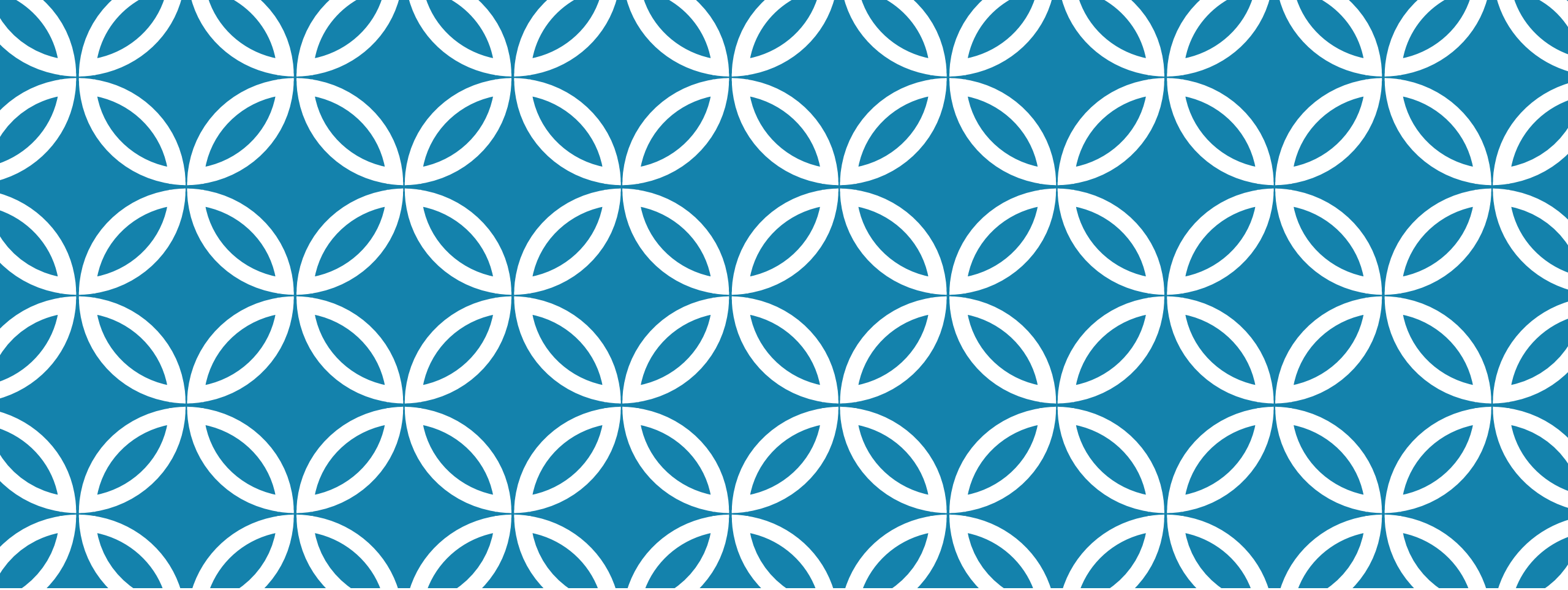

REVERSE ENGINEERING 17 CARS IN UNDER 10 MINUTES

BRENT STONE

Disclaimer About This Talk and The Github Repo

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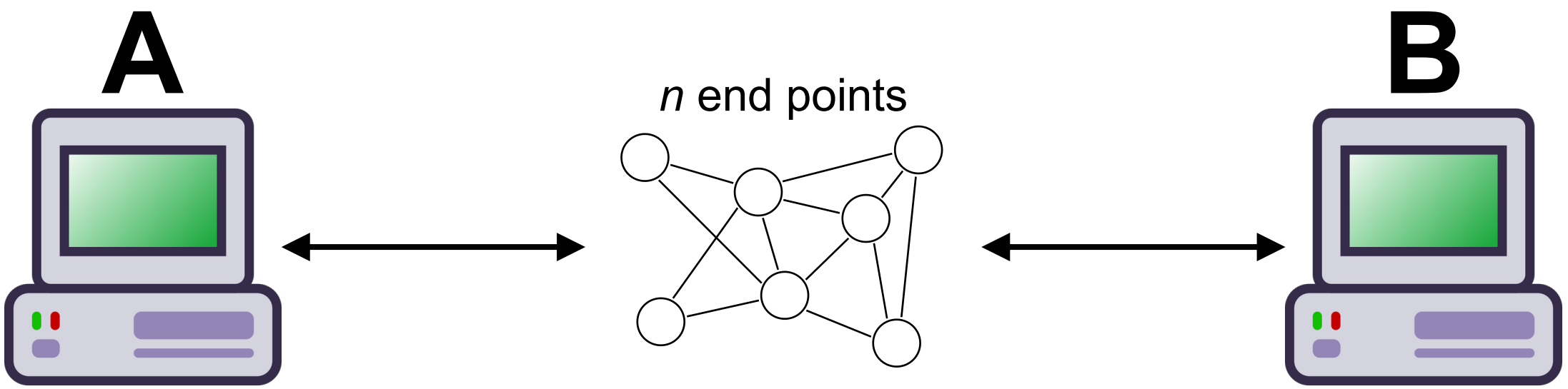
Case Numbers: 88ABW-2019-0910, 88ABW-2019-0024

