AHA - Adaptive Honeypot Alternative

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Introduction

Related work

- Honeypots are resources designed to be under attack [5]
- End eighties / early nineties first experiments by Clifford Stoll [6], Steven Bellovin [1] and Bill Cheswick [2]
- They mainly reported how they trapped attackers and the related activities
- In 1998 Fred Cohen discussed the deception techniques that can be used while dealing with attackers [3]
- Lance Spitzner writes that honeypots are particularly useful to learn from attackers
- Jose Antonio Coret re-implemented an SSH server in python as honeypot [4]

Introduction

Attack Scenario

Step	Attacker	Honypot	Comment
0	SSH connect		Attacker penetration
1		Returns shell	Full access
2	id		System identification
3		Execute id	
4	uname		System identification
5		Execute uname	
6	ps aux		Already compromised?
7		Execute ps	
8	wget URL_0		Acquire tool
9		Execute wget	
10	$./ssh - brute$		Misuse the system
11		Return error	Strategical block
12	wget URL_1		Additional tool
13		Execute wget	
14	./configure	Build attacker tool	Source code
15		Allow	Make attacker happy

Introduction

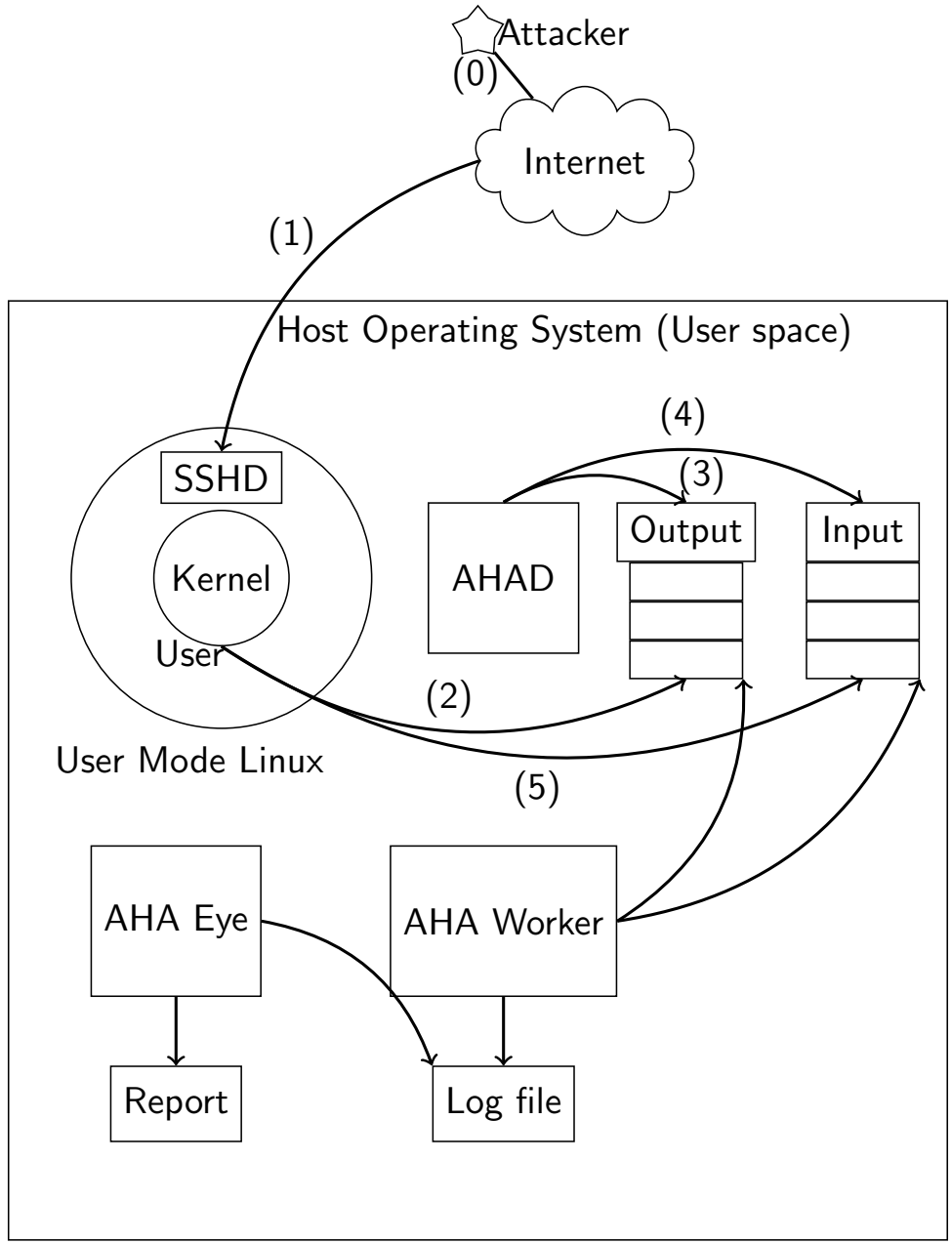
Contribution

- Create framework serving as building blocks for adaptive honeypots
- Optimize information retrieval from attackers (skills, tools, used time, social background, used language)
- Based on a Linux operating system exposing a vulnerable SSH server

Adaptation mechanisms

- Allow the execution of a program
  - Behave like a regular high-interaction honeypot
  - Do not interfere with the execution flow
- Block the execution of a program
  - Strategically block the execution of a program
  - Challenge the attacker
- Substitute the executed program
  - Make attacker believe that they downloaded the wrong program
  - Make attacker believe that their repository is not available
- Insult the attacker
  - Irritate attacker
  - Reveal his ethic background
  - Differentiate between automated attacks and human attackers
  - See if attackers bounce through compromised hosts

AHA framework - Overview



Components interaction

- Linux system call hooks
  - sys_execve
  - sys_clone
  - sys_exit
- Send messages to AHA daemon
