How to Discover Exposed Automotive Devices As a Basis of Generating Honeypots

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- This presentation is based on the joint research with Takahiro Ueda, Takayuki Sasaki, and Katsunari Yoshioka.
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Increasing black-hat attacks on connected cars

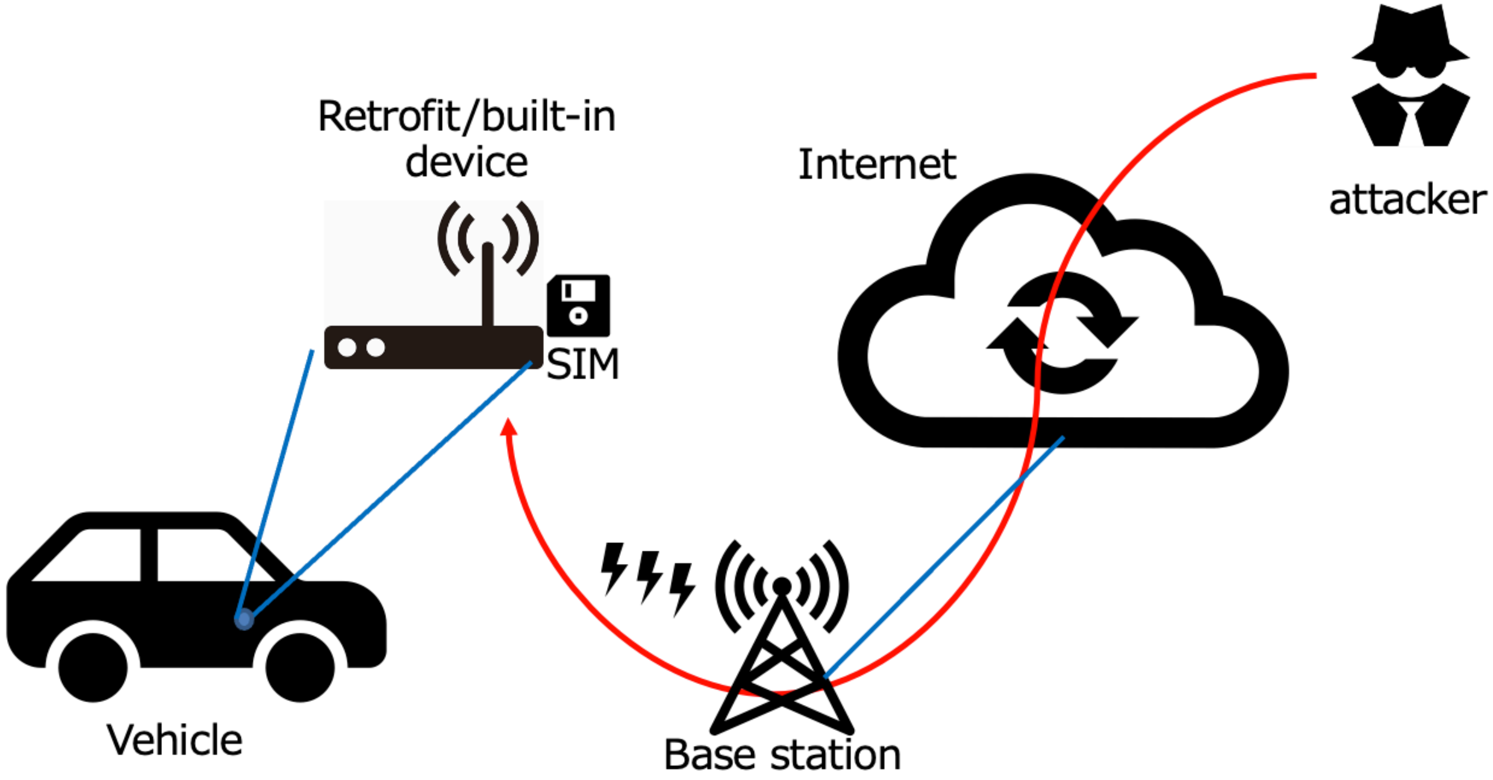
- Attacks on connected cars are increasing.
- For example, Upstream reports that the percentage of black-hat attacks went up to 56.9% in 2021.
- There are many communication channels to access connected cars.
- The same report says that remote attacks greatly outnumbered physical attacks in 2021.

Upstream, 2022 Global Automotive Cybersecurity Report, https://upstream.auto/2022report/

https://www.researchgate.net/publication/333132722_A_strategy_for_vehicular_honeypots

◆Our primary focus: direct attacks on connected devices

We focus on the case where a device inside a car is directly accessible from the Internet (via mobile network) as it can be an immediate threat.



