Explore the Possibility of Fine-grained Non-encrypted Distributed MLaaS: an Adversary View

Progress Talk for *CyberSec & Privacy*, Type: Research

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1. Clarification of Problem and Methodology

2. Filling the Logic Chain

3. First-stage Experiment

4. Challenges and Solutions

5. Next Step

The problem

- Old: IP protection in distributed AI model training
- Our assumption: The model is uncrypted and the pirates **can not** control all the devices. [1] All the devices are untrusted.
- Our goal: To protect the IP of the model, including getting a copy of the **whole** model or get **similar** performance of the model with efforts **lower than** retraining the model.

[1] We do not take **Trusted Execution Environment** into consideration, for it is not practical in our scenario.

The Methodology: Adversary View

- Not the Adversary Analysis in the Complexity Theory
- Like the Repeated Game in Game Theory: We assume there is a pirate who wants to get the model. We update our strategy to protect the model according to the pirate's strategy, so does the pirate.

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S_0 (S for Service Provider): Our model for this problem

- We assume there exists an untrusted distributed system, which combine the pipeline parallelism and the data parallelism.
- Therefore each of the devices hosts a part of the model.

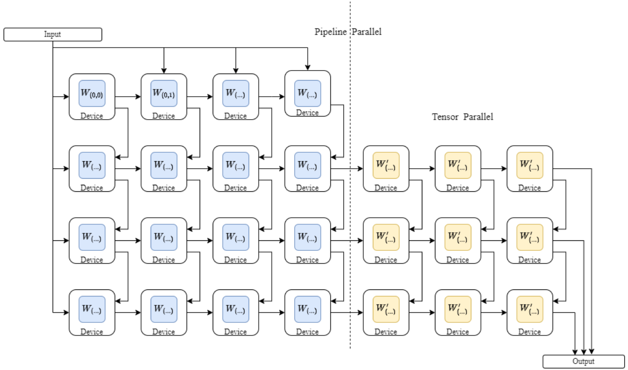


Fig. 1: Model

P_1 (P for Pirate): Naive Attack

- Just acquire part of the model from the devices.
- BUT how much is enough? (Please refer to the next part)

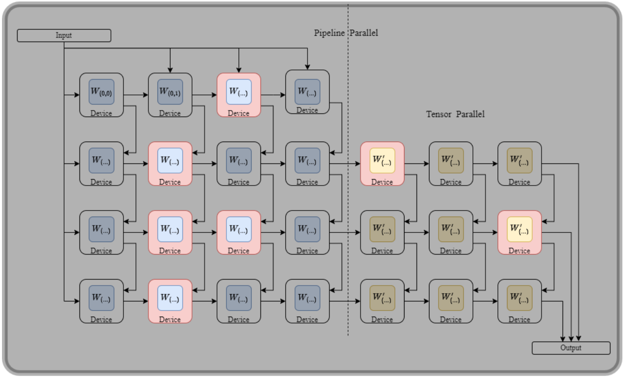


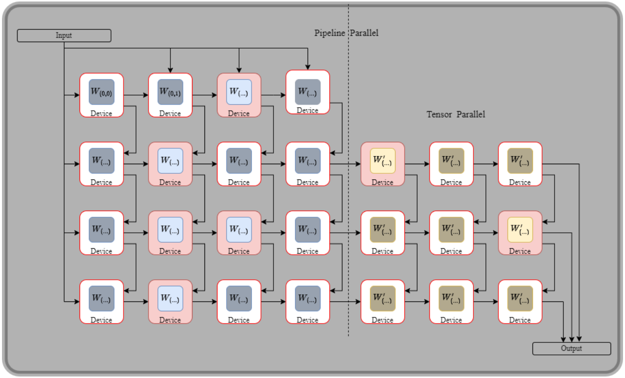
Fig. 2: Naive Attack

S_1: Not so promising: Complexity of the Operators!

- The posibility of putting the parameters to the right place is very low:
- $\frac{1}{A_N^N} = \frac{1}{O(N!)}$
- How about N ? Very large in our scenario. ('Fine-grained')
- How about some of them are not in the right place? (Please refer to the next part)

P_2: More technical Attack

- How could be search in such a large space?
- We could use machine learning to help us.
- Abstraction: Given a function $\mathbf{Val}$, a set of values S, among all the orders of S, find $max(\mathbf{Val}(\mathbf{order}(\mathbf{S})))$.



S_2: Do not be happy too early: Complexity of the Architecture!

- All of them are just floating-point numbers or integers tensors, how could you know which operator they belong to and which layer do they belong to?[2]
- You can not tell the difference between the 'Yellow' and the 'Blue' in the last slide!

[2] Or you may even do not know the what layers the model has.

