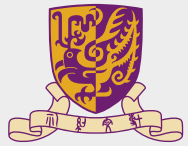
ABC: Automatic Bottom-up Construction of Configuration Knowledge Base for Multi-Vendor Networks

(Vision Paper)

Wenlong Ding[1], Libin Liu[2], Li Chen[2], Hong Xu[1]

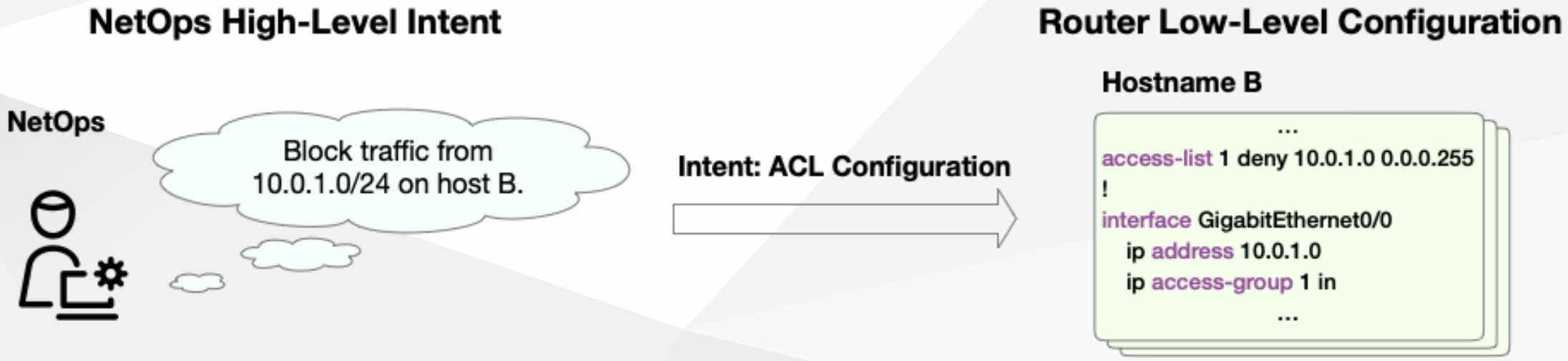
[1]The Chinese University of Hong Kong, Hong Kong, China
[2]Zhongguancun Laboratory, China

IEEE CogMI 2023



香港中文大學
The Chinese University of Hong Kong

Configuration Snippets Achieves Intended Network Behavior



Enterprises Uses Network Devices from Multiple Vendors

- **Benifits:** Cost savings, Vendor-specific functions, Change discontinued product.
- **Problem:** Different vendors have different configuration languages.
  - Different ***syntax*** for the same intent.

Cisco

```
access-list <ACL number>
{permit|deny} <protocol>
   source <ip> <mask>
   destination <ip> <mask>
```

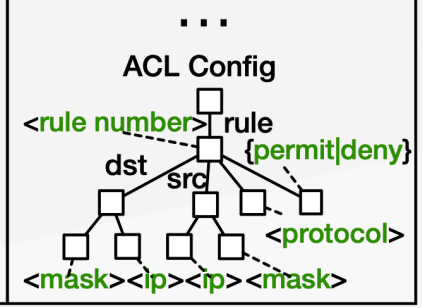
Huawei

```
acl number <ACL number>
 rule <rule number>
   {permit|deny} <protocol>
   source <ip> <mask>
   destination <ip> <mask>
```

ACL Configuration

How to manage network configuration with different vendor devices?

Configuration Knowledge Base Manages Multi-Vendor Network

Intent	Config Snippet Templates			Unified Config Model
	Cisco	...	Huawei	
Add VLAN	vlan <vlan_id>		vlan branch <vlan_id>	Add Vlan id <vlan_id>
... Add ACL	... access-list <ACL number> {permit|deny} <protocol> source <ip> <mask> destination <ip> <mask>	...	... acl number <ACL number> rule <rule number> {permit|deny} <protocol> source <ip> <mask> destination <ip> <mask>	... 