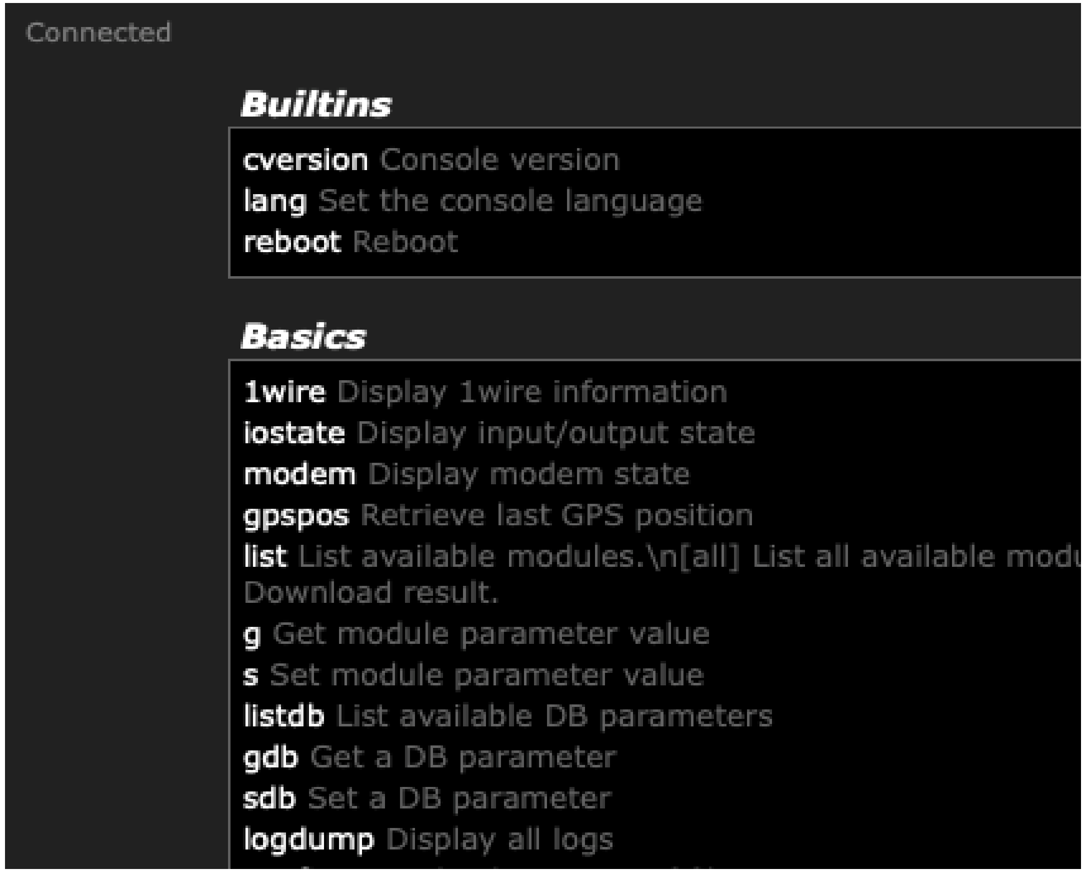
Example: Telematics Gateway - C4max

- C4max, a telematics gateway unit (TGU), was assigned global IP addresses with several services open including telnet without authentication.
- It also connects to the internal vehicular network.

```
22/tcp OpenSSH5.1
23/tcp telnet
80/tcp http
```

No-authentication

WebUI(80/tcp)



Connected

Builtins

```
cversion Console version
lang Set the console language
reboot Reboot
```

