Detailed computation of probabilities of occurrence

Ranwa Al Mallah

LiTrans, Ryerson University, Ontario, Canada

David López

GiiTraL, Universidad Nacional Autónoma de México, Mexico City, Mexico

Bilal Farooq

LiTrans, Ryerson University, Ontario, Canada

1. Detailed computation of probabilities of occurrence

The un-normalized probability of occurrence is the sum of the three actors attributes: capacity (c), opportunity (o) and motivation (m). The c, o, m values vary from 1 to 4, with 4 corresponding to a higher likelihood. The un-normalized probability of occurrence $P(G_i, S_i, A_k)$ as follows:

$$P(G_i, S_j, A_k) = c(G_i, S_j, A_k) + o(G_i, S_j, A_k) + m(G_i, S_j, A_k)$$

such that:

$$f: S_j \mapsto G_i: f \text{ is given by Table 1}$$
 $c(G_i, S_j, A_k) \in \{1, 2, 3, 4\}$
 $o(G_i, S_j, A_k) \in \{1, 2, 3, 4\}$
 $m(G_i, S_j, A_k) \in \{1, 2, 3, 4\}$
 $i \in \{1, 2, ..., 5\}$
 $j \in \{1, 2, ..., 22\}$
 $k \in \{1, 2, 3, 4, 5\}$

The Tables 2 to 6 show the rates assigned to $c(G_i, S_j, A_k)$, $o(G_i, S_j, A_k)$, $c(G_i, S_j, A_k)$ for a given attack goal, G_i , scenario, S_j , and actor A_k

Email addresses: ranwa.almallah@ryerson.ca (Ranwa Al Mallah), dlopezfl@iingen.unam.mx (David López), bilal.farooq@ryerson.ca (Bilal Farooq)

Table 1: Possible scenarios per attack goal

Attack goal	Label	Scenarios
Gain knowledge about the data-market	G_1	$S_1, S_3, S_4, S_7, S_8, S_{10}, S_{12}, S_{20}$
Access sensitive data on the nodes of	G_2	$S_1, S_3, S_4, S_7, S_8, S_{10}, S_{12}, S_{20}$
the network	<u> </u>	3, 5, 5, 4, 5, 7, 5, 6, 5, 10, 5, 12, 5, 20
Manipulate and modify blockchain in-	G_3	$S_1, S_{10}, S_{11}, S_{14}, S_{15}, S_{16}, S_{17}, S_{18}, S_{19}, S_{21}$
formation	0,	3 1, 5 10, 5 11, 5 14, 5 13, 5 16, 5 1/, 5 18, 5 19, 5 21
Sabotage activities	G_4	$S_1, S_2, S_5, S_6, S_7, S_8, S_9, S_{10}. S_{11}, S_{12}, S_{13},$
Subotage activities	04	$S_{14}, S_{15}, S_{16}, S_{17}, S_{18}, S_{19}, S_{21}, S_{22}$
Induce participants in the blockchain	G_5	$S_1, S_2, S_5, S_6, S_7, S_8, S_9, S_{10}. S_{11}, S_{12}, S_{13},$
network to make errors	U5	$S_{14}, S_{15}, S_{16}, S_{17}, S_{18}, S_{19}, S_{21}, S_{22}$

Table 2: Probability of occurrence of identified threats for G_1 - Gain knowledge about the data-market

