

Enabling Multi-Layer Threat Analysis in Dynamic Cloud Environments - Supplemental

Salman Manzoor[§], Antonios Gougliadis, Matthew Bradbury and Neeraj Suri
Lancaster University, UK

Email: {s.manzoor1, a.gougliadis, m.s.bradbury, neeraj.suri}@lancaster.ac.uk

Listing 1: CPN ML implementation of Equation (1)

```

1 colset Usernames = string; (* Type of Usernames is string *)
2 colset Passwords = string; (* Type of Passwords is string *)
3 colset UNxPW = record un:Usernames * pw:Passwords; (* Type for multiple fields *)
4 var un:Usernames; (* Variable of type Usernames *)
5 var pw:Passwords; (* Variable of type Passwords *)
6 var U,C:UNxPW; (* Variables of type UNxPW *)
7 Auth_S = [#un(U)<>O andalso #un(U)=#un(C) andalso #pw(U)=#pw(C)] (* Trans. guard*)
8 O' = O^#un(U) (* Username is added to online users *)
9 Auth_F = [#un(U)=O orelse #un(U)=#un(C) orelse #pw(U)=#pw(C)] (* Trans. guard *)

```

Listing 2: CPN ML implementation of Equation (8)

```

1 colset CPU = string; (* Type of CPU is string *)
2 colset RAM = int; (* Type of RAM is int *)
3 colset DISK = int; (* Type of RAM is int *)
4 colset USERNAMExCPUxRAMxDISK = record un:USERNAME * cpu:CPU * ram:RAM * disk:DISK
5 var VM_req:USERNAMExCPUxRAMxDISK; (* Variable of type USERNAMExCPUxRAMxDISK *)
6 colset LOCxDC= record loc:LOC * dc:DC; (* Type of multiple fields *)
7 var srvr:LOCxDC; (* Type of LOCxDC *)
8 colset VMCONF = product USERNAMExCPUxRAMxDISK * LOCxDC (* Immutable fields *)
9 var VM_req_srvr:VMCONF; (* Variable of type VMCONF *)
10 colset IP = string; (* Type of IP is string *)
11 colset MAC= string; (* Type of MAC is string *)
12 colset IPxMAC= record ip:IP * mac:MAC; (* Type of multiple fields *)
13 var ret_dhcp:IPxMAC; (* Variable of type IPxMAC *)
14 colset DI = string; (* Type of DI is string *)
15 var get_di:DI; (* Variable of type DI *)
16 colset FCONF = product VMCONF * DI * IPxMAC;
17 var config:FCONF;
18 Final_confs = [#mac(ret_dhcp) = ret_vnic] (* Trans. guard*)

```

Listing 3: CPN ML implementation of Equation (10) and Equation (12)

```

1 colset SERVICE = string; (* Type of service is string *)
2 colset ISSUE = string; (* Type of ISSUE is string *)
3 colset SERxISS = record s:SERVICE * i:ISSUE;
4 var ser, rc, iss:SERxISS; (* Variable of type SERxISS *)
5 var act, atk:STRING;
6 PreCon_S = [#s(ser) = #s(rc) andalso #i(ser) = #i(rc)] (* Trans. guard*)
7 Exploit_S = if #i(iss) = act
8     then 1"bypass"
9     else empty (* Trans. guard and output condition merged *)

```

[§]. The research was conducted when the author was affiliated with Lancaster University.