General Use Networks



FLEXIBLE

- Modify End Points
- Modify Routing

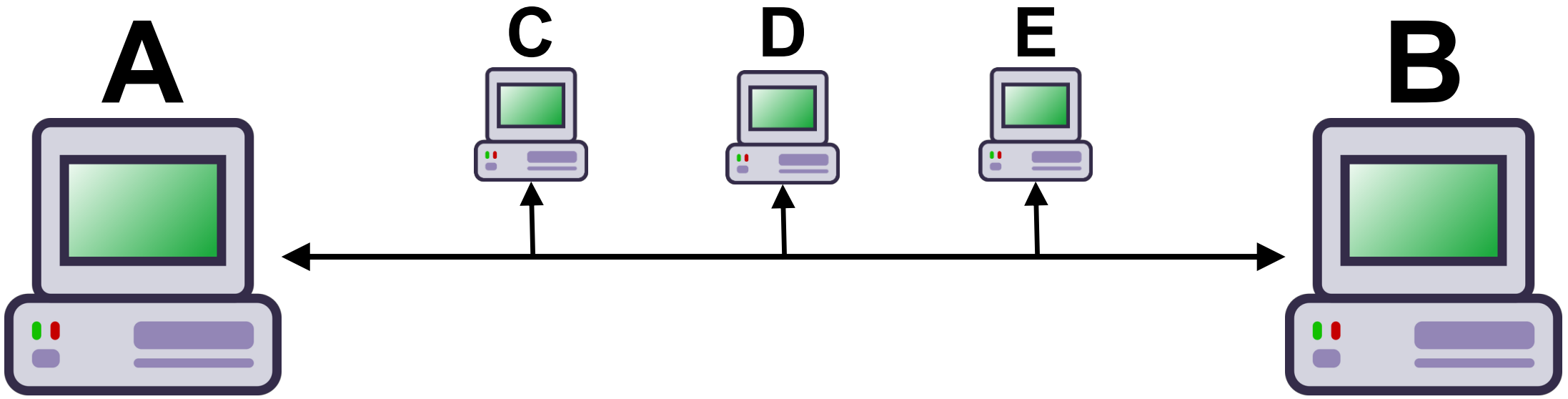
Meta Data

UNDETERMINABLE

- No delivery guarantee
- No timeliness guarantee

Meta Data

Control Networks



DETERMINABLE

- Delivery Guarantee
- Timeliness Guarantee

Meta Data

INFLEXIBLE

- Fixed End Points
- Fixed Routing

Meta Data

interwebs

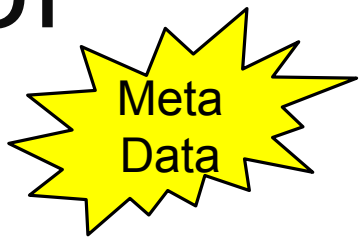
VoIP

Lots of people helping others play with general use networks…

IoT

smart phones

Automated Reverse Engineering of **General Use Networks**



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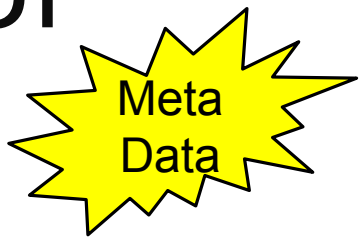
Automated Reverse Engineering of **General Use Networks**



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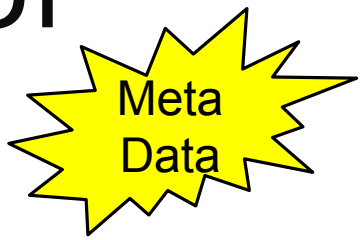
Automated Reverse Engineering of **General Use Networks**



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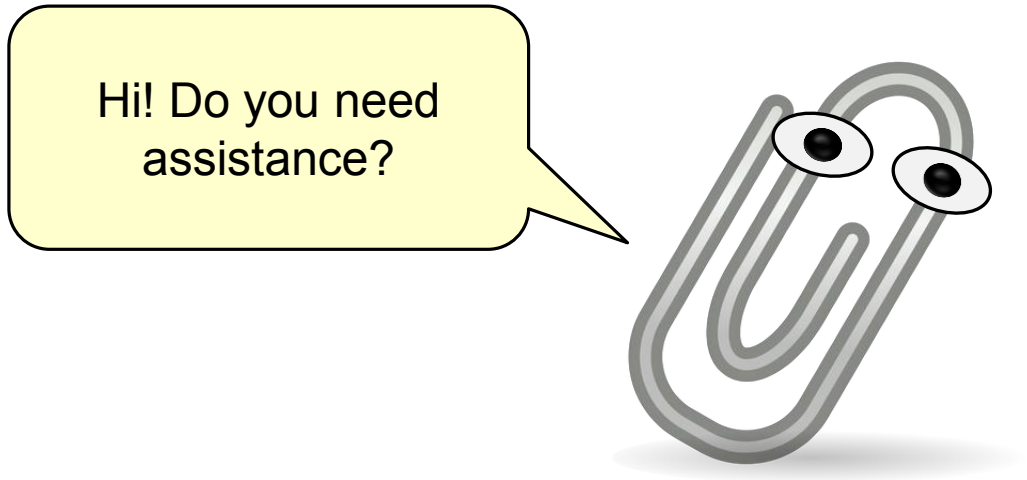
But what about robots, cars, and other control networks?

Now your computer can help!



#Started canhandler on can0
#Setup complete: 48.7387
#Format:

Time:	ID	DLC	Data							
48.740:	4a8	8	00	00	00	40	00	00	00	00
48.740:	020	7	00	00	07	01	00	00	2f	
48.742:	0b4	8	00	00	00	00	ac	00	00	68
48.742:	025	8	00	11	00	00	78	78	78	a6
48.743:	024	8	02	00	[illegible]	08	62	04	81	1f
48.743:	235	6	0[illegible]			00	00	3d		
48.744:	499	8	0[illegible]			00	00	00	00	00
48.745:	49a	8	00	85	[illegible]		80	28	a8	
48.746:	49b	8	0[illegible]	a[illegible]		00	00	48	10	
48.746:	262	5	20	00	0[illegible]		89			
48.747:	49d	8	61	60	0[illegible]		9d	19	c6	c5
48.747:	1c4	8	00	00	00	00	00	00	00	cd
48.749:	0aa	8	1a	6f	1a	6f	1a	6f	1a	6f
48.749:	0b6	4	00	00	00	ba				
48.749:	224	8	00	00	00	00	00	00	00	08
48.751:	127	8	68	10	00	08	00	0c	ed	a9
48.751:	020	7	00	00	07	01	00	00	2f	
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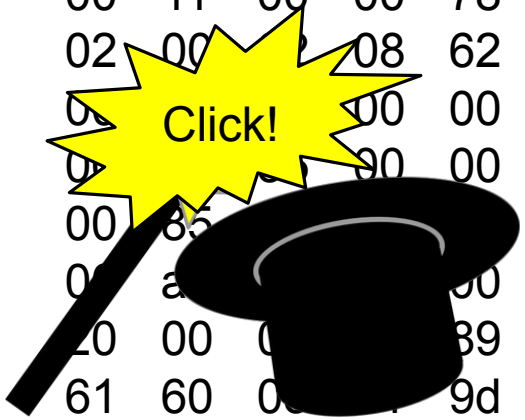
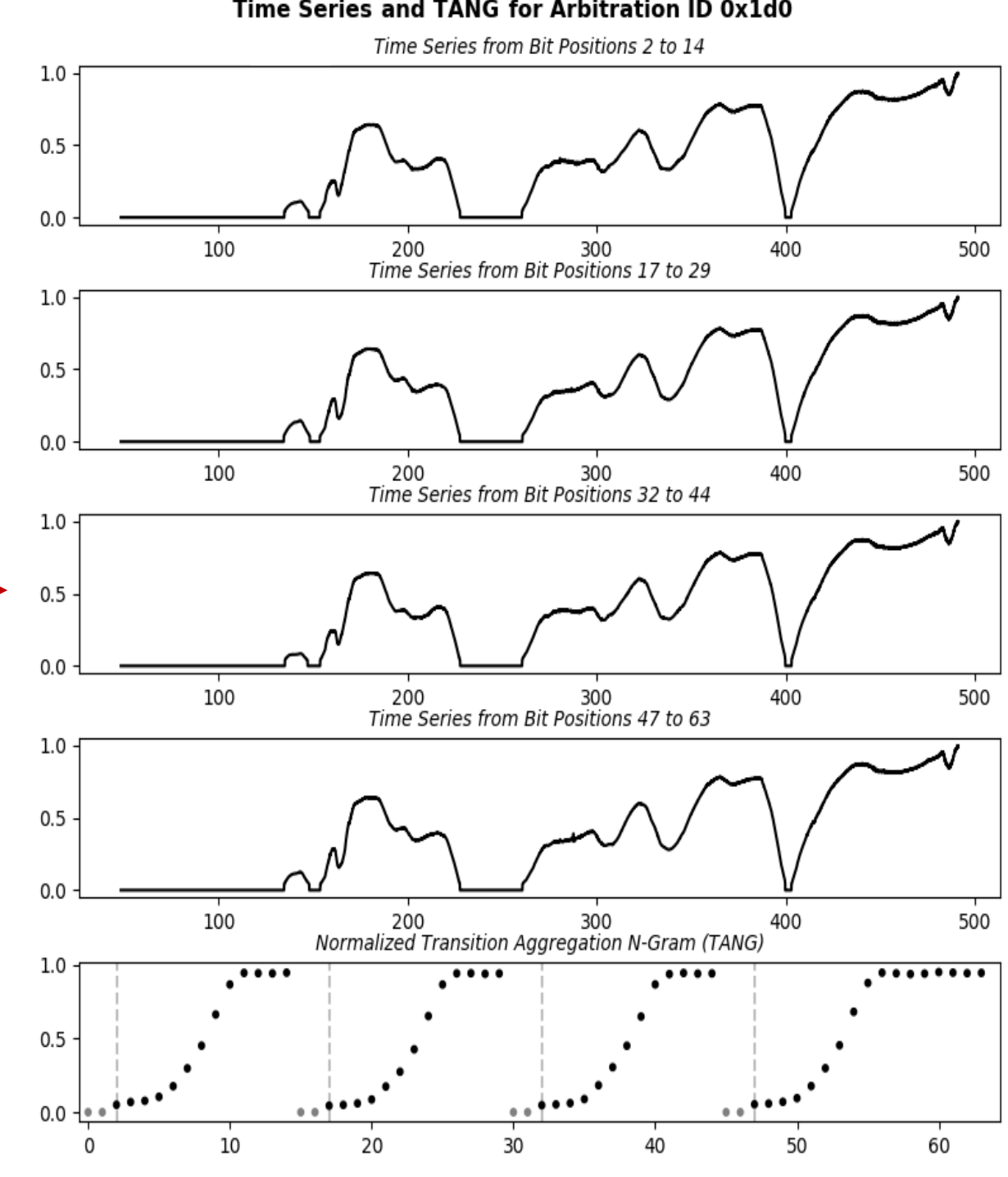
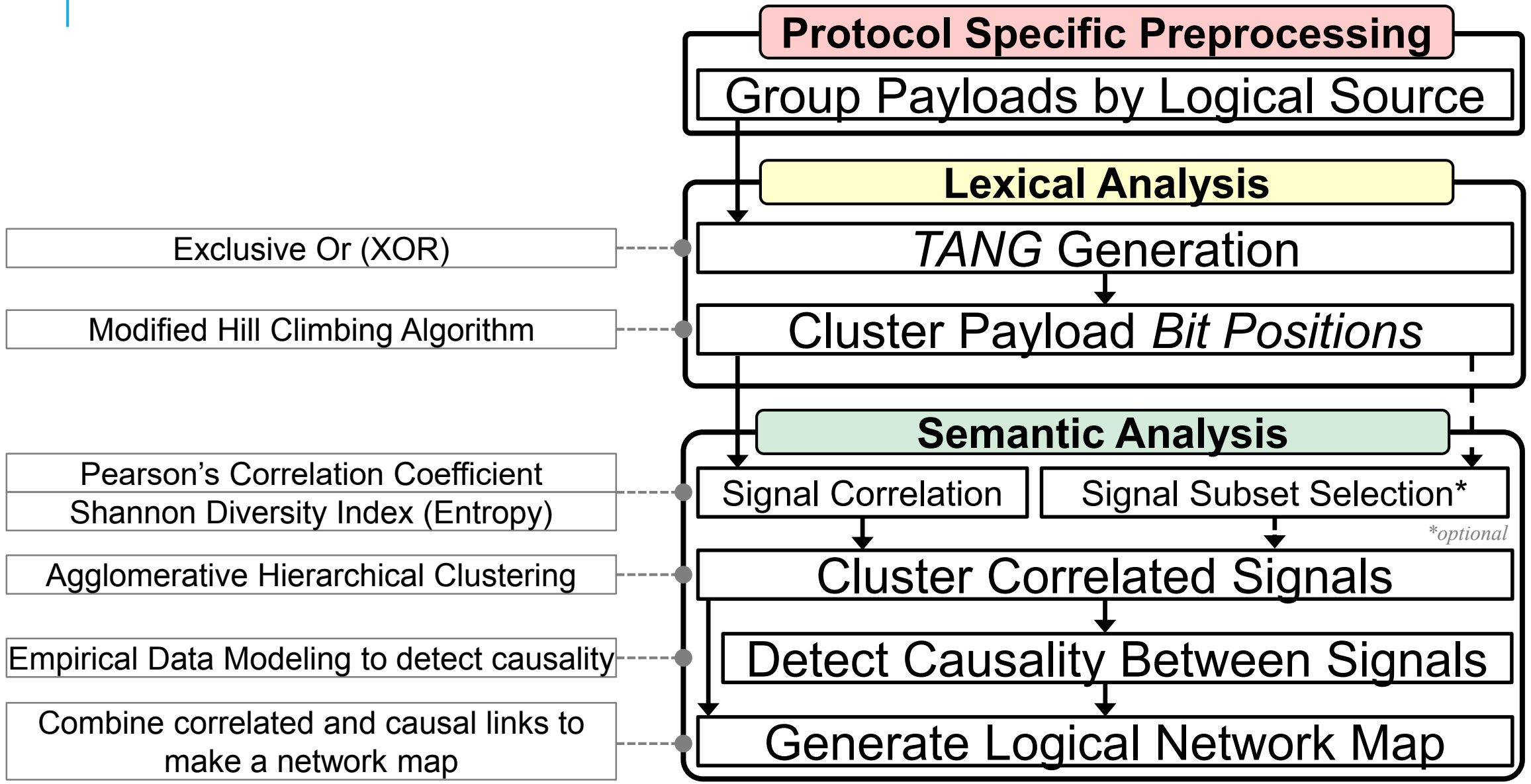
48.752:	025	8	00	11	00	00	82	82	82	c4

.....