S _j	A_k	c	0	m	P
	A_1	3	3	2	8
C	A_2	2	3	4	9
S_1	A_3	2 1	3	3	8
	A_4	1	3 2	3 3	6
	A_1 A_2	1		1	4
C	A_2	2	2 2	3	7
S_3	A_3	2	2 1	2	4 7 6
	A_4	1 2 2 2 2 2 2 2 2 2 3 2 2 2 2 2 1 2 2 1 2 1	1	2 2 2	5 4 8 7 7
	A_1	1	1	2	4
S_4	A_2	2	2	4	8
34	A_3	2	1 2 2	3	7
	$\begin{vmatrix} A_2 \\ A_3 \\ A_4 \end{vmatrix}$	2	2 2 2 2 2	3	7
	A_1	2	2	1	5
C	A_2	2	2	2	6
S_7	A_3	1	2	1	4
	A_3 A_4	2	2	1	5
	A_1	3	2 2 1	2	7
C	A_2	2	2	2 2	6
S_8	A_3	2	1	1	4
	A_4	2	1	1	4
	$ \begin{array}{c c} A_3 \\ A_4 \\ \hline A_1 \\ A_2 \end{array} $	2	1	1	4
C	A_2	1	1	2	4
S_{10}	A_3	1	1	2	3
	A_3 A_4	1	1	1	3
	A_1	2	1	1	4
C	A_2	2 2 1 1	1	ı	5 6 4 5 7 6 4 4 4 3 3 3 4 5 3
S_{12}	A_3	1		2 1	3
		1	1 1	1	3
	$\begin{array}{ c c } A_4 \\ A_1 \\ A_2 \end{array}$		2	1	5
C	A_2	2	2	2	6
S 20	A_3	2 2 2 1	2 2 2 2		5 6 5 4
	A_4	1	2	1	4

Table 3: Probability of occurrence of identified threats for G_2 - Access sensitive data on the nodes of the network

S _j	A _k	c	0	m	P
	A_1		3	3	9
	A_2	2	3	3	8
S_1	A_3	2	3 3	3	8
	A_4	1	2	4	7
	A_1	1	1	2	4
C	A_2	2	2	2	6
S_3	A_3	2	2	3	7
	A_{2} A_{3} A_{4} A_{1} A_{2} A_{3} A_{4}	3 2 2 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	2 1 2 2 1 2 2 2 2 1	3 3 4 2 2 2 3 4	7
	A_1 A_2 A_3 A_4 A_1 A_2 A_3 A_4	1	2	1	4
S_4	A_2	3	2	2	7
34	A_3	3	2	2	7
	A_4	2	1	3	6
	A_1	2	3	1	6
S_7	A_2	2	2	1	5
37	A_3	2	2	2	6
	A_4	2	1	2	5
	A_1	3	2	2	7
S_8	A_2	1	1	2	4
38	A_3	2	2	2	6
	A_1 A_2 A_3 A_4 A_1 A_2 A_3 A_4	2	2	2	6
	A_1	2	2	1	5
S 10	A_2	2	1	1	4
3 10	A_3	2	1	2	5
	A_4	1	1	2	4
	A_1	2	1	2	5
S 12	A_2	1	1	2	4
3 12	A_3	1	1	2	4
	A_4	1	1	2	4
	A_1 A_2 A_3 A_4 A_1 A_2 A_3	2	3 2 2 1 2 2 2 2 1 1 1 1 1 1 1 1 1 2 2 2 1	1 2 2 3 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2	9 8 8 7 4 6 7 7 6 6 5 6 5 7 4 6 6 5 4 5 4 4 4 5 5 6 5 6 5 6 6 5 6 6 6 7 7 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7
S 20	A_2	1	2	2	5
3 20	A_3	2 1 1 1	2	3	6
	A_4	1	1	3	5

Table 4: Probability of occurrence of identified threats for G_3 - Manipulate and modify blockchain information