Basics

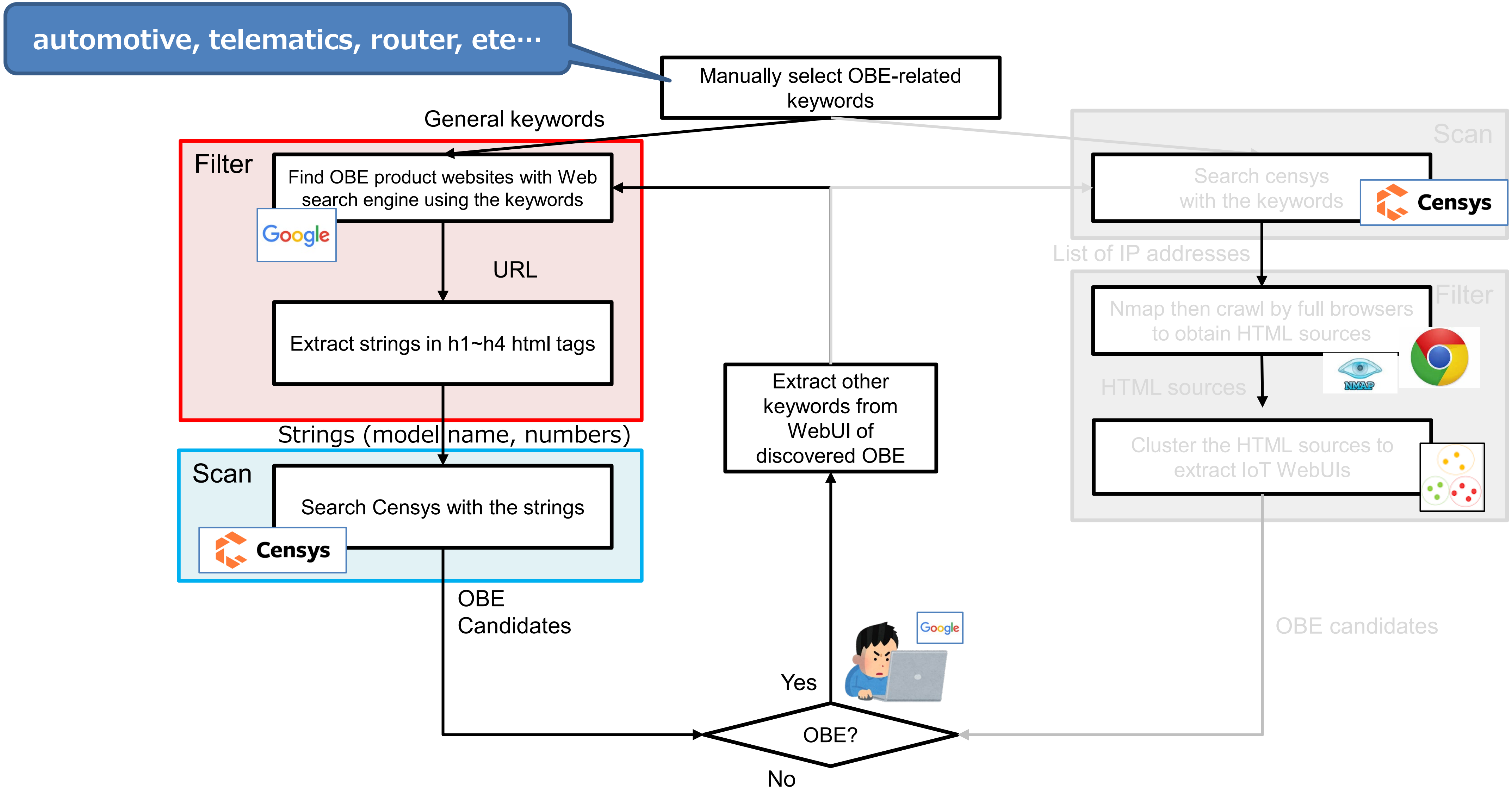
```
1wire Display 1wire information
iostate Display input/output state
modem Display modem state
gpspos Retrieve last GPS position
list List available modules.\n[all] List all available modu
Download result.
g Get module parameter value
s Set module parameter value
listdb List available DB parameters
gdb Get a DB parameter
sdb Set a DB parameter
logdump Display all logs
```

Jose Carlos Norte. Hacking industrial vehicles from the internet: http://jcarlosnorte.com/security/2016/03/06/hacking-tachographs-from-the-internets.html