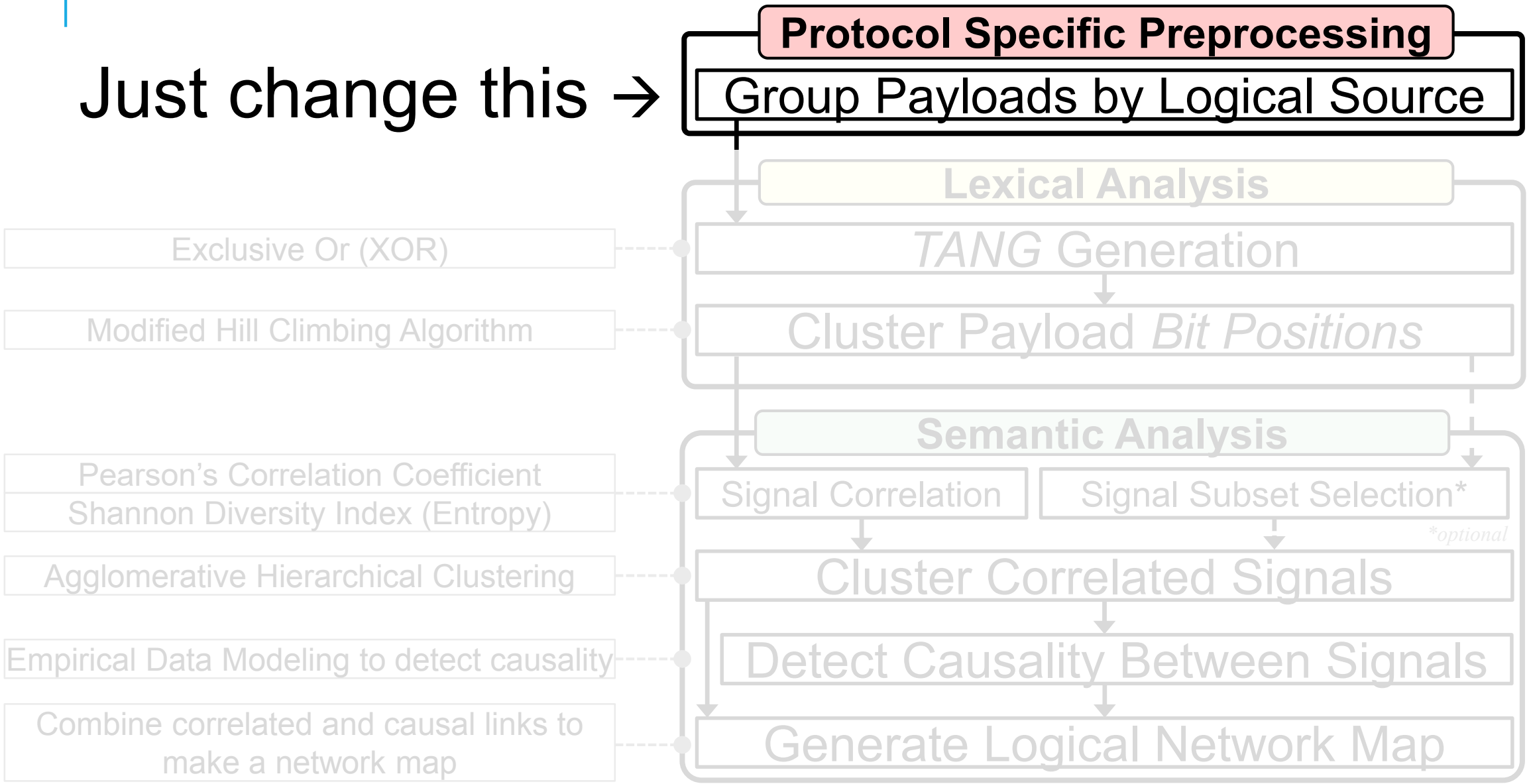


Code on GitHub does this…

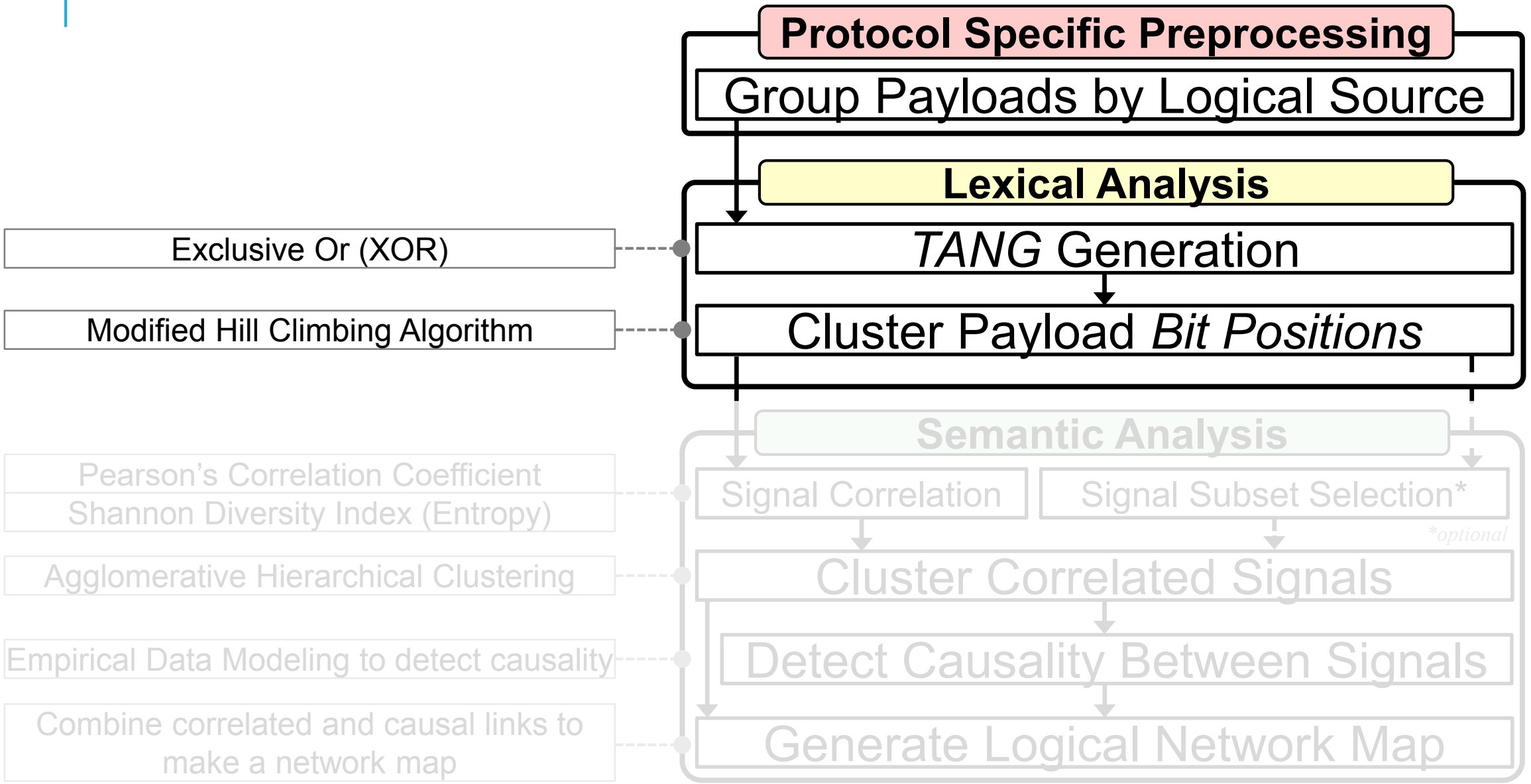


Different Control Network Protocol?