- A decision must be taken (not included in the framework)
- Exchange Messages
  - Export message $\rightarrow$ export kernel information to the daemon
  - Reply message $\rightarrow$ decision taken by the daemon
  - Export and reply messages are tighly linked $\rightarrow$ unique message identifier

Components interaction

```
1  type=1
2  file=/usr/bin/vi
3  argument=vi
4  env=TERM=screen
5  env=SHELL=/bin/bash
6  env=SSH_CLIENT=192.168.1.2 41836 22
7  env=SSH_TTY=/dev/pts/0
8  env=USER=gabriela
9  env=PATH=/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin
10 env=LANG=en_US.UTF-8
11 env=HISTCONTROL=ignoreboth
12 env=SHLVL=1
13 env=HOME=/home/gabriela
14 env=LOGNAME=gabriela
15 env=SSH_CONNECTION=192.168.1.2 41836 192.168.1.1 22
16 env=_=/usr/bin/vi
17 pid=1100
18 ppid=1075
19 rppid=1075
20 DONE=1
```

Reply message

```
1  struct ReplyMessage{
2      int block;
3      int substitue;
4      int insult;
5  };
```

Components description

User Mode Linux surgeries

Building an UML from a vanilla kernel

```
1 make defconfig ARCH=um
2 make ARCH=um
```

Modified kernel files

File	Function
arch/um/kernel/exec.c	`sys_execve`
arch/um/kernel/process.c	`exit_thread`
arch/um/sys-i386/syscalls.c	`sys_clone`
os-Linux/main.c	`__init`

Purpose: Export program execution data and let the daemon take the decisions

Components description

User Mode Linux surgeries

Sys_execve hook

```
long sys_execve(char __user *file, char __user *__user *argv,
        char __user *__user *env)
{
    long error;
    char *filename;
    struct ReplyMessage msg;
    filename = aha_dump_execve(file,argv,env);
    if (filename){
        aha_get_reply_message(filename,&msg);
        kfree(filename);
        /* Implement decisions taken by AHA */
        if (msg.block) {
            error = msg.block;
            goto out;
        }
        if (msg.insult) {
            aha_handle_insult_messages(&msg,file,argv);
        }else {
            if (msg.substitute) {
                aha_handle_substitutes(&msg,file,argv);
            }
        }
   }
```

Components description

AHA daemon

Operation

- Read messages initiated by the User Mode Linux
- Is the program execution related to an attacker?
- Take a decision and put it in the input queue