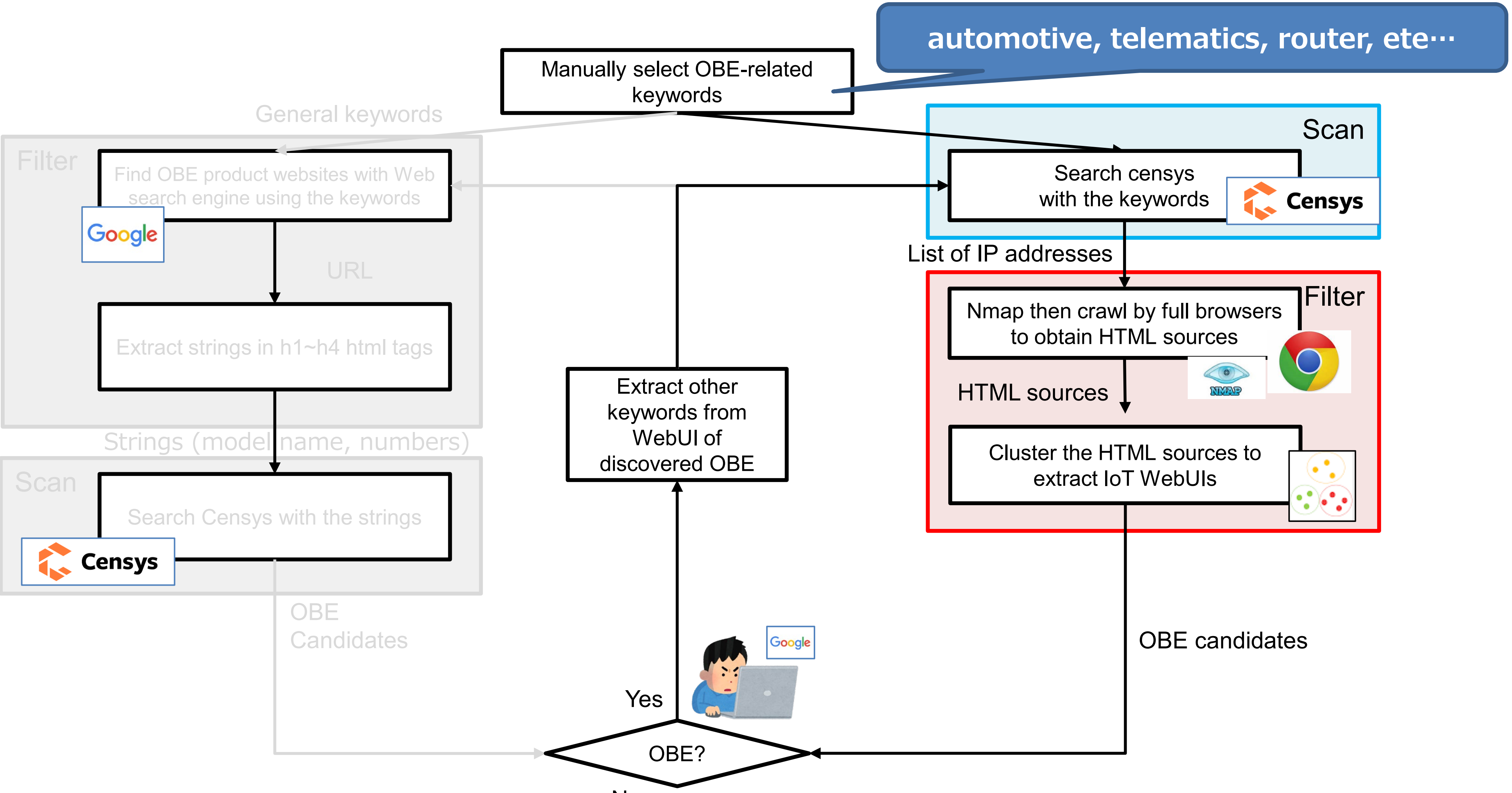
◆ Research Questions

1. How many and what kind of OBE (On-board Equipment) products can be discovered on the Internet?
   >>> Internet-wide scan for discovery
2. What is the likelihood that the exposed OBE products could be compromised and become an entry point for further attacks against the in-vehicle network?
   >>> Surface security investigation on discovered devices
3. Is any of the discovered devices attacked? If so, is it targeted?
   >>> We have started development of a honeypot imitating discovered devices and analyze observed attacks

On Board Equipment discovery method


automotive, telematics, router, ete…
Manually select OBE-related keywords
General keywords
Filter
Find OBE product websites with Web search engine using the keywords
Google
URL
Extract strings in h1~h4 html tags
Strings (model name, numbers)
Scan
Search Censys with the strings
Censys
OBE Candidates
Extract other keywords from WebUI of discovered OBE
Google
Yes
OBE?
No
Scan
Search censys with the keywords
Censys
List of IP addresses
Nmap then crawl by full browsers to obtain HTML sources
Filter
NMAP
HTML sources
Cluster the HTML sources to extract IoT WebUIs
OBE candidates

On Board Equipment discovery method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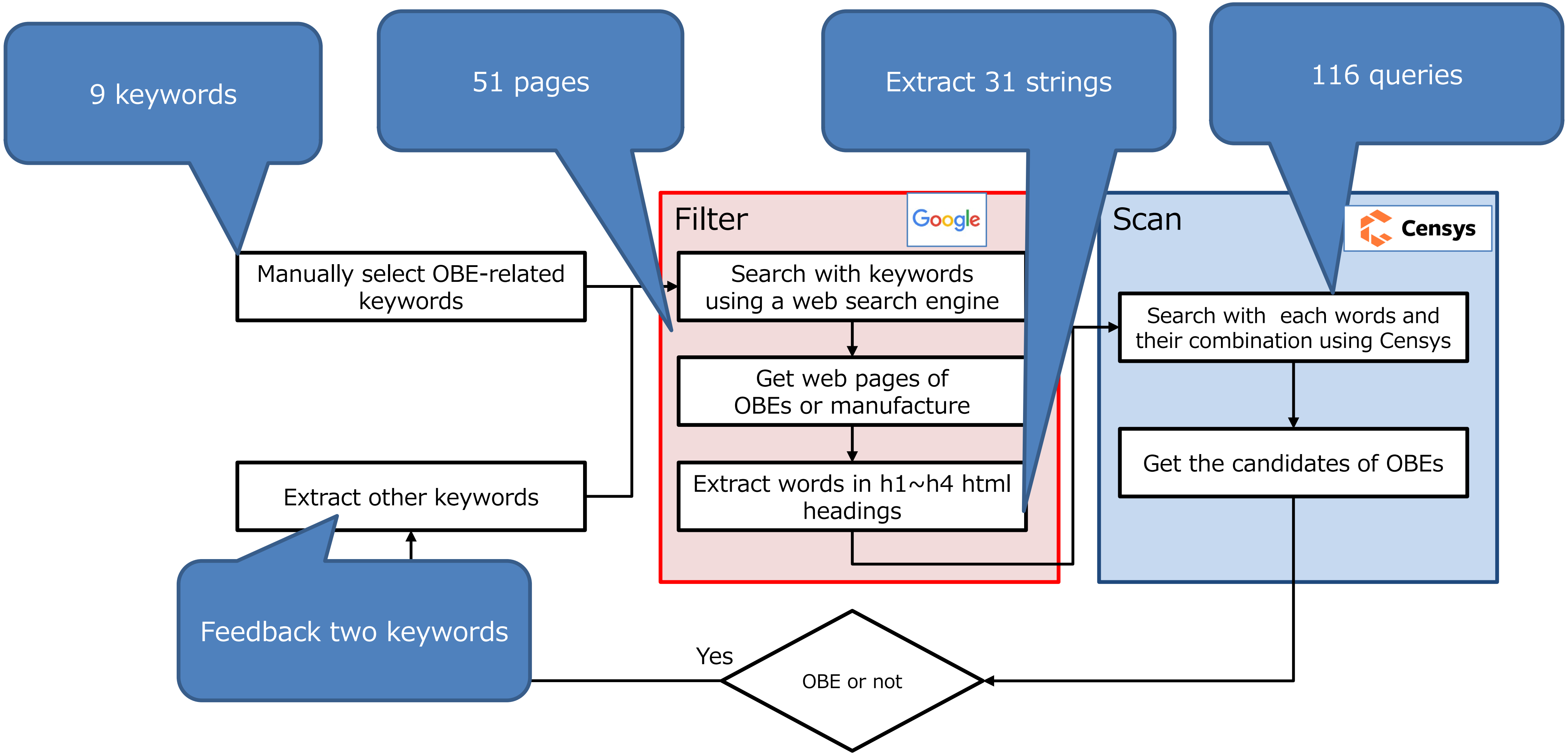
Extract other keywords from WebUI of discovered OBE
Google
OBE candidates
Yes
OBE?
No