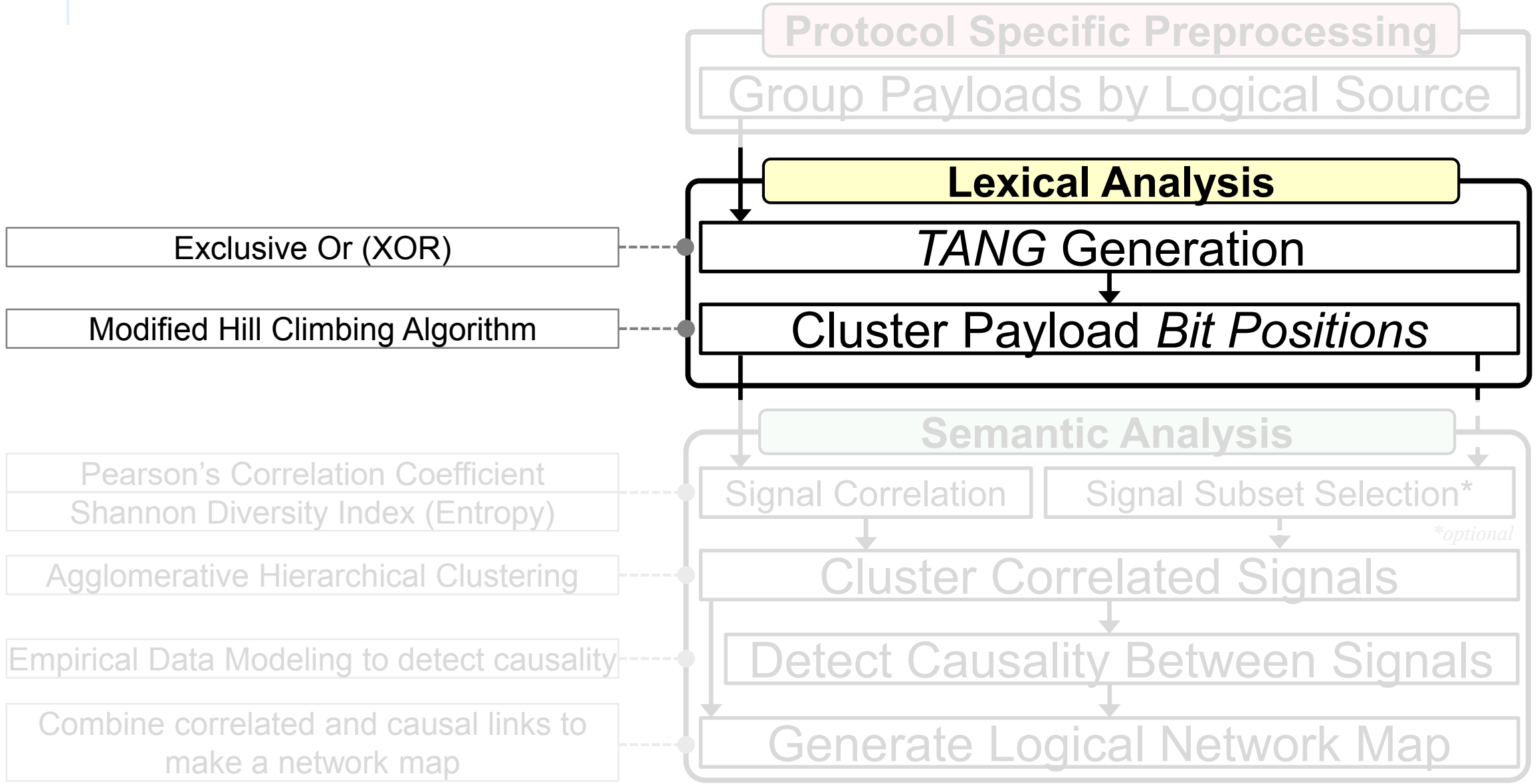
Just change this →



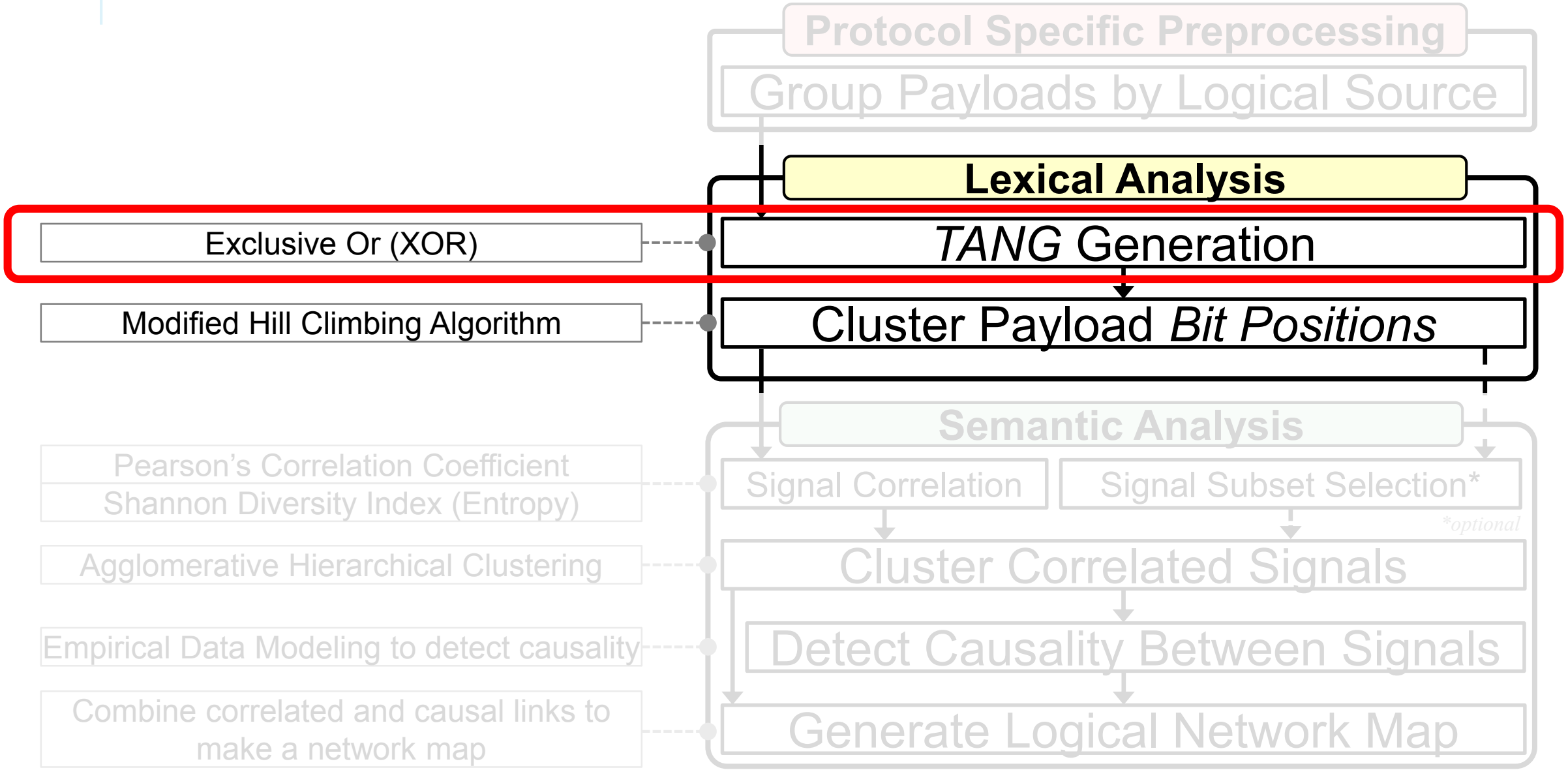
The demo is doing this…



I'll walk you through this…