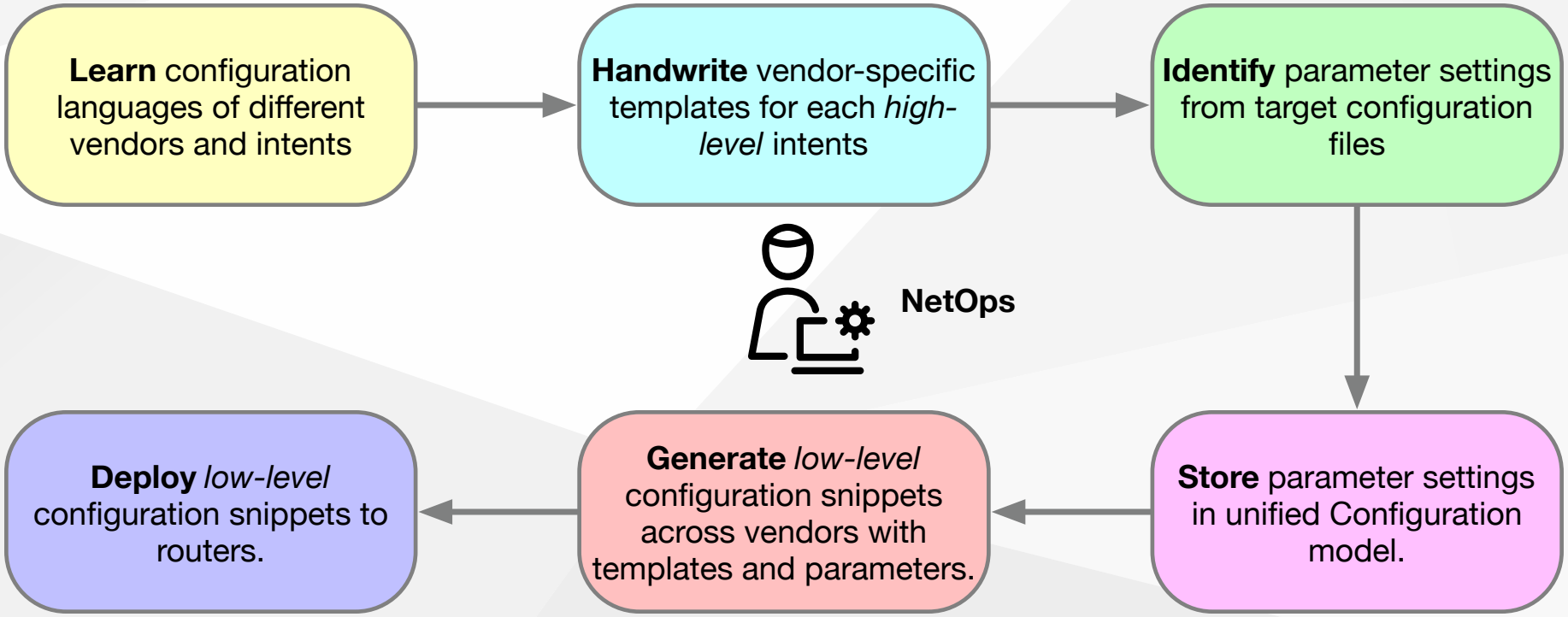
Configuration snippet templates of the same intent are grouped together.

Parameters of a certain intent are stored in an **unified confirguration sturcture**.

Easy to **Share** and **transfer** configuration in multi-vendor network.

Problem: Existing Works Require Huge Human Efforts

Exisiting works use the Top-down CKB construction method.



Problem: Existing Works Require Huge Human Efforts

- Different exsisiting works use different unified Configuration model:
  - **Robotron** (Sigcomm'16): FBNet
  - **OpenConfig:** common configuration tree (CCT)
  - **Nassim** (Sigcomm'22): vendor parsing model
- The top-down CKB construction will be conducted throughout the network's lifecycle whenever a new vendor or intent come.
  - **Time consuming:** (our experience) two years to develope vendor-specific templates for $O(10^5)$ routers for six vendors based on CCT.
  - **Expert knowledge:** NetOps needs to learn configuration language for every new vendor and intent.

We need to to develop an automated system for constructing the CKB!

