CS3251 HW1

Dezhi Fang, dezhifang@gatech.edu, 903133949, dfang30

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Problems

Problem 1

`WebATM` Protocol extends `HTTP` protocol by adding the following verbs: `ID`, `AUTH`, `CARD_AUTH`, `AMOUNT`, `WITHDRAW` and `BYE`. `WebATM` also defines several headers used in the process: `AUTH_TOKEN` and `TRANSACTION_TOKEN`. `WebATM` should only be used with `HTTPS` with strict cryptography verification. ATMs must not proceed with any further actions should the Bank fails the verification.

Headers

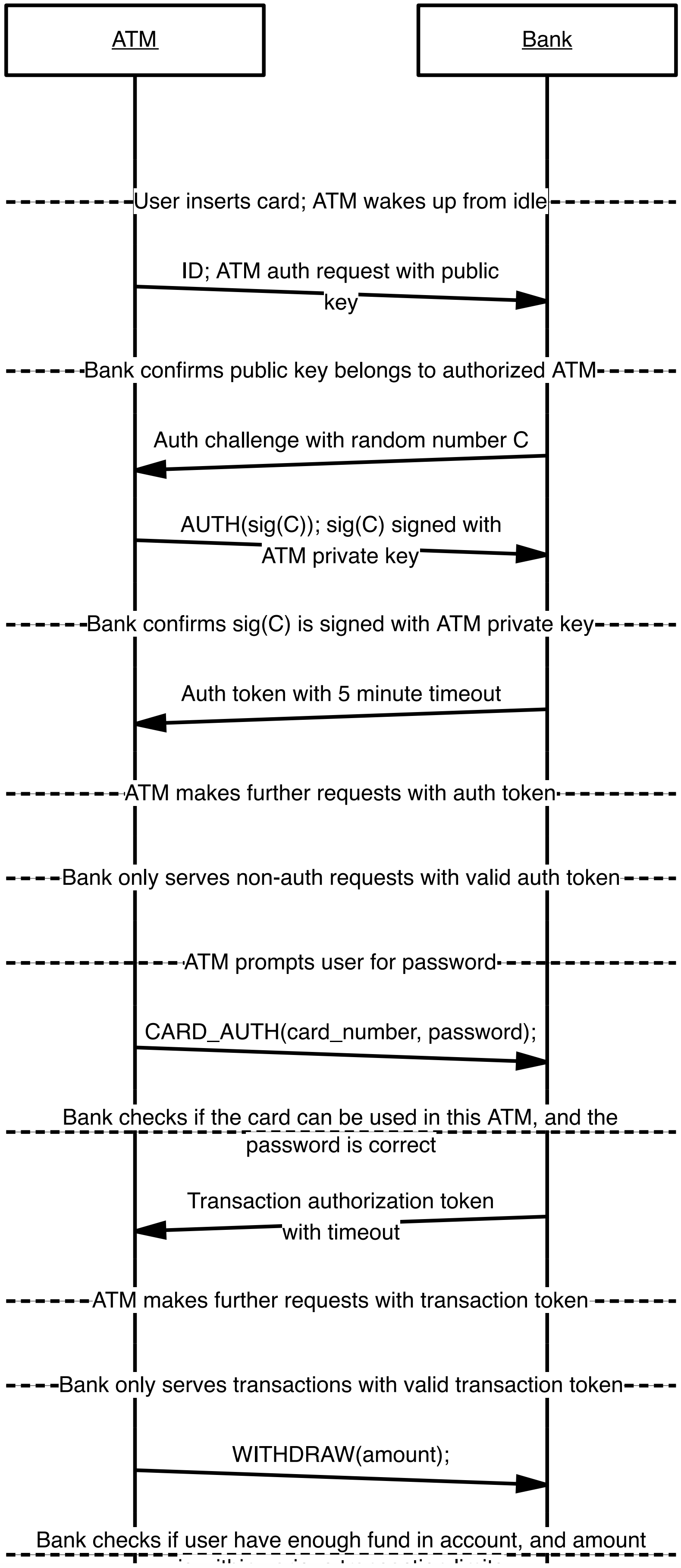
- `AUTH_TOKEN`: Authentication token Bank replied to the ATM upon the ATM successfully verifies its identity (that the ATM is a Bank authorized device). By default, times out in 5 minutes.
  - These verbs will only be processed with a valid `AUTH_TOKEN` header: `CARD_AUTH`,