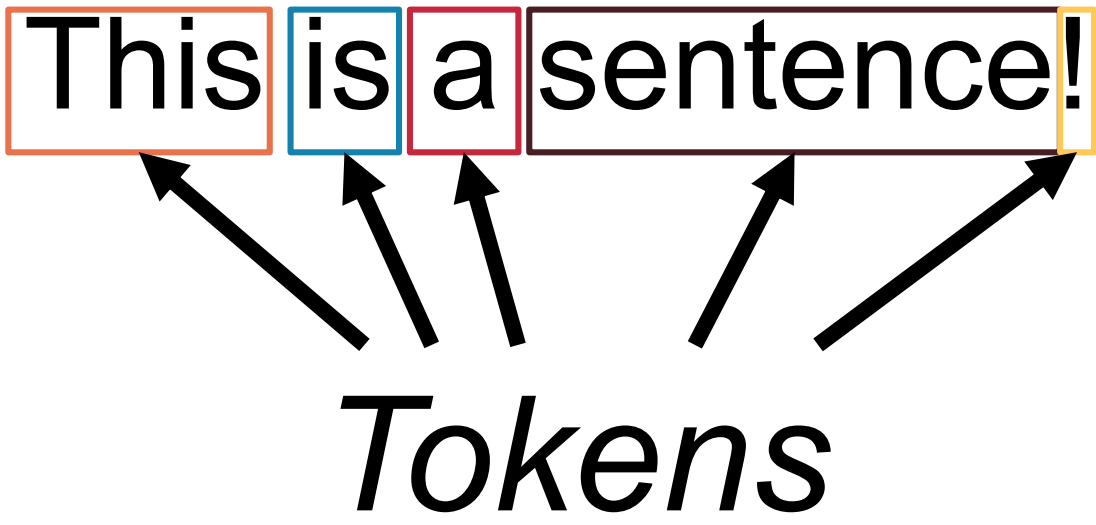
Unsupervised Reverse Engineering



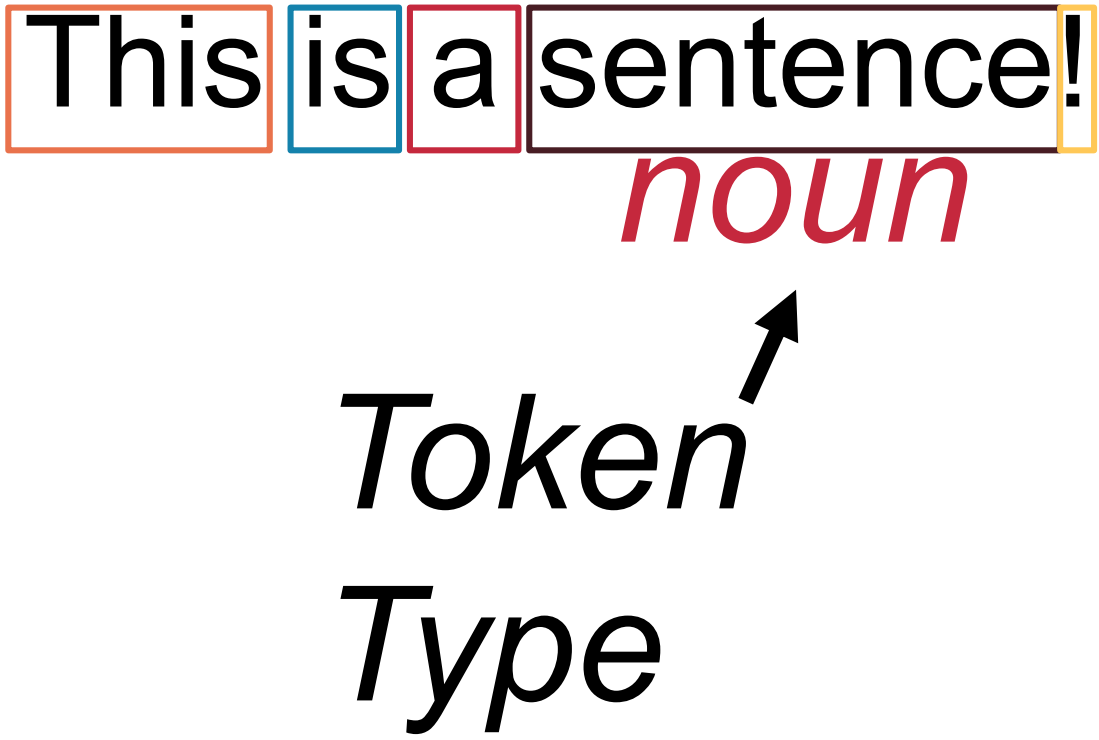
Lexical & Semantic Analysis

This is a sentence!