Result Summary

- How many?
  - 12 OBE models
  - 2,532 devices
- What kind?
  - All devices are vehicle routers or gateways
- Where?
  - Mobile networks
  - Europe, US, Asia, South America

device name	Web-base/Cluster-base	#devices	Discovered countries	AS
A	Clustering-based	278	NL 26.0% SE 18.9% US 16.3%	DTAG internet service / KPN KPN network
B	Clustering-based	391	ES 59% MA 20.3% DE 11.9%	VODAPONE_ES / DTAG ineternet service
C	Web-search-engine-based	821	US 96.5% BR 2.2%	CELLCO-PART
D	Web-search-engine-based	186	IT 59.1% DE 40.0%	VODAPONE_IT ASN
E	Web-search-engine-based	88	DE 95.6%	DTAG internet service
F	Both	104	US 60.0% ES 11.8% AU 10.0%	CELLCO-PART / TELEPONICA_DE_ESPANA
G	Web-search-engine-based	5	TW 100.0%	HINET Data Communication
H	Web-search-engine-based	360	ES99.4%	VODAPONE_ES / TELEPONICA_DE_ESPANA
I	Web-search-engine-based	3	DE 100%	INTERNETX_AS / DTAG internet service
J	Web-search-engine-based	67	US 51.5% FR 19.6% CN9.6%	CELLCO-PART / CELLCO
K	Web-search-engine-based	144	ES 99.9%	VODAPONE_ES / TELEPONICA_DE_ESPANA
L	Web-search-engine-based	85	us 84.3%	CELLCO-PART / CELLCO

Experiment details (web-search)