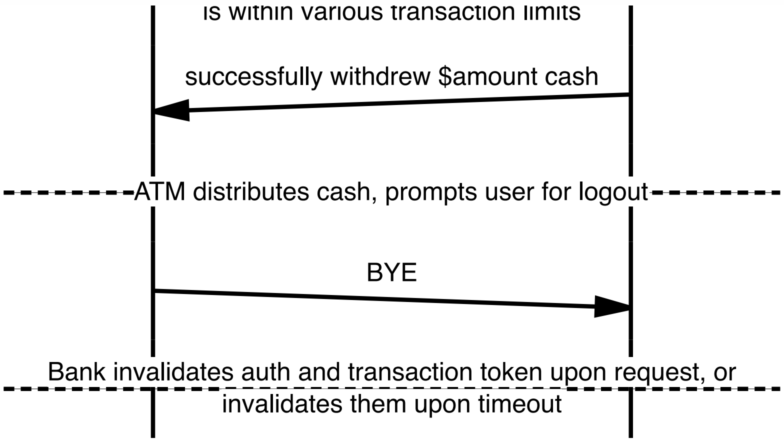
`AMOUNT`, `WITHDRAW` and `BYE`.
  - This token establishes the ATM's identity.
- `TRANSACTION_TOKEN`: Authentication token Bank replied to the ATM upon the ATM authenticates a credit card with its password. By default, times out in 5 minutes.
  - These verbs will only be processed with a valid `TRANSACTION_TOKEN` header: `AMOUNT` and `WITHDRAW` .
  - This token authorizes the ATM to perform transactions on a user's account.

Verbs

- `ID`: ATM sends this request with its public key.
  - Upon receiving this request, the bank verifies if the ATM is authorized.
    - If authorized, replies with an authentication challenge (ramdom number) `C`.
- `AUTH`: ATM sends this request with authentication challenge `C` signed with its private key, `sig(C)`.
  - Upon receiving this request, the bank verifies that `sig(C)` is actually signed with the ATM's private key.
    - If confirmed, replies ATM with `AUTH_TOKEN` .
- `CARD_AUTH`: ATM sends this request with header `AUTH_TOKEN`, card number and user's password input.
  - Upon receiving this request, the bank verifies if the card number and password correctly authenticates the user.
    - If confirmed, replies ATM with `TRANSACTION_TOKEN` that authorizes the ATM of transaction on the user's account.
    - If not verified, replies ATM with an error.
- `AMOUNT`: ATM sends this request with header `AUTH_TOKEN` and `TRANSACTION_TOKEN`.
  - Upon receiving this request, the bank replies with the amount of funds available in the card associated with `TRANSACTION_TOKEN`.
- `WITHDRAW`: ATM sends this request with header `AUTH_TOKEN` and `TRANSACTION_TOKEN`, and with the amount requested by user.
  - Upon receiving the request, the bank first checks if the user's account has more available funds than requested by the user and the amount is within transaction limits.
    - If the check fails, respond the user with an error.
    - If the check succeeds, decrement the user's account with the amount requested, and responds the client with the amount successfully withdrew.
- `BYE`: ATM sends this request with header `AUTH_TOKEN` and, optionally, `TRANSACTION_TOKEN`.
  - Upon receiving the request, the bank invalidates the `AUTH_TOKEN` and

`TRANSACTION_TOKEN` if they are not already timed out.