Code Organization

- AHAActions → core functions to interact with the User Mode Linux
- KERNEL_ERRORS → Strategical blocking (taken from the Kernel Source)
- ReplyMessage → Create a binary reply message for the User Mode Linux
- ProcessTree → Maintain in the daemon a clone of the process tree of the UML

Components description

AHA Worker

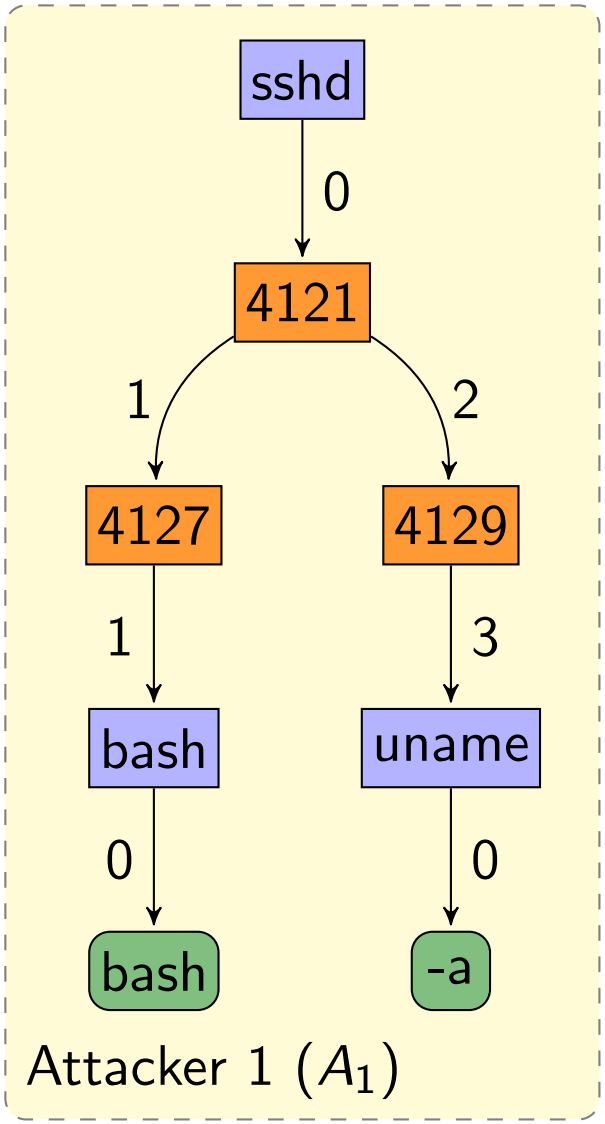
- Execution performance is critical
- AHA daemon only takes decisions
- AHA Worker periodically polls the queues
- Merges messages in a log file
- Avoid overfilled queues

Components description

AHA Eye

- Monitoring is essential for honeypot operation
- Human readable form is desired
- AHA Eye uses the log file from AHA Worker
- Creates a report $\rightarrow$ attacker's bash session

Is the program related to an attacker or the system?