Insight: A Bottom-Up CKB Construction Method

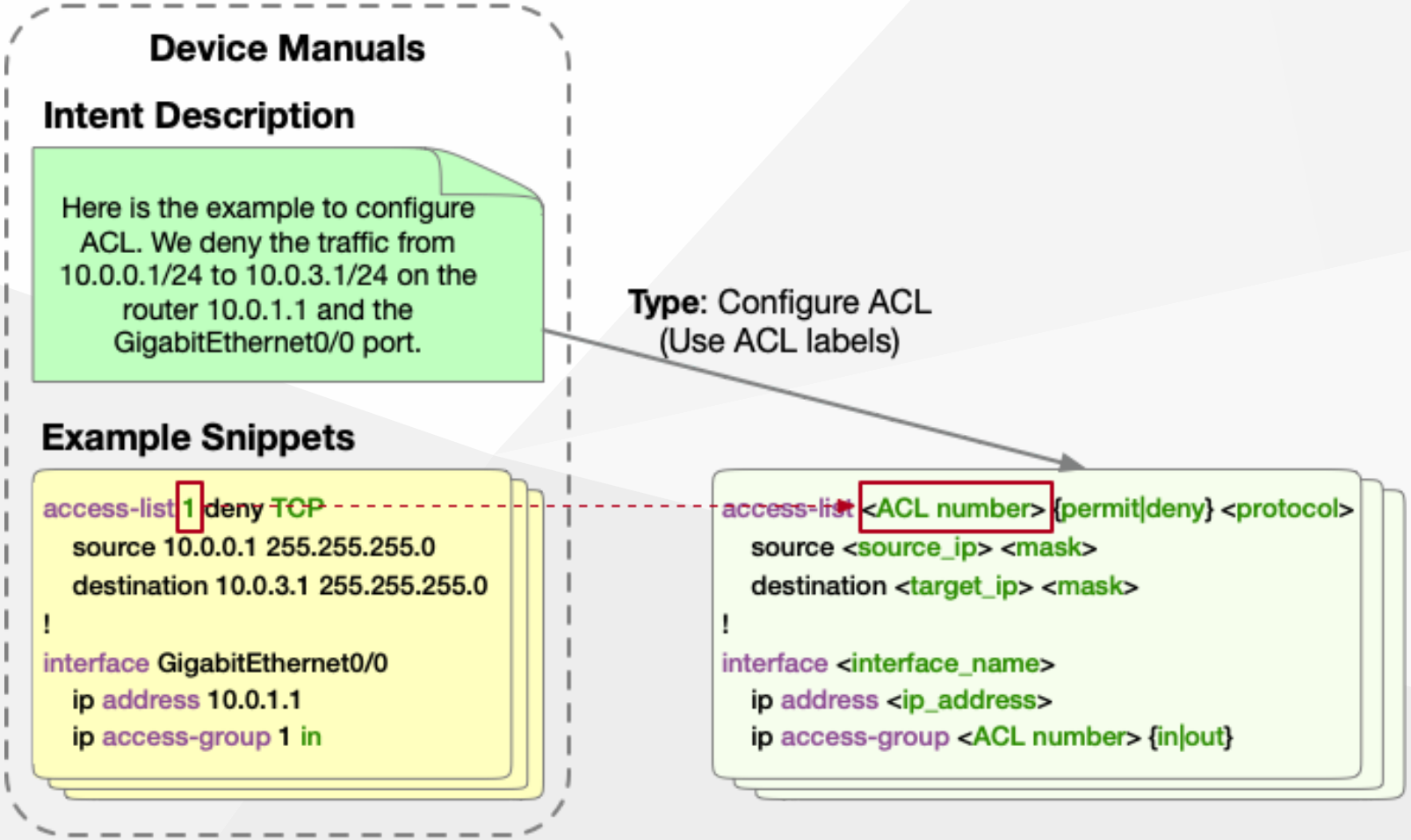
- **Key Challenge:** Differences in vendor-specific configuration languages
  - Intentinally made by vendors: Discourage vendor-switching of customers

Insight: Different vendors share similar high-level intents and parameter types.

- **Solution:** Extract parameters in example snippets in **device mannuals** to generate snippet templates.
  - Regardless of syntax diversity of different vendor languages, but just indentify certain entity of parameters.

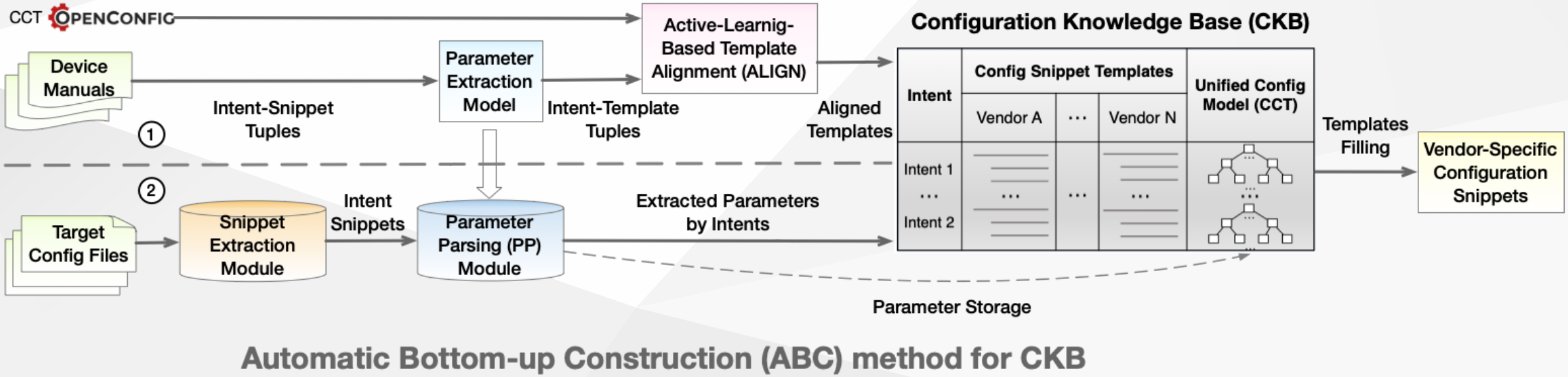
Insight: A Bottom-Up CKB Construction Method

- Example snippets in **device mannuals** are managed according to *intents*.