ATM
Bank
User inserts card; ATM wakes up from idle
ID; ATM auth request with public key
Bank confirms public key belongs to authorized ATM
Auth challenge with random number C
AUTH(sig(C)); sig(C) signed with ATM private key
Bank confirms sig(C) is signed with ATM private key
Auth token with 5 minute timeout
ATM makes further requests with auth token
Bank only serves non-auth requests with valid auth token
ATM prompts user for password
CARD_AUTH(card_number, password);
Bank checks if the card can be used in this ATM, and the password is correct
Transaction authorization token with timeout
ATM makes further requests with transaction token
Bank only serves transactions with valid transaction token
WITHDRAW(amount);
Bank checks if user have enough fund in account, and amount


is within various transaction limits
successfully withdrew $amount cash
ATM distributes cash, prompts user for logout
BYE
Bank invalidates auth and transaction token upon request, or invalidates them upon timeout

Problem 7

Time to encode first packet: $56bytes/(64000bps/8) = 7ms$

Time to transmit a packet: $56 \times 8/(2 \times 10^6)sec = 224\mu s$

Total delay: $7ms + 10ms + 224\mu s = 17.224ms$.

Problem 8

1. 20 users
2. 0.1
3. $C(120, n)(0.1)^n(0.9)^{120-n}$
4. $1 - \sum_{n=0}^{20} C(120, n)(0.1)^n(0.9)^{120-n}$

Problem 18

For detailed trace logging, see Appendix A. Traces are done in an AWS EC2 server in `us-east-1` towards Google Public DNS (`8.8.8.8`).

Trace	Mean	Stddev	Number of Routers
Trace 1	9.309	0.02052	15 (16 - 1)
Trace 2	9.14633	0.14238	16 (17 - 1)
Trace 3	9.43733	0.17753	16 (17 - 1)

Number of routers changed from the second trace.

Problem 22

1. $(1 - p)^N$
2. $\frac{1}{(1-p)^N} - 1$

Problem 23

1. L/R_s
2.
   1. Yes. If the first packet haven't finished transmitting in R_c while the second packet arrives at the router, the second packet could be queued.
   2. Time for router to transmit the first packet: L/R_c. Time for server to transmit the second packet: L/R_s. Answer: $L/R_c - L/R_s$.

Problem 31

1. $\frac{8\times10^6}{2\times10^6} \times 3 = 12s$
2.
   1. $\frac{10^4}{2\times10^6}s = 5ms$
   2. $\frac{10^4}{2\times10^6}s \times 2 = 10ms$
3. $\frac{8\times10^6}{2\times10^6}s + 2 \times 5ms = 4.01s$. Similar to pipelining, segmentation is able to fully utilize the network by having multiple packets on the wire at a given time. Segmentation significantly improves the time to transmit large messages.

Problem 33

Time to send = $(cell(\frac{F}{S}) + 2) \times \frac{80+S}{R})$ => $S = \sqrt{40F}$