Legend

Program name

PID

Command line argument

Classified programs

$\sum ts$	Program name
0	*sshd*
2	
5	

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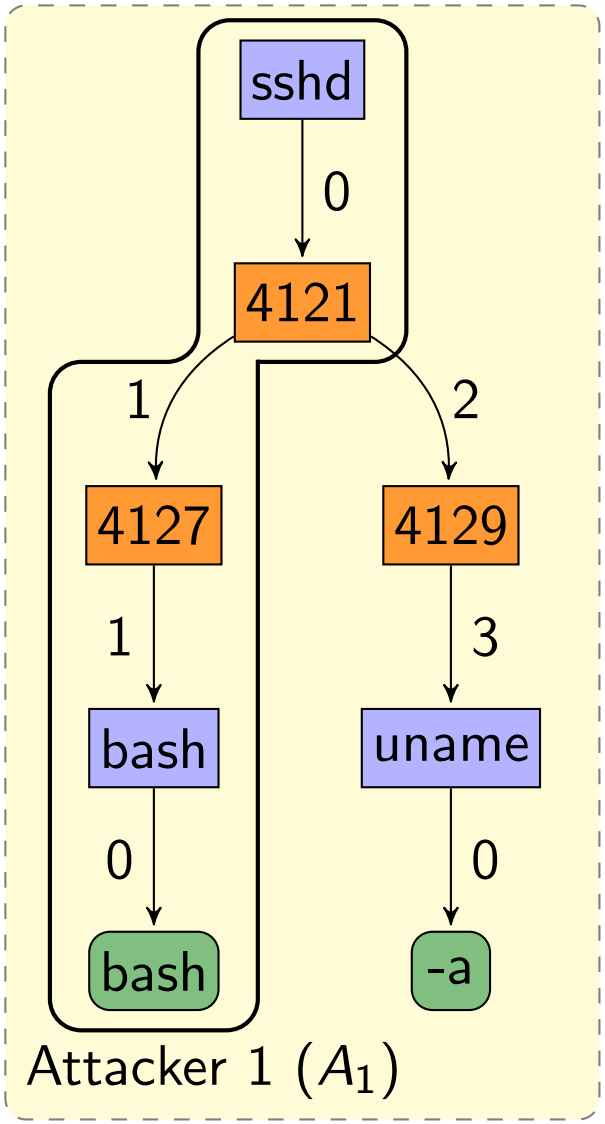

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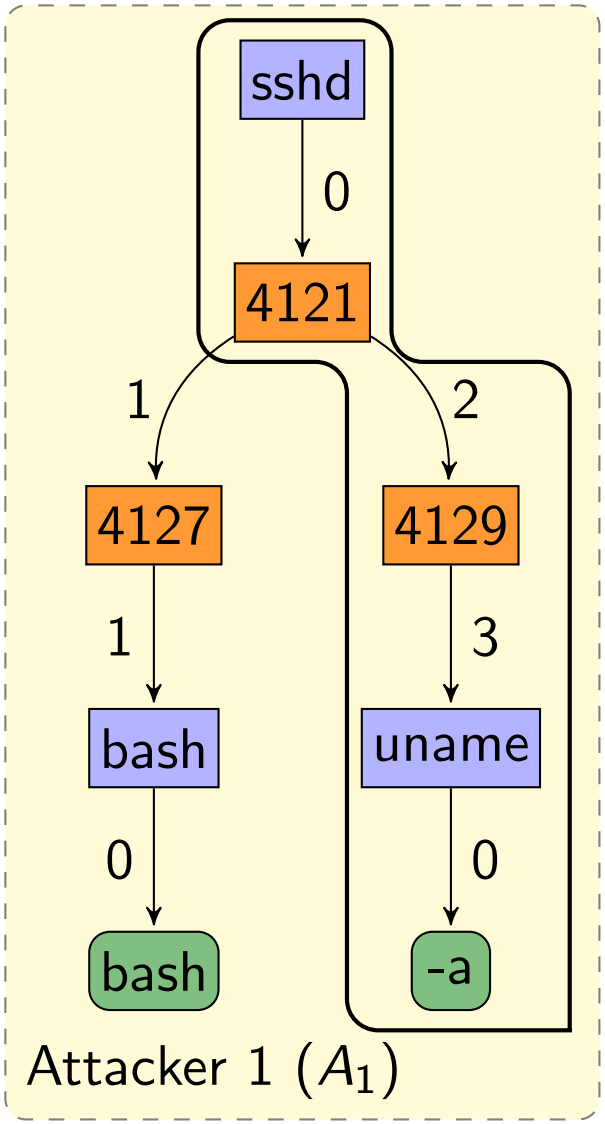

Legend

- Program name
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2	*bash*
5	*uname*

