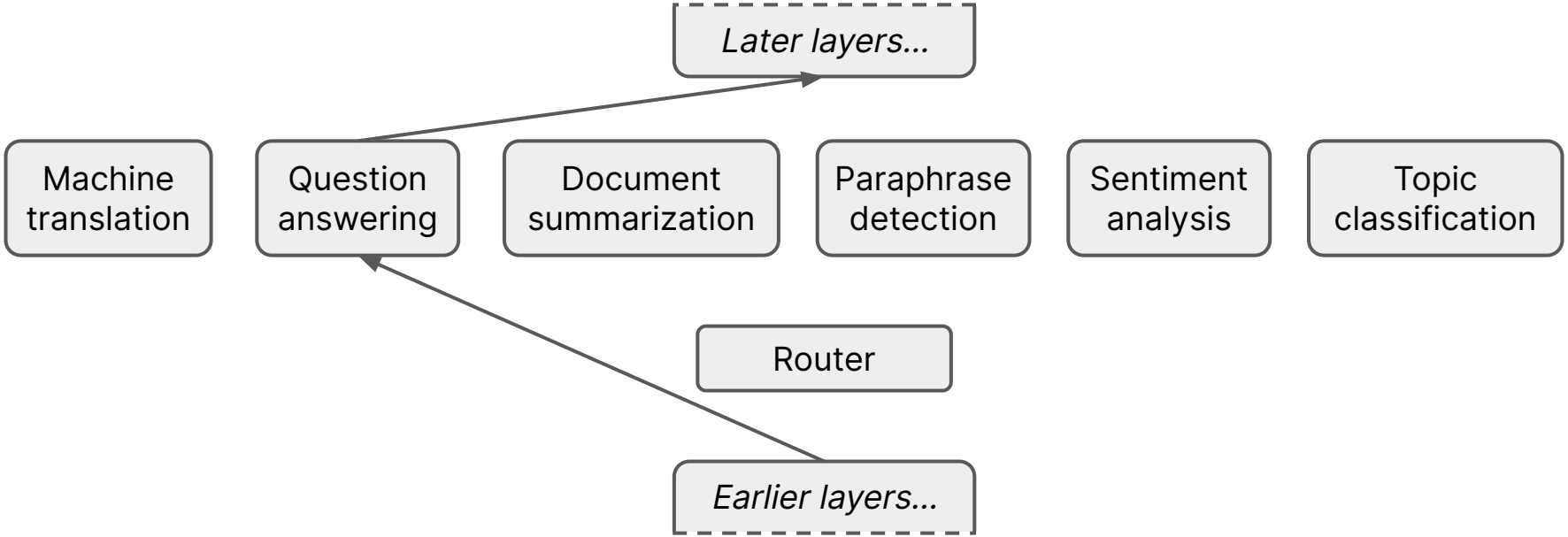
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- **Could consider adapters beyond task-level.** For example, we could say each task has some particular domain and language, and have separate domain and language adapter sets.
- **Some precedent in AdapterHub.** This model could be seen as a next-generation version; here, adapters ship with the model, routing can be learned, and there is a more principled way of tracking changes.

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