ABC Workflow: NLP-Based Bottom-Up CKB Construction

ITC Mapping: *Learn* parameter parsing (PP) rules, *Generate* configuration templates, and *Align* templates from different vendors based on intents.

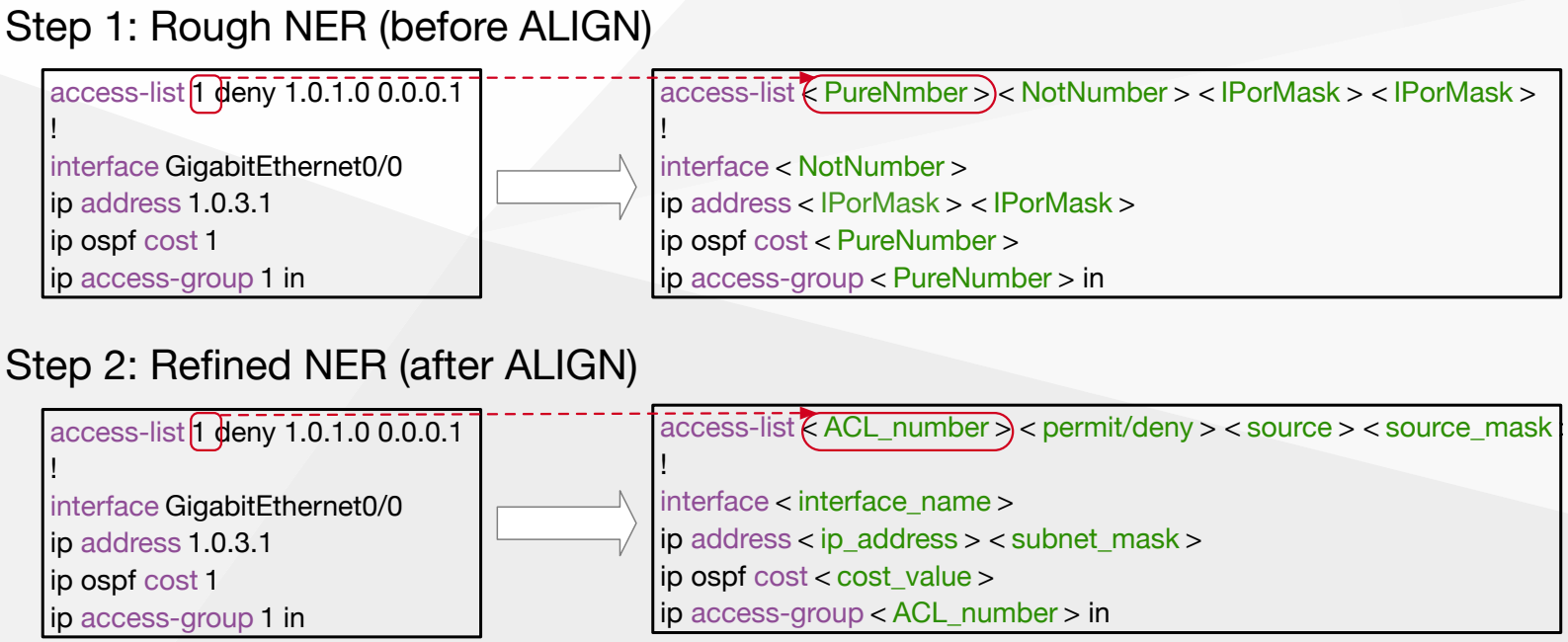


Automatic Bottom-up Construction (ABC) method for CKB

Target Configuration Storage: *Extract* Snippet by intents, *Parse* parameters of intent snippets, and *Store* the parameters in CKB.

Challenges & Preliminary Solutions: Parameter Parsing (PP)

- **Task:** A Named Entity Recoganition (NER) task to extract labels from template snipptes.
- **Challegnes:** Hard to know specific label type until we know intent type of a snippet.
  - ACL group number in ACL Config and OSPF seesion number in OSPF Config are both pure numbers.
- **Preliminary Solution:** Two-step NER task.