and modi					P
S_{j}	A _k	c	0	m	
	A_1	2	3	3	8
S_1	A_2	1	2	3	6
	A_3	1	2	3	6
	A_4	2	2	4	8
	A_1	3	1	1	5
S_{10}	A_2	1	1	2	4
	A_3	1	1	1	3
	A_4	3	3	2	8
	A_1	1	1	2 3	4
S_{11}	A_2	1	2		6
	A_3	1	1	2	4
	A_4	4	3	4	11
	A_1	1	1	1	3
S 14	A_2	1	1	1	3
	A_3	1	1	1	3
	A_4	3	2	2	7
	A_1	1	1	1	3
S ₁₅	A_2	1	1	1	3
- 13	A_3	1	1	1	3
	A_4	2	1	2	3 5 3
	A_1	1	1		3
S_{16}	A_2	1	1	1	3
~ 10	A_3	1	1	1	3 5
	A_4	1	1	3	
	A_1	1	1	1	3
S 17	A_2	1	1	2	4
5 17	A_3	1	1	1	3
	A_4	2	2	2	6
	A_1	3	1	2	6
S_{18}	A_2	2	2	2	6 4
5 18	A_3	1	1	2	
	A_4	3	2	2	7
	A_1	1	1	1	3
S 19	A_2	1	1	1	3 3 6
D 19	A_3	1	1	1	3
	A_4	2 1	2	2	
	A_1	2	1	2	5 3 3
S_{21}	A_2		1	1	3
J 21	A_3	1	1	1	3
	A_4	4	2	2	8

Table 5: Probability of identified threats for G_4 - Sabotage activities

Table 6: Probabil	ities	for (G_5	- I	ndı	ice	participants	in	the
blockchain networ	rk to	mak	e e	rro	rs				
	S_j	A _k	c	0	m	P			

S_j	$\mathbf{A}_{\mathbf{k}}$	c	0	m	P
	A_1	3	3	4	10
S_1	A_2 A_3	2 2	2 2	4	8
	A_4	2	2	2	6
	A ₁	4	4	4	12
	A_1 A_2	4	4	4	12
S_2	A_3	4	4	4	12
	A_4	4	4	2	10
	A ₁	3	1	3	7
	A_1 A_2	1	1	2	4
S_5	A_3	1	1	2	4
	A_4	1	2	4	7
	A ₁	2	1	2	5
	A_2	1	1	2	4
S_6	A ₃	1	1	2	4
	A ₄	1	2	2	5
	A ₁	4	1	2	7
	A_2	2	1	1	4
S_7	A_3	2	1	1	4
	A_4	1	1	2	4
	A ₁	4	1	2	7
	A_1 A_2	3	1	2	6
S_8	A_3	3	1	2	6
	A_4	1	2	2	5
	A_4 A_1	2	1	3	6
	A_1 A_2	1	1	2	4
S_9	A12			2	4
	A_3 A_4	1	1 2	2	5
	A_4 A_1	2	1	3	6
		1	1	2	4
S_{10}	A ₂	1	1	2	4
	A_3 A_4	2	2	3	7
	A_1	1	1	3	5
	A_2	1	2	3	7
S_{11}	A_3	1	1	4	6
	A_4	4	3	3	10
	A ₁	3	1	2	6
	A_2	2	1	2	5
S_{12}	A_3	2	1	2	5
	A_4	1	2	1	4
	A ₁	2	2	2	6
	A_2	2	1	2	5
S_{13}	A_3	2	1	2	5
	A_4	1	2	2	5
	A ₁	1	1	1	3
	A_2	1	2	1	4
S_{14}	A_3	1	1	1	3
	A_4	2	2	3	7
	A ₁	1	1	1	3
_	A_2	1	1	1	3
S_{15}	A ₃	1	1	1	3
	A ₄	2	2	2	6
	A ₁	1	1	1	3
	A_2	1	1	2	4
S_{16}	A_3	1	1	2	4
	A ₄	1	1	3	5
	A ₁	1	1	2	4
	A_2	1	1	1	3
S_{17}	A_3	1	1	1	3
	A_4	2	1	2	5
	A ₁	3	1	2	6
	A_2	2	2	2	6
S_{18}	A_3	2	1	2	5
		4	3	2	9
	A_{A}		1	1	3
	A_4 A_1	1			
	A_1	1	1	1	3
S 19	A_1 A_2	1	1	1	3
S 19	A_1 A_2 A_3	1	1 1 2	1	3
S 19	A ₁ A ₂ A ₃ A ₄	1 1 2	1 2	1 2	3 6
	$A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_1$	1 1 2	1 2	1 2 2	3 6 5
S ₁₉	A_1 A_2 A_3 A_4 A_1 A_2	1 1 2 2	1 2 1 1	1 2 2	3 6 5 3
	A ₁ A ₂ A ₃ A ₄ A ₁ A ₂ A ₃	1 1 2 2 1 1	1 2 1 1 1	1 2 2 1 1	3 6 5 3 3
	A ₁ A ₂ A ₃ A ₄ A ₁ A ₂ A ₃ A ₄	1 1 2 2 1 1 4	1 2 1 1 1 2	1 2 1 1 2	3 6 5 3 8
S ₂₁	A ₁ A ₂ A ₃ A ₄ A ₁ A ₂ A ₃ A ₄ A ₁	1 1 2 2 1 1 4	1 2 1 1 1 2	1 2 2 1 1 2 3	3 6 5 3 8 11
	A ₁ A ₂ A ₃ A ₄ A ₁ A ₂ A ₃ A ₄	1 1 2 2 1 1 4	1 2 1 1 1 2	1 2 1 1 2	3 6 5 3 8