Appendix A

Traceroute logs

Trace 1, 7PM Sep 8

```
traceroute to 8.8.8.8 (8.8.8.8), 30 hops max, 60 byte packets
 1  216.182.226.44 (216.182.226.44)  11.454 ms 216.182.224.138 (216.182.224.138)
20.640 ms 216.182.226.38 (216.182.226.38)  19.083 ms
 2  100.66.12.144 (100.66.12.144)  14.788 ms 100.66.8.58 (100.66.8.58)  17.798 ms
100.66.12.212 (100.66.12.212)  19.180 ms
 3  100.66.14.86 (100.66.14.86)  17.062 ms 100.66.14.230 (100.66.14.230)  41.476 ms
100.66.14.2 (100.66.14.2)  16.025 ms
 4  100.66.7.225 (100.66.7.225)  15.793 ms 100.66.6.203 (100.66.6.203)  16.647 ms
100.66.6.195 (100.66.6.195)  21.768 ms
 5  100.66.4.69 (100.66.4.69)  23.107 ms 100.66.4.33 (100.66.4.33)  39.708 ms
100.66.4.225 (100.66.4.225)  12.909 ms
 6  100.65.9.1 (100.65.9.1)  0.770 ms 100.65.9.225 (100.65.9.225)  0.492 ms
100.65.8.193 (100.65.8.193)  0.365 ms
 7  205.251.244.196 (205.251.244.196)  1.312 ms 52.93.24.26 (52.93.24.26)  2.722 ms
205.251.245.54 (205.251.245.54)  1.176 ms
 8  54.239.111.30 (54.239.111.30)  871.679 ms 52.93.24.9 (52.93.24.9)  1.939 ms
54.239.111.22 (54.239.111.22)  72.890 ms
 9  54.239.111.30 (54.239.111.30)  873.585 ms 54.239.109.25 (54.239.109.25)  1.312 ms
54.239.111.18 (54.239.111.18)  43.330 ms
10  72.14.203.120 (72.14.203.120)  1.198 ms 72.14.216.104 (72.14.216.104)  1.118 ms
1.165 ms
11  108.170.246.2 (108.170.246.2)  1.221 ms 72.14.216.104 (72.14.216.104)  1.478 ms
108.170.246.48 (108.170.246.48)  1.897 ms
12  108.170.235.157 (108.170.235.157)  2.478 ms  2.400 ms 108.170.246.48
(108.170.246.48)  1.816 ms
13  216.239.50.93 (216.239.50.93)  2.061 ms 216.239.48.2 (216.239.48.2)  9.740 ms
216.239.48.9 (216.239.48.9)  9.552 ms
14  216.239.48.9 (216.239.48.9)  9.483 ms  9.722 ms 216.239.48.6 (216.239.48.6)  12.866
ms
15  * * *
16  google-public-dns-a.google.com (8.8.8.8)  9.310 ms  9.288 ms  9.329 ms
```

Trace 2, 8PM Sep 8

```
traceroute to 8.8.8.8 (8.8.8.8), 30 hops max, 60 byte packets
 1  216.182.224.116 (216.182.224.116)  12.733 ms 216.182.224.178 (216.182.224.178)
21.230 ms 216.182.226.50 (216.182.226.50)  16.142 ms
 2  100.66.8.164 (100.66.8.164)  20.354 ms 100.66.8.142 (100.66.8.142)  264.723 ms
100.66.12.250 (100.66.12.250)  11.874 ms
 3  100.66.10.202 (100.66.10.202)  15.670 ms 100.66.11.226 (100.66.11.226)  15.432 ms
100.66.10.162 (100.66.10.162)  15.747 ms
 4  100.66.6.139 (100.66.6.139)  16.337 ms 100.66.6.197 (100.66.6.197)  61.304 ms
100.66.7.161 (100.66.7.161)  20.604 ms
 5  100.66.4.7 (100.66.4.7)  20.574 ms 100.66.4.251 (100.66.4.251)  17.233 ms
100.66.4.9 (100.66.4.9)  20.561 ms
 6  100.65.8.225 (100.65.8.225)  0.674 ms 100.65.11.129 (100.65.11.129)  0.413 ms
100.65.8.225 (100.65.8.225)  0.301 ms
 7  205.251.245.235 (205.251.245.235)  1.219 ms 52.93.24.18 (52.93.24.18)  3.150 ms
205.251.244.194 (205.251.244.194)  1.269 ms
 8  52.93.24.9 (52.93.24.9)  1.223 ms 52.93.24.33 (52.93.24.33)  1.137 ms 52.93.24.9
(52.93.24.9)  1.150 ms
 9  54.239.109.10 (54.239.109.10)  25.865 ms 54.239.111.22 (54.239.111.22)  12.425 ms
54.239.108.145 (54.239.108.145)  1.388 ms
10  54.239.108.247 (54.239.108.247)  1.402 ms 72.14.216.104 (72.14.216.104)  2.683 ms
54.239.108.137 (54.239.108.137)  1.910 ms
11  72.14.212.130 (72.14.212.130)  2.385 ms 108.170.246.16 (108.170.246.16)  1.648 ms
72.14.203.120 (72.14.203.120)  1.363 ms
12  108.170.246.16 (108.170.246.16)  2.867 ms 216.239.49.197 (216.239.49.197)  2.565 ms
108.170.240.113 (108.170.240.113)  1.747 ms
13  216.239.48.6 (216.239.48.6)  13.502 ms 216.239.50.93 (216.239.50.93)  3.600 ms
216.239.48.31 (216.239.48.31)  11.470 ms
14  216.239.47.184 (216.239.47.184)  9.472 ms 216.239.48.181 (216.239.48.181)  9.368 ms
216.239.49.79 (216.239.49.79)  13.423 ms
15  216.239.48.181 (216.239.48.181)  8.729 ms 209.85.251.243 (209.85.251.243)  9.359 ms
72.14.234.53 (72.14.234.53)  8.763 ms
16  * * *
17  google-public-dns-a.google.com (8.8.8.8)  9.051 ms  9.310 ms  9.078 ms
```