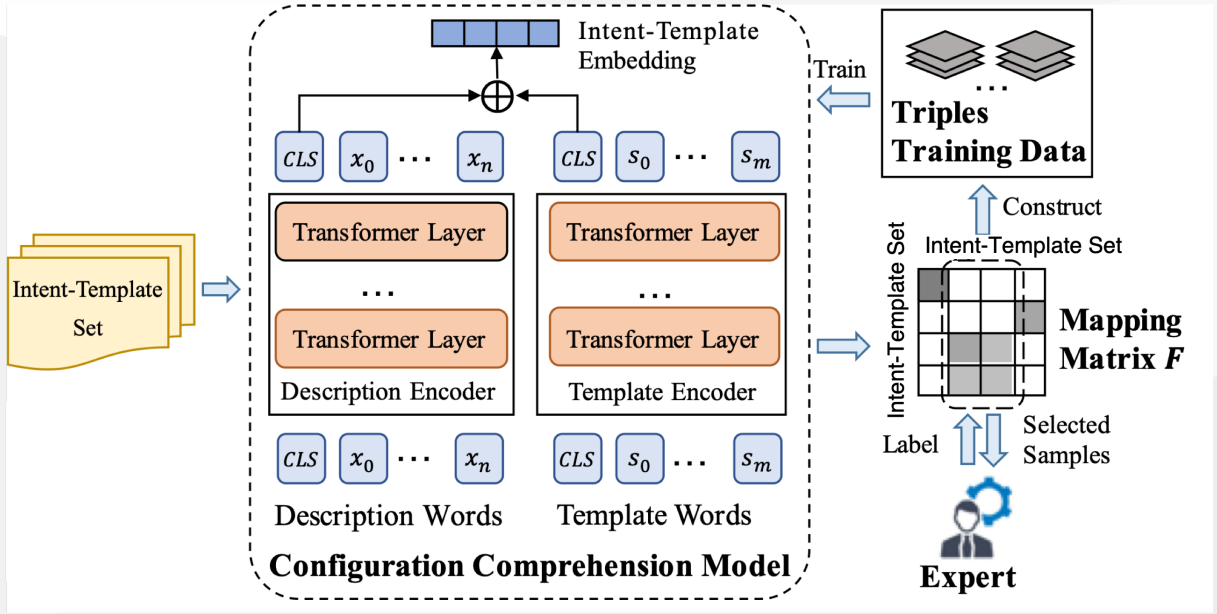


Challenges & Preliminary Solutions: Templates Alignment (ALIGN)

- **Task:** Align rough templates to their Unified Config model (CCT) by intent.
- **Challegnes:** NetOps cannot label rough templates from all vendors and intents to corresponding CCT for training.
- **Preliminary Solution:**
  1. An unsupervised method to group templates by intents with similarity check.
  2. Minimal labeling for the representative templates provided by the system.

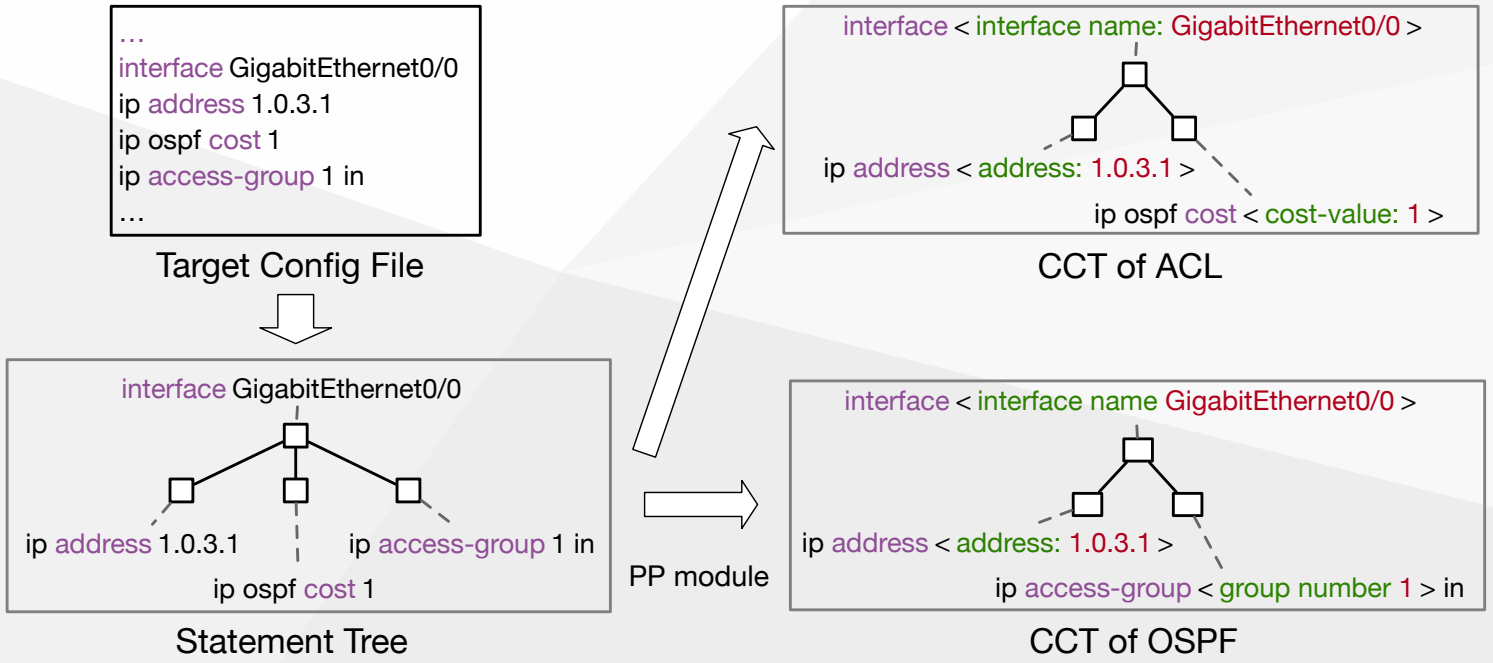
Challenges & Preliminary Solutions: Templates Alignment (ALIGN)