Lexical Analysis



Semantic Analysis



Lexical Analysis
Payload Tokenization

64-bit Payloads

Time	Bit 0	Bit 63
48.45	1	0
48.95	1	0
49.46	1	0
49.96	0	0
50.46	0	0
50.96	1	0
⋮	⋮ ⋮	⋮

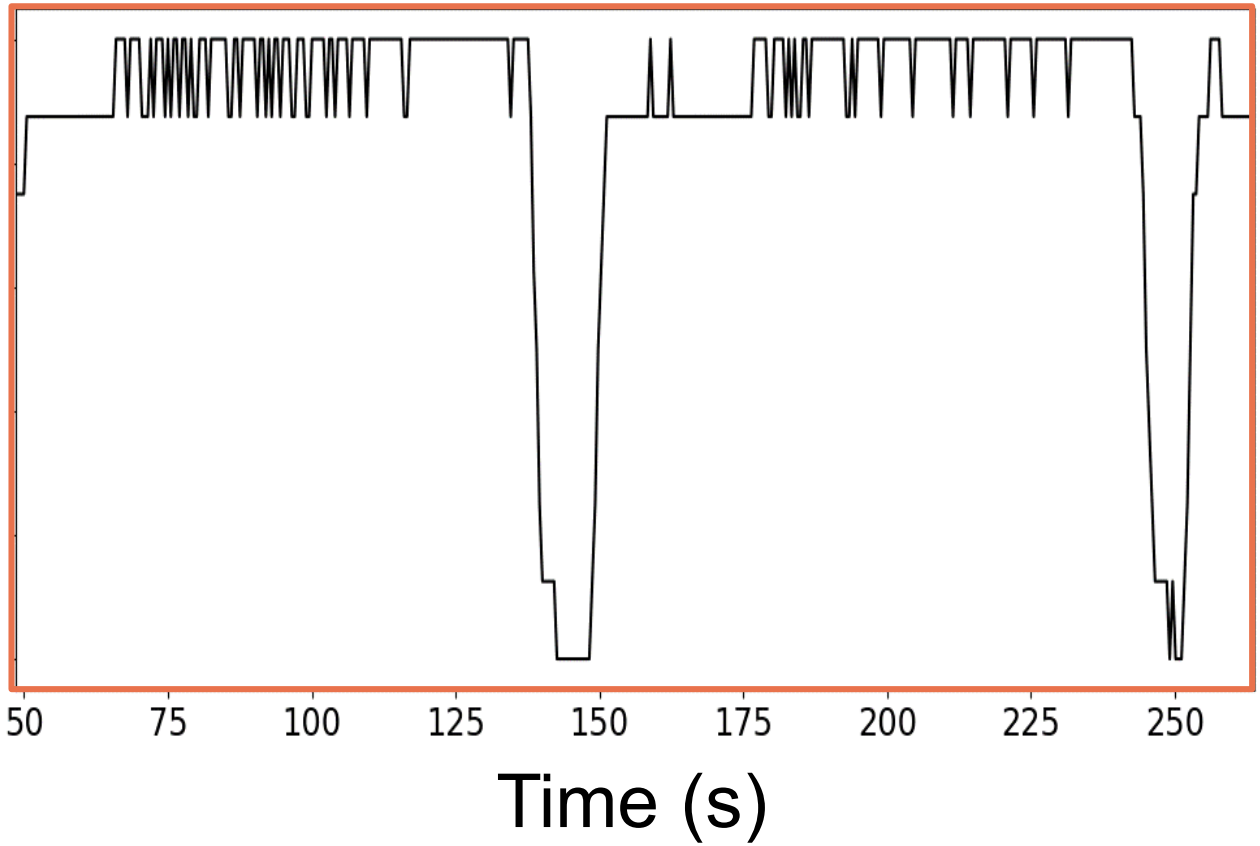
This is a sentence!

Lexical Analysis

Payload Tokenization

64-bit Payloads

Time	Bit 0	Bit 63
48.45	1	0
48.95	1	0
49.46	1	0
49.96	0	0
50.46	0	0
50.96	1	0
⋮	⋮ ⋮	⋮



Lexical Analysis

Payload Tokenization

64-bit Payloads

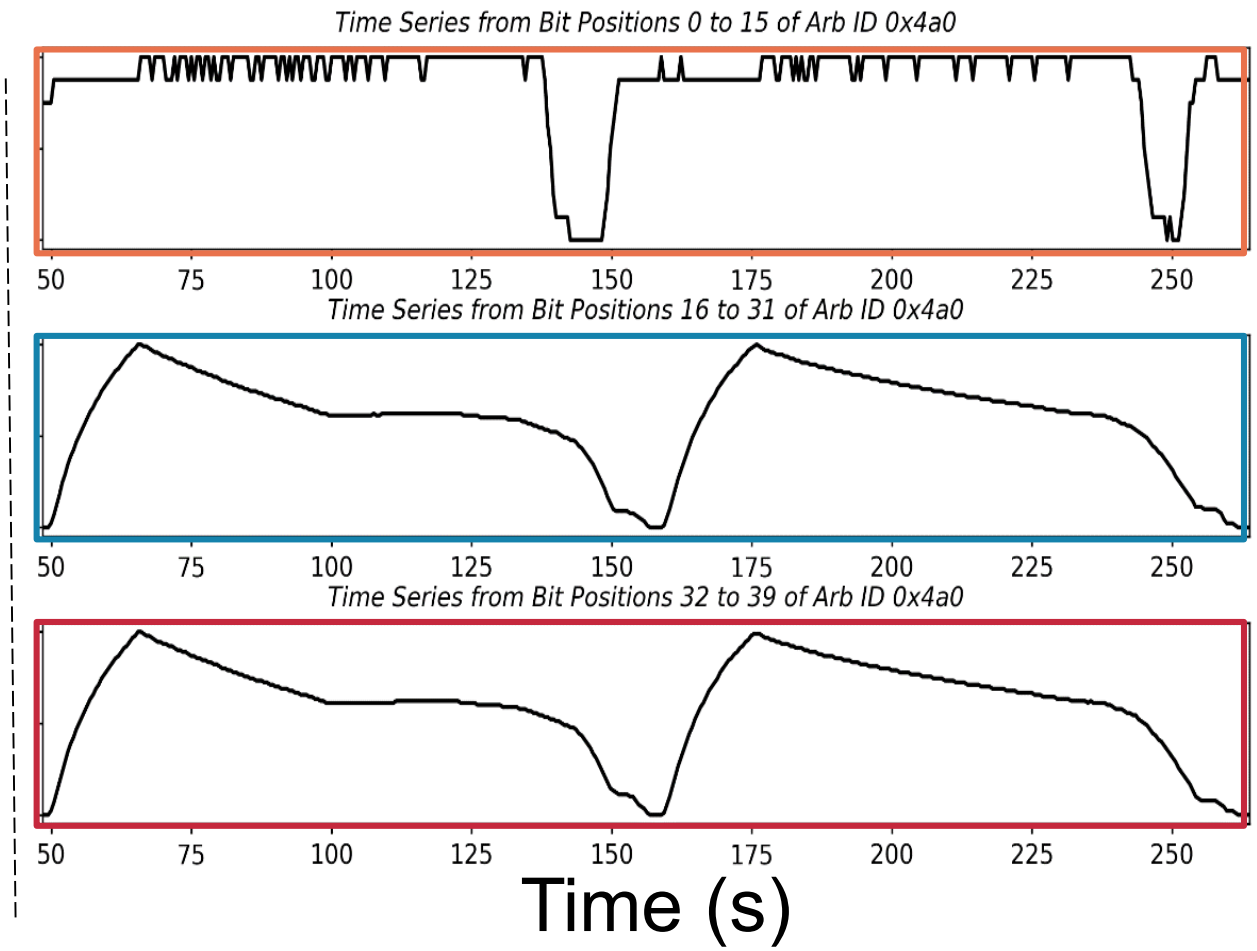
Time	Bit 0	Bit 63
48.45	1	0
48.95	1	0
49.46	1	0
49.96	0	0
50.46	0	0
50.96	1	0
⋮	⋮	⋮