Trace 3, 9PM Sep 8

```
traceroute to 8.8.8.8 (8.8.8.8), 30 hops max, 60 byte packets
 1  216.182.226.36 (216.182.226.36)  15.700 ms 216.182.224.172 (216.182.224.172)
19.040 ms 216.182.224.178 (216.182.224.178)  21.528 ms
 2  100.66.8.98 (100.66.8.98)  11.445 ms 100.66.8.142 (100.66.8.142)  19.613 ms
100.66.12.164 (100.66.12.164)  13.575 ms
 3  100.66.10.232 (100.66.10.232)  12.037 ms 100.66.10.50 (100.66.10.50)  22.330 ms
100.66.15.4 (100.66.15.4)  16.806 ms
 4  100.66.6.129 (100.66.6.129)  20.044 ms 100.66.6.51 (100.66.6.51)  18.636 ms
100.66.7.135 (100.66.7.135)  17.336 ms
 5  100.66.4.121 (100.66.4.121)  18.094 ms 100.66.4.227 (100.66.4.227)  21.120 ms
100.66.4.127 (100.66.4.127)  19.104 ms
 6  100.65.10.193 (100.65.10.193)  0.644 ms 100.65.10.129 (100.65.10.129)  0.320 ms
100.65.11.1 (100.65.11.1)  0.306 ms
 7  205.251.245.235 (205.251.245.235)  1.205 ms 205.251.244.200 (205.251.244.200)
1.237 ms 52.93.24.38 (52.93.24.38)  12.061 ms
 8  54.239.109.44 (54.239.109.44)  2.018 ms 52.93.24.35 (52.93.24.35)  1.329 ms
52.93.24.9 (52.93.24.9)  1.211 ms
 9  54.239.108.96 (54.239.108.96)  51.382 ms 54.239.108.145 (54.239.108.145)  2.053 ms
54.239.108.198 (54.239.108.198)  13.770 ms
10  72.14.216.104 (72.14.216.104)  1.209 ms 72.14.203.120 (72.14.203.120)  2.009 ms
72.14.212.130 (72.14.212.130)  1.327 ms
11  108.170.246.81 (108.170.246.81)  8.773 ms 72.14.216.104 (72.14.216.104)  1.220 ms
72.14.203.120 (72.14.203.120)  1.209 ms
12  216.239.49.185 (216.239.49.185)  2.944 ms 108.170.246.67 (108.170.246.67)  1.709 ms
216.239.48.101 (216.239.48.101)  1.963 ms
13  216.239.48.6 (216.239.48.6)  9.745 ms 216.239.49.197 (216.239.49.197)  2.399 ms
216.239.50.93 (216.239.50.93)  2.398 ms
14  209.85.251.61 (209.85.251.61)  9.420 ms 216.239.48.2 (216.239.48.2)  14.314 ms
216.239.48.181 (216.239.48.181)  9.240 ms
15  216.239.48.237 (216.239.48.237)  8.811 ms 72.14.234.53 (72.14.234.53)  9.208 ms
216.239.48.181 (216.239.48.181)  9.207 ms
16  * * *
17  google-public-dns-a.google.com (8.8.8.8)  9.642 ms  9.325 ms  9.345 ms
```