- Similarity based groupping:
  - Two-Encoder learning structure.
  - Triples Training data (p_i, q_{pos}, q_{neg}) generated based on similarity matrix F and thereshold.
  - Loss function maximizes distance of un-groupped tuples and minimize the groupped tuples. $Obj(p_i, q_{pos}, q_{neg}) = log(1 + e^{dis(p_i, q_{qos}) - dis(p_i, q_{neg})})$
- Provide human labeling templates for F_{ij} near 0.5 (most confusing F_{ij}).



Challenges & Preliminary Solutions: Snippet Extraction

- **Task:** Extract snipptes by intnets from the target configuration file.
- **Challegnes:** Target configuration file consists of multiple intnet snippets and different intnet snippets may be mixed together.
- **Preliminary Solution:** Parallel matching with the statement tree.



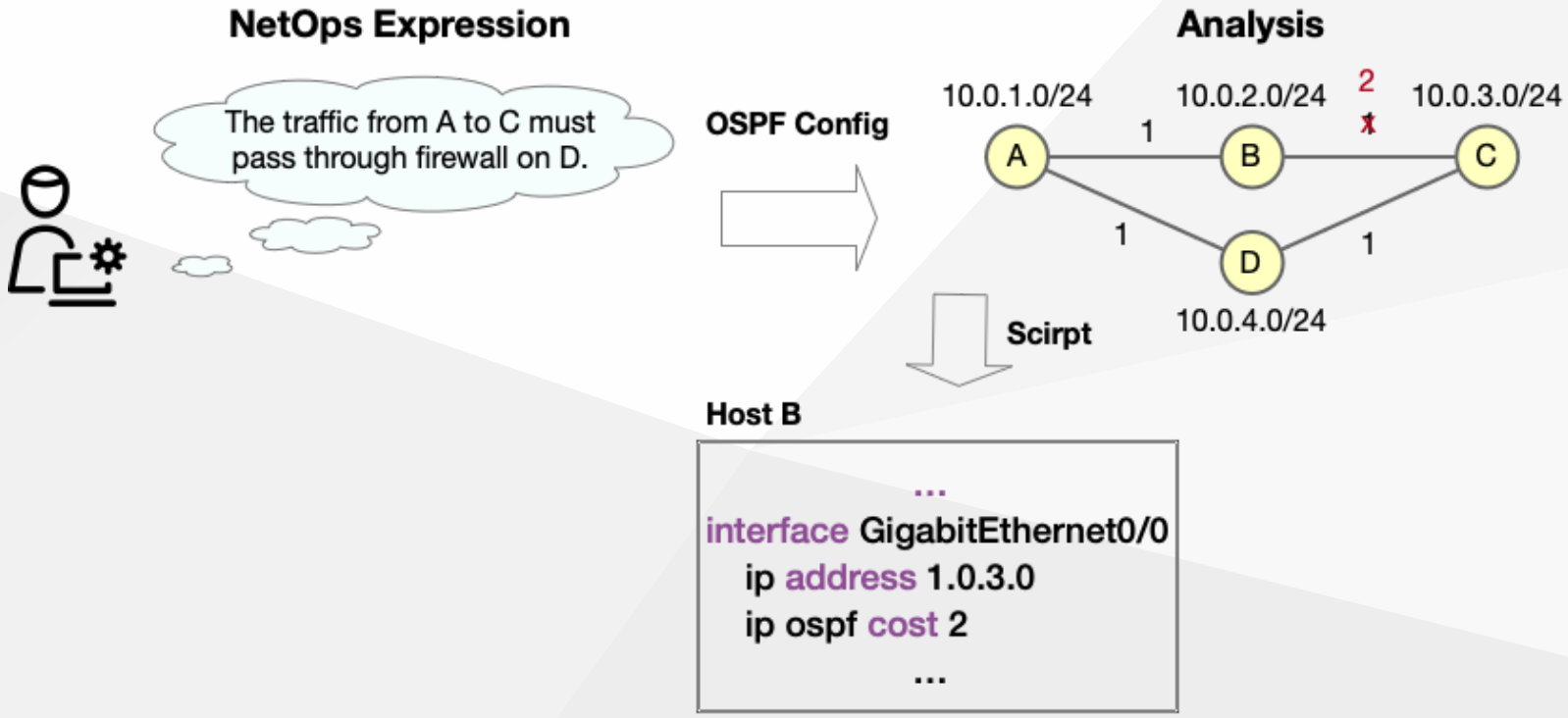
Parallel Matching

Vision for Future Works

- We encourage community to improve workflow of *ABC* and solve its challenges with more advanced methods (e.g. newly proposed LLM).
- More vision on our *automated network configuration* topic following *ABC*:
  - Intent-based Network Configuration
  - Network Configuration Synthesis
  - Intent-based Network Inquiry and Summarization

Vision Works: Intent-based Network Configuration

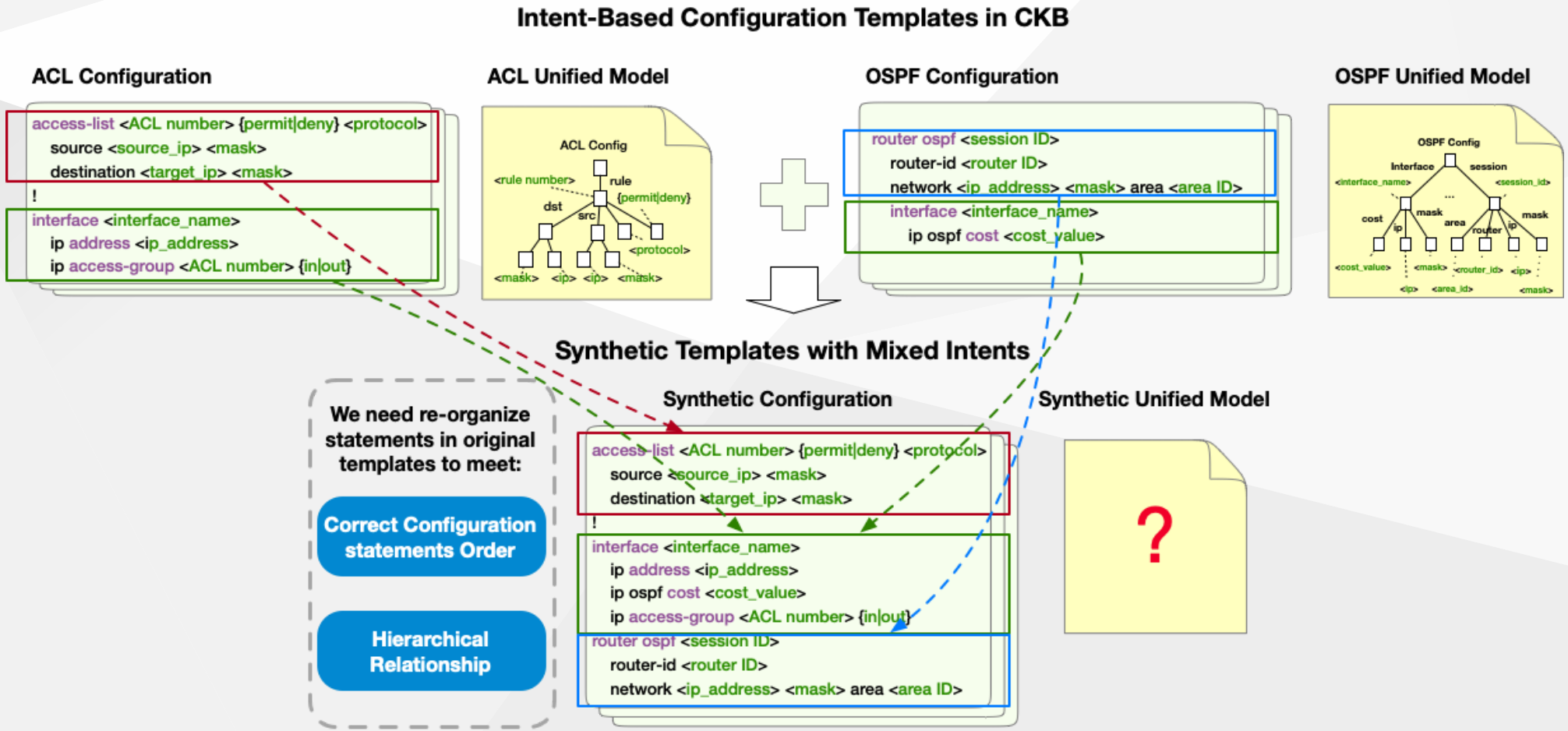
Solve parameter settings directly from human intents, without having any target configuration file.