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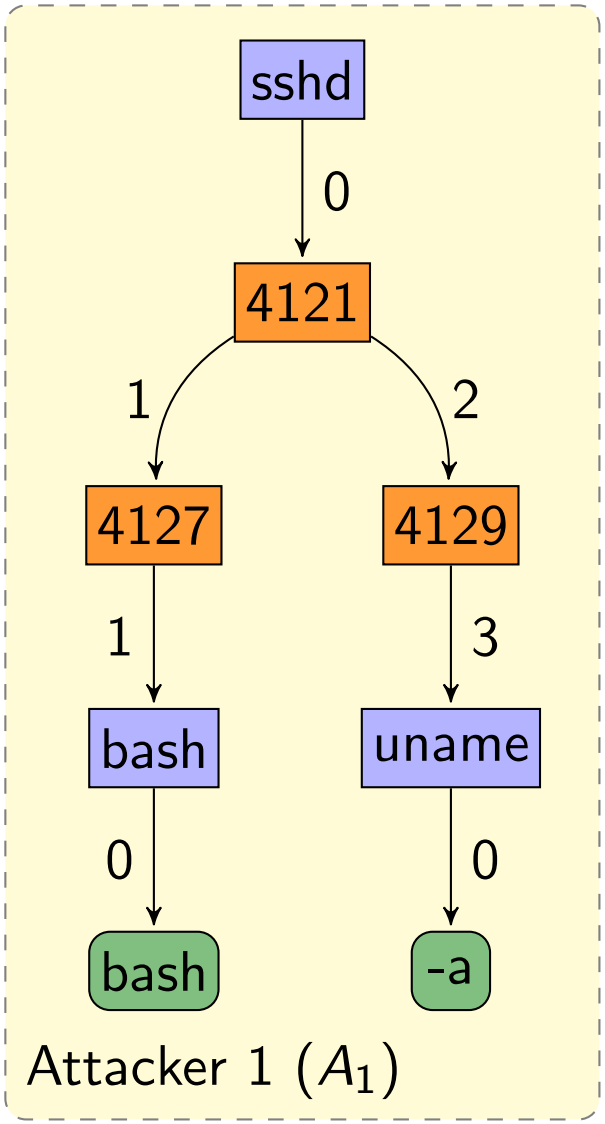


Legend

- Program name
- PID
- Command line argument

Classified programs

$\sum ts$	Program name
0	*sshd*
2	*bash*
5	*uname*

$\vec{A_1} =< sshd, bash, uname >$

Insulting the attacker

```
1  void aha_handle_insult_messages(struct ReplyMessage *msg,
2                                  char __user* file,
3                                  char __user* __user* argv)
4
5      char buf[16];
6      char* addr;
7      int cnt;
8
9      if(!copy_to_user(file,"/sbin/insult",13)){
10         cnt = snprintf((char*)&buf,16,"%d",msg->insult);
11         if ((cnt > 0) && (cnt<15))
12             buf[cnt+1]=0;
13             if (!get_user(addr,argv))
14                 copy_to_user(addr,buf,cnt+1);
15      }
16
```

Substituting programs works similarly

Gathering insults from an attacker

Problem

- Insults = invalid programs
- Handled by Bash

Solution (ugly)

- Hook bash using the `NOTFOUND_HOOK`
- Use helper application that just accepts the arguments
- When the helper application is started a `sys_execve` is induced
- This is then visible for the AHA daemon

Case Studies

Example Session (94.52.64.x username: test)