9 keywords

51 pages

Extract 31 strings

116 queries

Manually select OBE-related keywords

Filter

Google

Search with keywords using a web search engine

Get web pages of OBEs or manufacture

Extract words in h1~h4 html headings

Scan

Censys

Search with each words and their combination using Censys

Get the candidates of OBEs

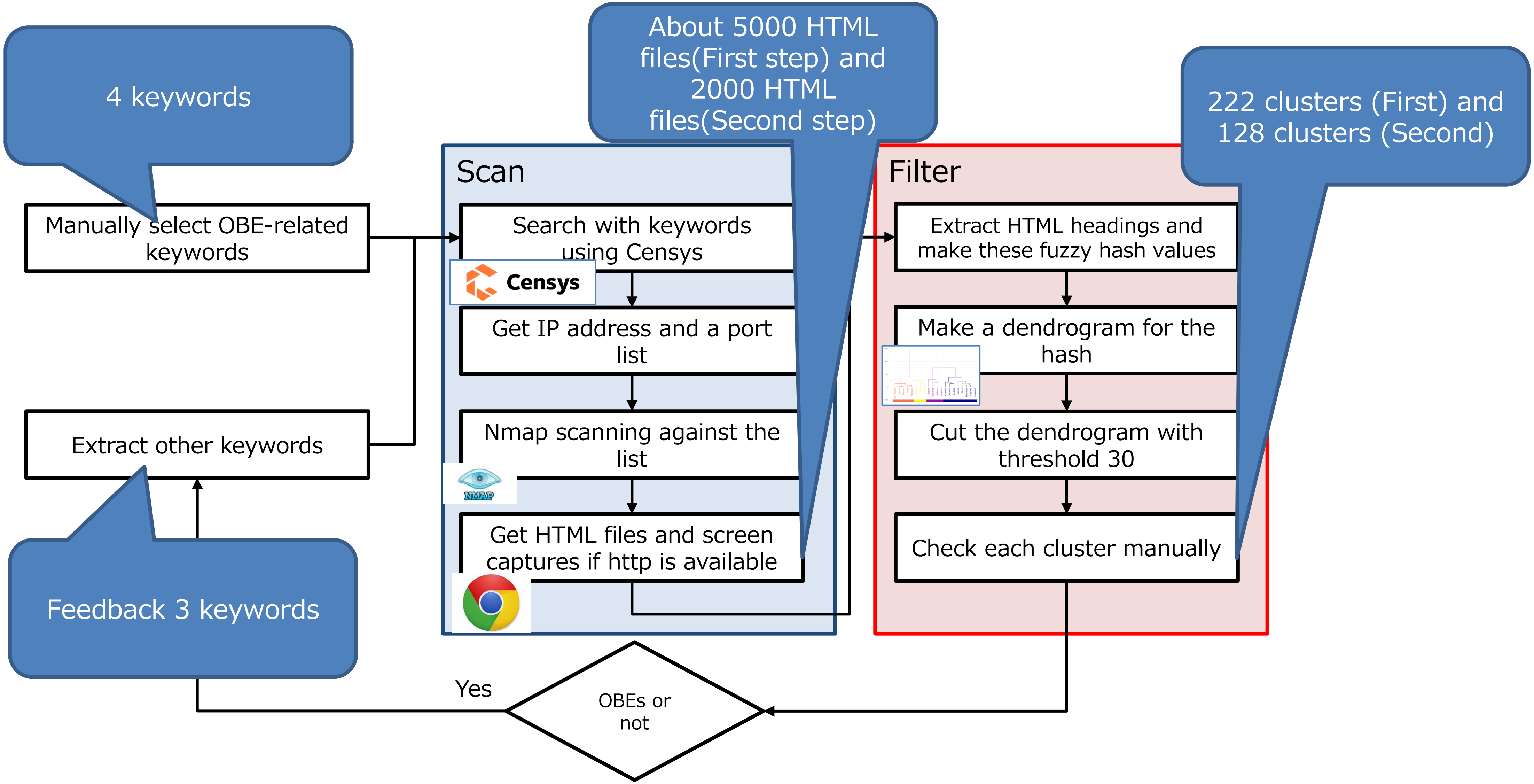
Extract other keywords

Feedback two keywords

Yes

OBE or not

Experiment details (clustering)



4 keywords

Manually select OBE-related keywords

Extract other keywords

Feedback 3 keywords

About 5000 HTML files(First step) and 2000 HTML files(Second step)

Scan

Search with keywords using Censys

Censys

Get IP address and a port list

Nmap scanning against the list

Get HTML files and screen captures if http is available

Filter

Extract HTML headings and make these fuzzy hash values

Make a dendrogram for the hash

Cut the dendrogram with threshold 30

Check each cluster manually

222 clusters (First) and 128 clusters (Second)

OBEs or not

Yes

Example: Discovered device 1/2

- Device F
  - Description
    - Multi-Port LTE-A Pro Rugged Vehicle Router for Public Safety Fleets and Industrial IoT.
  - Interfaces
    - Gigabit Ethernet ports (4), RS-232, USB 2.0, Configurable I/O and analog inputs

Example: Discovered device 2/2

- Device G
  - Description of the manual
    - This device enables WAN connectivity for moving vehicles and contribute a reliable bi-directional communication for other on-board electronic devices.
  - Interfaces
    - 3-port gigabit Ethernet, digital IO, and RS232 serial.
    - A communication hub for other on-board electronic devices

Device Security

We investigated device security from network observations and online manuals.

7 out of 12 products run telnet/FTP

8 out of 12 products run outdated software

9 out of 12 products are confirmed/capable to connect to in-vehicle NW

4 out of 12 products expose sensitive information (e.g. location)

device name	Build-in/Retrofit	Manufacture country	Telnet/FTP	Weak default password	Outdated software	Telnet without Authentication	Connect to in-vehicle network	Information disclosure
A	Retrofit	US	-	-	Tildeslash monit 5.0	-	Confirmed by WebUI	Running process
B	Retrofit	FR	Telnet	-	OpenSSH 5.1	Possible	Confirmed by telnet	Location, ignition, and more…
C	?	US	-	Exists	Anonymized server name 1	-	-	-
D	?	DE	FTP, Telnet	-	OpenSSH 6.0p1 light httpd 1.4.26 PHP 5.2.6 Debian 7.0	-	Possible according to manual	-
E	?	DE	Telnet	-	Dropbear SSH 2017.75 light httpd 1.4.53 PHP 5.6.31	-	Possible according to manual	-
F	Retrofit	CA	Telnet	-	-	-	Possible according to manual	Location
G	Built-in	TW	-	-	-	-	Possible according to manual	-
H	Retrofit	FR	-	-	PHP 5.3.10	-	Possible according to manual	-
I	Built-in	SK	FTP	-	CrushFTP	-	-	-
J	Retrofit	CA	Telnet	-	-	-	Possible according to manual	Location
K	Built-in	ES	FTP	-	-	-	Possible according to manual	-
L	?	US	-	Exists	Anonymized server name 2	-	-	-