Actual situation will be more complex and challenging to solve.

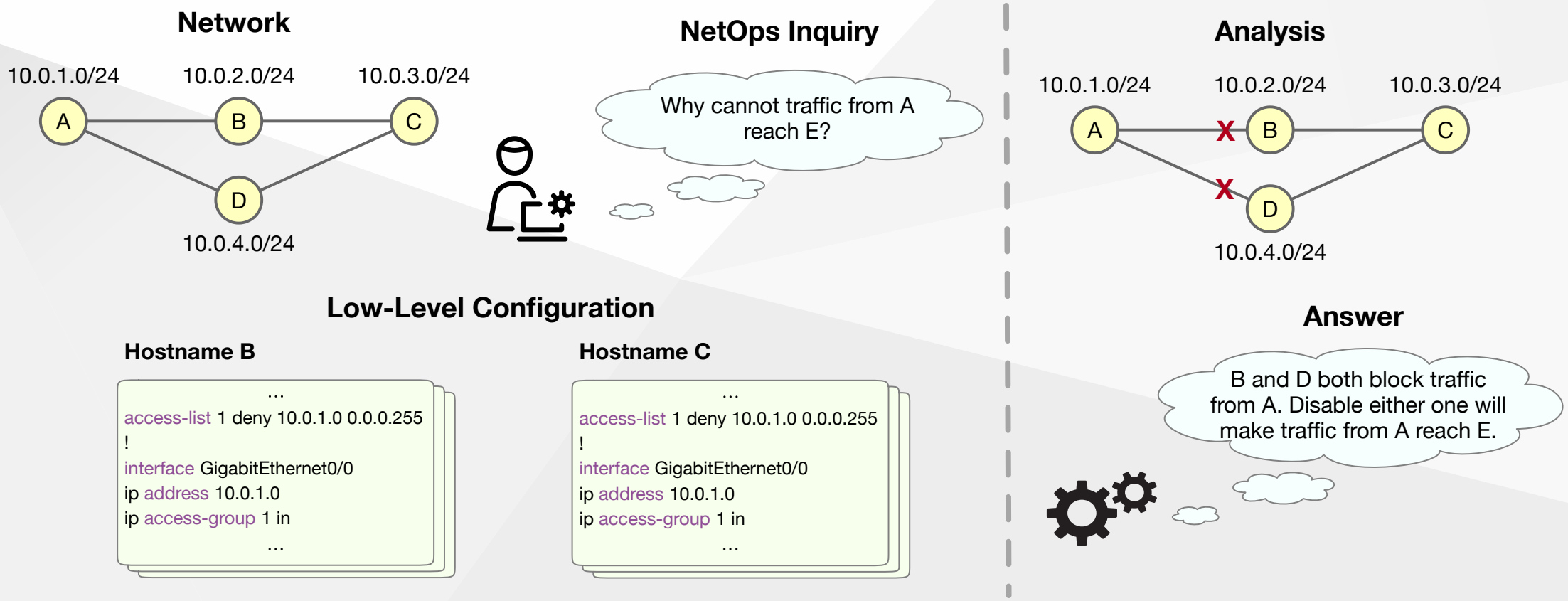
Vision Works: Network Configuration Synthesis

NetOps teams often propose multiple intents for a network, we need to efficiently synthesize templates of different intents from CKB.



Vision Works: Intent-based Network Inquiry and Summarization

It is challenging to know network status from configuration files because they are often lengthy and written in low-level grammar, we need automated tools help NetOps understanding and manage the network.



Summary

- We propose a new topic in traditional computer network (*Automated network configuration*) that is suitable for emerging NLP technologies.
- We gave a specific example in this topic: Automated Bottom-up Construction (*ABC*) for CKB. We present *ABC*'s workflow and possible technical challenges.
- We further propose more vision works following *ABC* in our topic and iThey have great potential to be well solved by emerging NLP technologies.

Thank you!

Q&A