w

. .. scbrute.tar .wp

w

18:28:21 up 6:46, 1 user, load average: 0.15, 0.03, 0.01

bash

I dont wanna do that

sh

wget http://www.dragutrau.xxx.su/xxx/yyy

I love you

kill -9 1

Core dumped

l

. .. scbrute.tar .wp

fetch

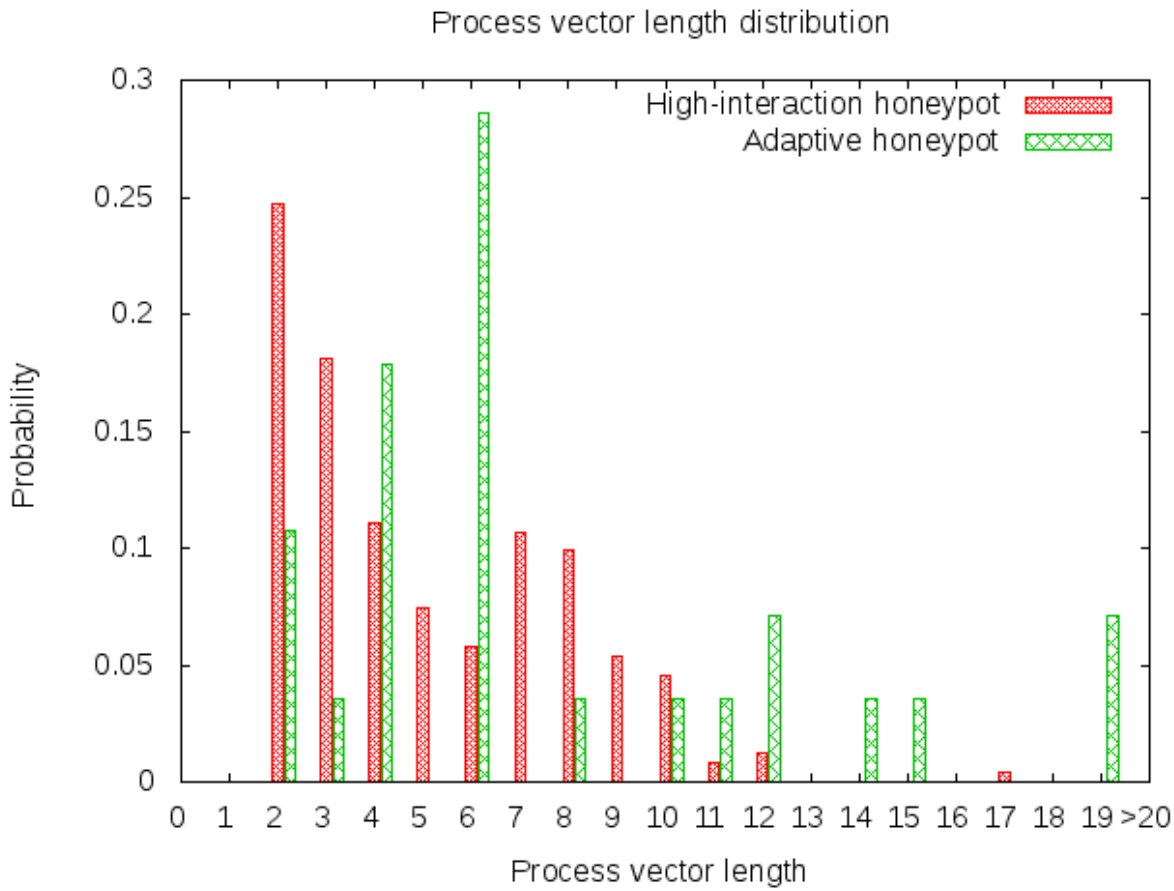
fuck you

exit

Case Studies

Experiment #1

Adaptive Honeypot vs High-Interaction Honeypot



Case Studies

Experiment #2

Insult Analysis

Language	Proportion	Country Code	Proportion
Undefined	51.8 %	RO	47%
Typographic errors	17.1%	DE	16%
Romanian	11.8%	ES	4%
English	9.2%	LU	4%
Smiley	5.3%	IT	4%
Slovak	5.3%	MK	4%
Croatian	1.0	LB	3%
Polish	1.0%	NL	2%
German	0.2%	GB	1%
others	33.06%	others	15%

Examples

muie, sex, fuck me, gogo, beto,hahahah, :)), pla, sugeo, please, sucker, bine, ?, noaon, qwerty ...

Future work and conclusions

- Future work
  - Execution slow-down $\rightarrow$ AHA is slower than an high-interaction honeypot
  - Evaluate timing attacks
  - Explore faster interprocess communication techniques
  - Insult program needs to be protected with rootkit techniques
  - Substituting a program can crash the program when the stack frame is too small
  - Vulnerable against indirect attacks $\rightarrow$ let the system continue the attack
  - Tests with the SKAS patch could be done
  - tty_read and tty_write could be monitored $\rightarrow$ insights about keystrokes
  - Instrument a virtual machine instead of User Mode Linux

Future work and conclusions

- Conclusions
  - Honeypots should become more intelligent and adaptive
  - Optimize information retrieval from attackers
  - Created an adaptive honeypot framework to investigate learning techniques
  - Extended User Mode Linux
  - Each system call related to program execution needs to be acknowledged by the AHA daemon
  - Freely available at git.quuxlabs.com

Demo in progress ...

Thank you for your patience ...

Questions and Answers

Thank you for your attention
Questions?
Comments for improvement?

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