rk to	mak			rs	P
S_j	A _k	c	3	m	10
	A_1 A_2	4	2	3	9
S_1	A ₃	4	2	3	9
	A_4	2	2	3	7
	A_1	4	4	4	12
S_2	A_2	4	4	4	12
52	A_3	4	4	4	12
	A_4	4	4	3	11
	A_1 A_2	2	1	2	5
S_5	A ₂	1	1	1	3
	A_4	1	2	3	6
	A ₁	2	1	1	4
S_6	A_2	1	1	1	3
56	A ₃	1	1	1	3
	A4	1	2	2	5
	A_1	3	1	3	7
S_7	A ₂ A ₃	1	1	1	3
	A ₄	1	2	1	4
	A ₁	3	1	3	7
S 8	A_2	2	2	2	6
38	A_3	2	1	2	5
	A_4	1	2	2	5
	A_1	2	1	2	5
S_9	A ₂	1	1	1	3
	A_3 A_4	1	1	2	4
	A ₁	1	1	2	4
c	A_2	1	1	1	3
S_{10}	A_3	1	1	1	3
	A_4	2	1	1	4
	A_1	1	1	2	4
S_{11}	A_2	1	2	2 2	5 4
	A ₃ A ₄	1 4	3	4	11
	A ₁	2	1	3	6
	A_2	1	1	3	5
S_{12}	A_3	1	1	3	5
	A_4	1	1	1	3
	A_1	2	1	2	5
S_{13}	A_2	1	1	2	4
	A_3 A_4	1	1	2	4 3
	A ₁	1	1	1	3
C	A_2	1	1	2	4
S_{14}	A_3	1	1	2	4
	A_4	2	2	4	8
	A_1	1	1	1	3
S_{15}	A ₂ A ₃	1	1	1	3
	A ₃	1	1	2	4
	A ₁	1	1	1	3
c	A_2	1	1	1	3
S_{16}	A_3	1	1	2	4
	A_4	1	1	2	4
	A_1	1	1	2	4
S_{17}	A_2 A_3	1	1	1	3
	A_3 A_4	2	1	2	5
	A ₁	2	1	1	4
¢	A_2	1	1	2	4
S_{18}	A_3	1	1	2	4
	A_4	3	2	3	8
	A ₁	1	1	1	3
S_{19}	A ₂ A ₃	1	1	1	3
	A ₄	1	1	2	4
	A ₁	2	1	2	5
S_{21}	A_2	1	1	1	3
<i>□</i> 21	A_3	1	1	1	3
	A4	3	2	2	7
	A_1 A_2	4	4	4	12 12
S_{22}	A_2 A_3	4	4	4	12
	A_4	4	4	4	12
			_		