Hey, Lumi!

Using Natural Language for Intent-based Network Management

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Deploying network policies is hard...
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“Block YouTube in the office”
Deploying network policies is hard...

“Block YouTube in the office”

“Inspect all traffic for student dorms.”
Deploying network policies is hard...

“Block YouTube in the office”

“Inspect all traffic for student dorms.”

“Rate limit employees streaming traffic”
Deploying network policies is hard...

“Block YouTube in the office”

“Inspect all traffic for student dorms.”

“Rate limit employees streaming traffic”
How to deploy network policies?
How to deploy network policies?

Higher-level

SDN

NETCONF

OPENCONFIG

>
How to deploy network policies?
What if we use natural language?
1. Allows network operators to express their high-level intents in **Natural Language**
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2. Relies on a **high-level intent language** to ask for confirmation on intents before deployment
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2. Relies on a **high-level intent language** to ask for confirmation on intents before deployment
3. **Learns over time** using operator knowledge
1. Allows network operators to express their high-level intents in **Natural Language**

2. Relies on a **high-level intent language** to ask for confirmation on intents before deployment

3. **Learns over time** using operator knowledge

4. Evaluated using **real-world intents** from US University network policies, and a **User Study**
Supported policies

ACL
QoS
Middlebox chaining
Temporal behavior
Related work

Network Configuration

Learns through Feedback

Hey network, can you understand me?

✓

✓

✓

✓
Lumi in a Nutshell

“Hey, Lumi! Inspect traffic for the dorm.”
Lumi in a Nutshell

“Hey, Lumi! Inspect traffic for the dorm.”

Client

Config

Network

Information Extraction

Tagged Entities:
{
middlebox: ['dpi'],
target: ['dorm']
}

Intent Assembly

Nile intent:
define intent id:
for endpoint('dorm')
add middlebox('dpi')

Intent Confirmation

“Is this right?”
define intent id:
for endpoint('dorm')
add middlebox('dpi')

Intent Deployment

Merlin program:
[x:
(ipDst =10.1.2.0/24)
-> .* dpi .*]
Information Extraction

Named Entity Recognition

1. Intent text
2. Word Embedding
3. Left-to-right LSTM
4. Right-to-left LSTM
5. Concatenation
6. CRF Layer
7. Build Dictionary

{ middlebox: ['dpi'], target: ['dorm'] }
Lumi in a Nutshell

“Hey, Lumi! Inspect traffic for the dorm.”

Client → Lumi → Network

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Intent Assembly
Network Intent Language (Nile)

High legibility

High expressivity
“Add a firewall and intrusion detection from gateway to backend for client B with at least 100 mbps of bandwidth, and allow HTTPS only.”

```
define intent intentId:
    from   endpoint("gateway")
    to     endpoint("backend")
    for    group("B")
    add    middlebox("firewall"), middlebox("ids")
    set    bandwidth("min", "100", "mbps")
    allow  protocol("https")
```
Lumi in a Nutshell

“Hey, Lumi! Inspect traffic for the dorm.”

Client → Lumi → Network

Config

![Diagram showing the process of Lumi]

Information Extraction
- Tagged Entities: 
  
  ```
  { 
    middlebox: ['dpi'],
    target: ['dorm']
  }
  ```

Intent Assembly
- Nile intent:
  ```
  define intent id: for endpoint('dorm') add middlebox('dpi')
  ```

Intent Confirmation
- “Is this right?”
  ```
  define intent id: for endpoint('dorm') add middlebox('dpi')
  ```

Intent Deployment
- Merlin program:
  ```
  [x: (ipDst = 10.1.2.0/24) -> : * dpi : *]
  ```
Intent Confirmation

- Machine learning is always prone to mistakes
- Training data is hard to come by
  - Use operator knowledge!
- Iterate to extract key-value pairs
  - Re-train NER model each time
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Intent Extraction
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{
middlebox: [‘dpi’],
target: [‘dorm’]
}

Intent Assembly
Nile intent:
define intent id:
for endpoint(‘dorm’)
add middlebox(‘dpi’)

Intent Confirmation
“Is this right?”
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Intent Deployment
Merlin program:
[x:
(ipDst =10.1.2.0/24)
-> * dpi *]

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User Study
User Study

Completely anonymous and entirely online

- Subjects were put in the shoes of a **campus network operator**
- Asked to complete **5 tasks** using our developed Lumi prototype
User Study
Subjects Profiling

- **26 Participants**

**Region**
- **South America**: 65.4%
- **North America**: 23.1%
- **Asia**: 3.8%
- **Europe**: 7.7%

**Expertise**
- **Novice**: 3.8%
- **Beginner**: 3.8%
- **Proficient**: 15.4%
- **Competent**: 42.3%
- **Expert**: 19.2%
User Study
Information Extraction and Feedback

# of Tasks Completed

- 0 Tasks: 7.7%
- 3 Tasks: 34.6%
- 4 Tasks: 53.8%
- 5 Tasks: 5.7%

Impact of Feedback

- Feedback Accepted: 89.5%
- Feedback Rejected: 4.8%
End-to-end system to allow using natural language for network management
- Uses Nile as an abstraction layer for intent confirmation.
- Learns over time through operator feedback.

What’s next:
- Make Lumi production-ready
- Support for more features for use case scenarios other than Campus Networks
Thank you!
Questions?

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http://lumichatbot.github.io