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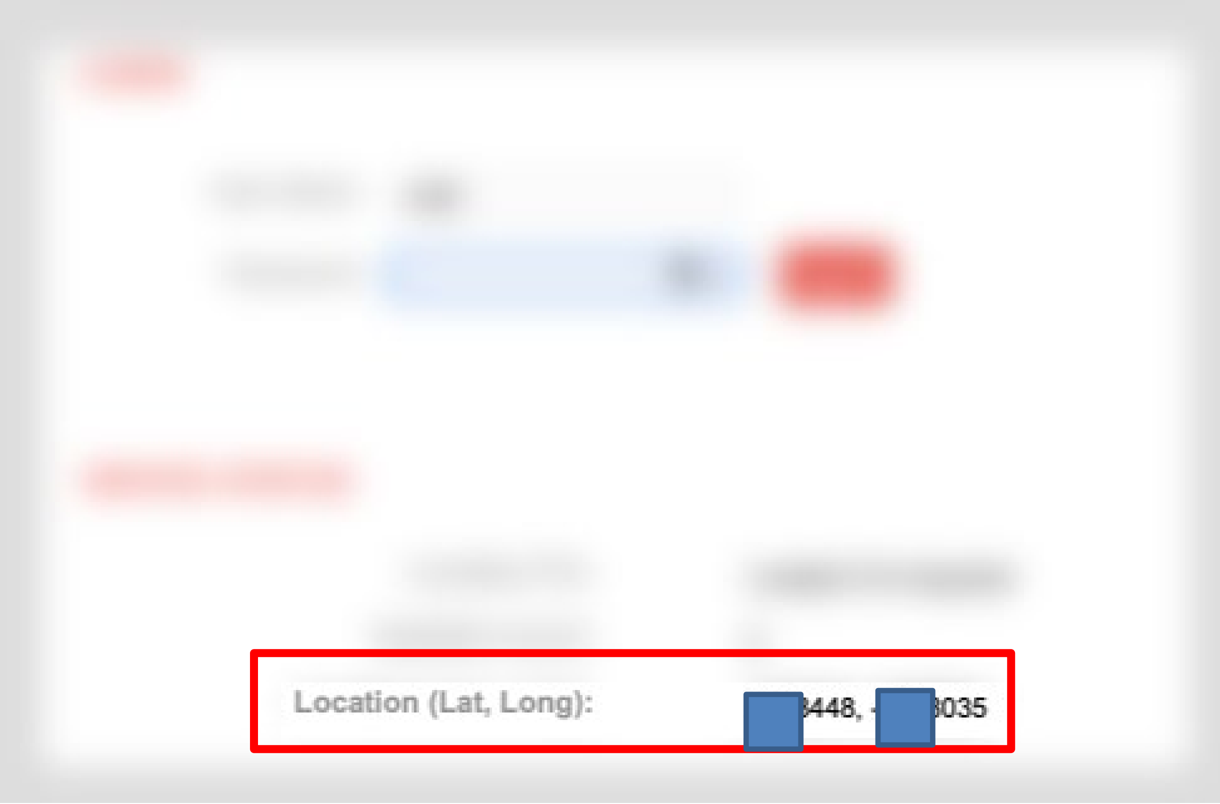
L	?	US	-	Exists	Anonymized server name 2	-	-	-

Location privacy issue

- Device G opens 80/tcp and has a login console. The console discloses GPS location.



Location (Lat, Long): [redacted]448, -[redacted]035

Notification to the manufacturers

- As a result of the security investigation, we identified that most devices have security concerns.
- From the viewpoint of responsible disclosure, we notified 11 manufacturers of the devices with security concerns.

Questionnaire for manufactures

- With the notification document, we sent the following questions to OBE manufacturers.
  - Q1. Is the Web UI image from your product [product name]?
  - Q2. Were you aware of any security concerns?
  - Q3. Would you consider taking any mitigating actions regarding this security notification and what is it?
- 7 out of 11 manufacturers responded to our notification, and one manufacturer answered to our questionnaire.