P_3: Stream Hijacking

- To get the architecture of the model, the pirate can monitor the stream between the devices and the centralized server.
- It is a Pattern Recognition task! [3]

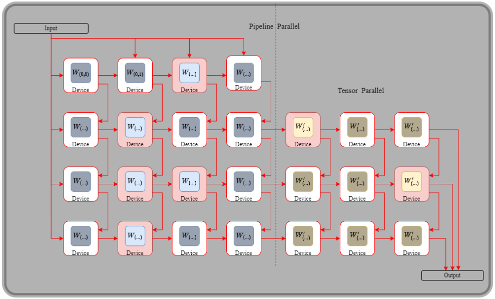


Fig. 4: Take the stream

[3] It could be a self-supervised learning task, and I will work on it.

S_3: Stream Obfuscation

- Padding all the messages to the same length.
- Add some useless messages to the normal stream, in case of being analyzed by the pirate.
- Here is a trade-off between the additional stream and the communication cost.[4]

[4] I will work on a feasible algorithm here.

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Only get part of the model (in the right position)

- Actually it just a prune task. 256x256 divided and drop
- When the model has 10 percents of the parameters, there are limited loss compared to the original model.

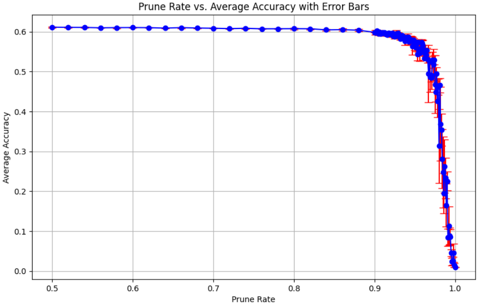

Fig. 5: Exp1

Only get part of the model (not int the right position)

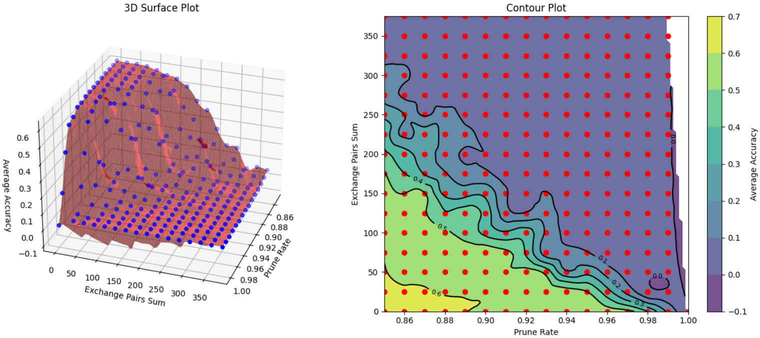

Fig. 6: Exp2

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Methodology Problems (and maybe my feelings)

- I once chose llama 3.1 as the object of the experiment. And I tried Whisper-3large as the objects too.
- Not Good, too complicated. (Actually I still need to learn the structure of these models from 0.)
- I did not follow the regular logical flow that *from simple to complicated*

Trivial Problems (and maybe my feelings)

- Within the great wall, it is too hard to conduct the experiments on the ML models.
- Most tools are not valid and call for special configurations. (Huggingface-cli, Kaggle, Dataloader, transformer package, Docker...)
- Downloading is too slow, abort some plans for the size. e.g. the ImageNet.

Trivial Problems (and maybe my feelings)

Poor!

Fig. 7: Rubbish

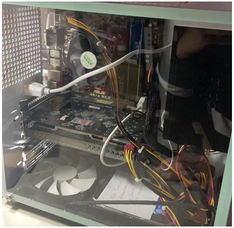

Fig. 8: my 750Ti, old and exhausted

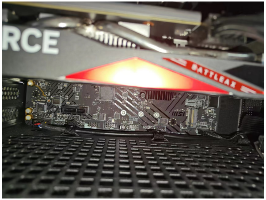

Fig. 9: Ron's 聖女騎士です 4060 saved from the mining farm.

- Actually I have no hardware to do training & inference.
- Thanks to the sponsor of my friend Ron Zhang(THU, Dep of Auto), otherwise I cannot see the results until the universe~~(or, maybe, the NVIDIA)~~ is down.

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- P_2, P_3 and S_3.
- Something breaks the assumption.
  Callback:
  Our assumption: The model is uncrypted and the pirates **can not** control all the devices. All the devices are untrusted.
  1. S_4: What about part of the model is trusted?
     P_5: We can try it! [5]
  2. P_n: What about most of the devices are pirates'?
     ~~I 'm Sauron! Errrrr~~
     S_{n+1}: ...
- Paper(report, exactly) writing.(have being working on it...)

[5] I will not work on this but just do a Literature Review, for it is an individual domain named model inverse attack.

Thanks!