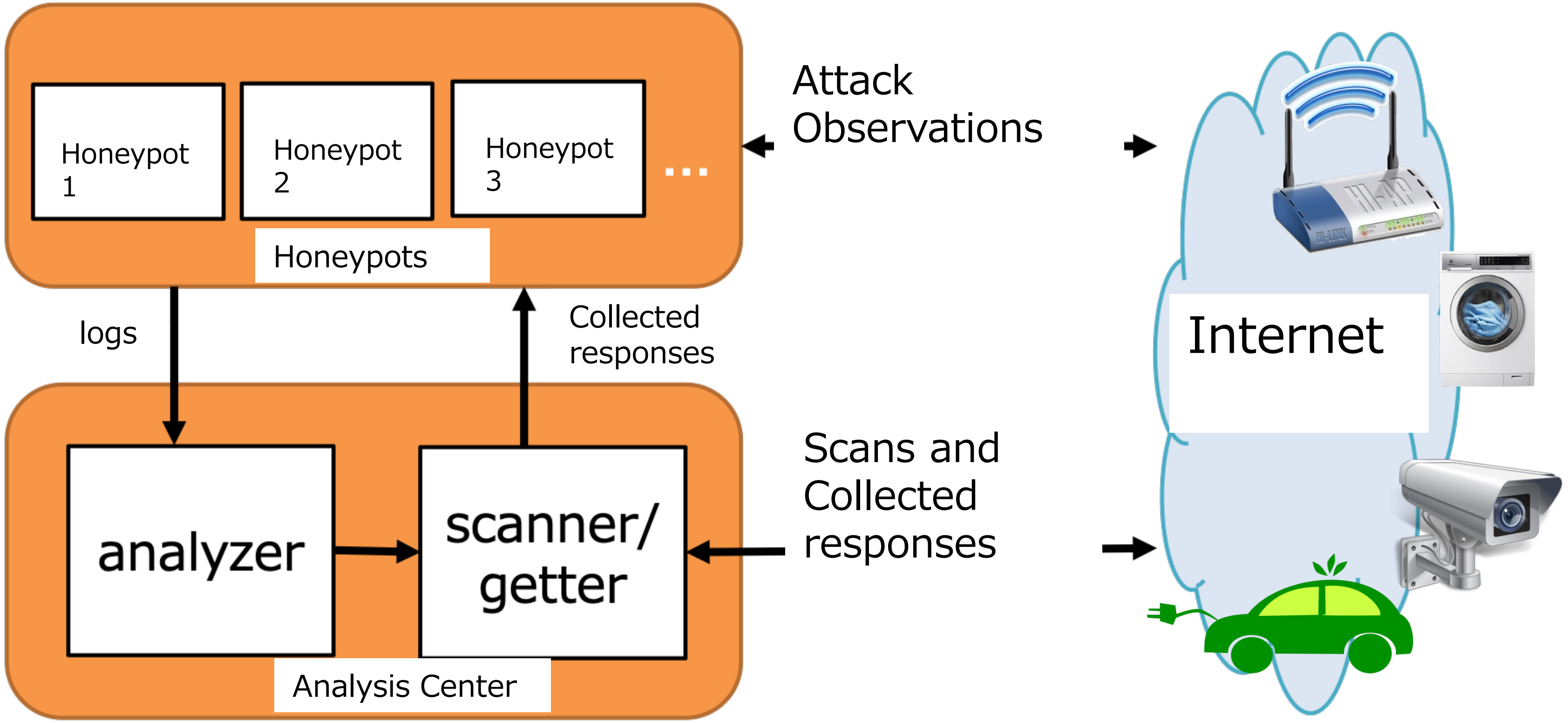
Responses from manufacturers

Manufacturer	Device	Our notification	Our questionnaire	Response from Manufacturers
1	A	Responded	Unanswered	It's a specification, not a vulnerability
2	B	Responded	Answered	Will remind clients to apply the available update with correct configuration for the affected devices
3	C	Responded	Unanswered	It's a specification, not a vulnerability
3	D	Responded	Unanswered	It's a specification, not a vulnerability
4	E	Acknowledgement	Unanswered	
4	F	Acknowledgement	Unanswered	
5	G	Ignored	Ignored	
7	I	Acknowledgement	Unanswered	It is great to hear from you that our product, device I is listed at your survey for vehicle solutions. Could you share the report for our reference? Thank you.
8	J	Ignored	Ignored	
5	K	Ignored	Ignored	
9	L	Ignored	Ignored	

For those manufacturers who did not respond at all, we also sent notification to the corresponding national CERT to inform the issue.

Creating honeypot imitating discovered devices (work-in-progress)

X-pot, our adaptive IoT honeypot, uses collected responses from Internet-wide scans as responses of honeypots.



We utilize this concept for vehicular honeypot.

Summary

- We focused on the case that On Board Equipment directly connects to the Internet.

- We proposed a discovery method of connected OBE and found 12 OBE models (2,532 devices). They were routers or gateways for vehicles.

- We have started preliminary observations by our honeypots imitating discovered devices.

◆ Related publications

Takahiro Ueda, Takayuki Sasaki, Katsunari Yoshioka, and Tsutomu Matsumoto, "An Internet-wide View of Connected Cars: Discovery of Exposed Automotive Devices," Proc. The 2nd International Workshop on Security and Privacy in Intelligent Infrastructures (SP2I 2022), 2022.

Takayuki Sasaki, Akira Fujita, Carlos Hernandez Ganan, Michel van Eeten, Katsunari Yoshioka, Tsutomu Matsumoto, "Exposed Infrastructures: Discovery, Attacks and Remediation of Insecure ICS Remote Management Devices," Proc. 43rd IEEE Symposium on Security and Privacy (IEEE S&P), 2022.

Seiya Kato, Rui Tanabe, Katsunari Yoshioka, Tsutomu Matsumoto, "Adaptive Observation of Emerging Cyber Attacks targeting Various IoT Devices," IFIP/IEEE International Symposium on Integrated Network Management (IM), 2021.