This is a sentence!

Lexical Analysis
Payload Tokenization

64-bit Payloads

Time	Bit 0	Bit 63
48.45	1	0
48.95	1	0
49.46	1	0
49.96	0	0
50.46	0	0
50.96	1	0
⋮	⋮ ⋮	⋮



Payload Tokenization

By Least Significant Bit

Bit Position:	0	1	2	3	4	5	6	7	8	9
Observed Payloads	0	1	1	1	0	0	0	0	0	0
	1	0	0	0	0	0	0	0	0	1
	1	0	0	1	0	0	0	0	1	0
	1	0	1	0	0	0	0	0	1	1
	1	0	1	1	0	0	0	1	0	0
	1	1	0	0	0	0	0	1	0	1
	1	1	0	1	0	0	0	1	1	0
	1	1	1	0	0	0	0	1	1	1

Payload Tokenization

By Least Significant Bit

Bit Position: 0 1 2 3 4 5 6 7 8 9

Exclusive-OR gate



A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0

0	1	1	1	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	1
1	0	0	1	0	0	0	0	1	0
1	0	1	0	0	0	0	0	0	1
1	0	0	1	0	0	0	1	0	0
1	1	0	0	0	0	0	1	0	1
1	1	0	1	0	0	0	1	1	0

Payload Tokenization

By Least Significant Bit

Bit Position: 0 1 2 3 4 5 6 7 8 9

Exclusive-OR gate



A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0

1	1	1	1	0	0	0	0	0	1
0	0	0	1	0	0	0	0	1	1
0	0	1	1	0	0	0	0	0	1
0	0	0	1	0	0	0	1	1	1
0	1	1	1	0	0	0	0	0	1
0	0	0	1	0	0	0	0	1	1
0	0	1	1	0	0	0	0	0	1

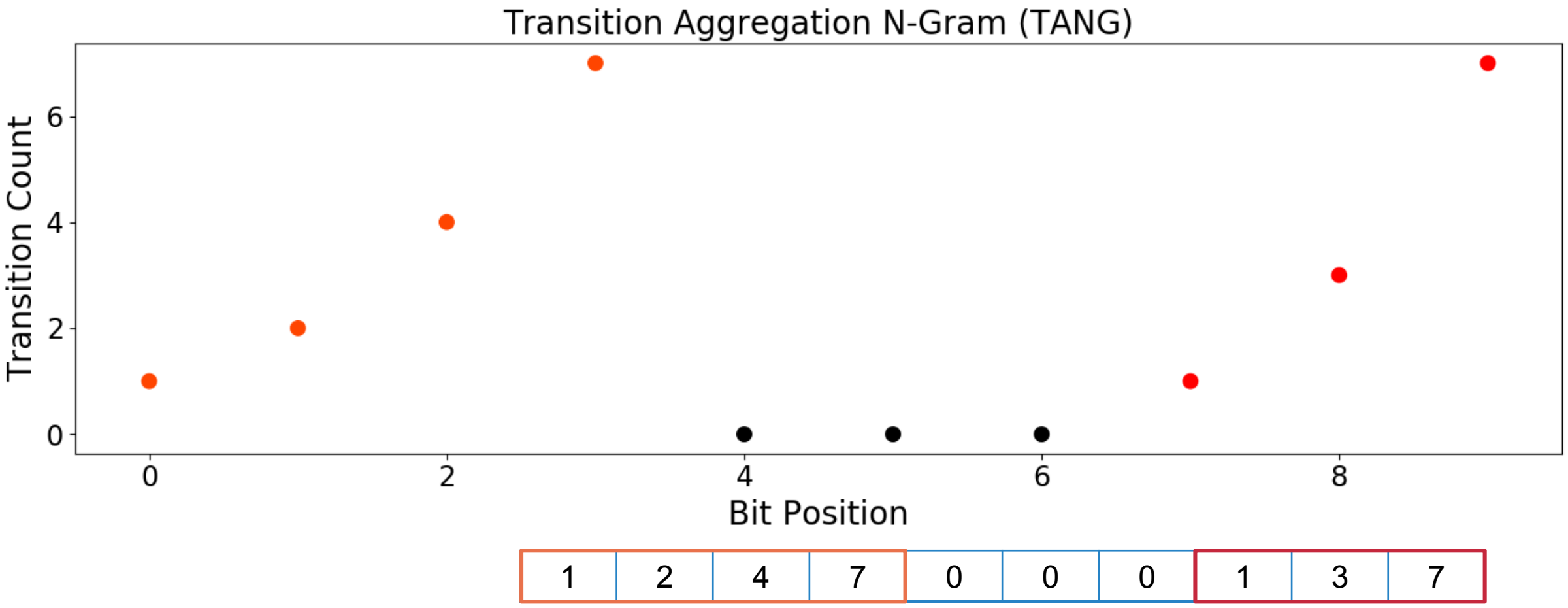
Payload Tokenization

By Least Significant Bit

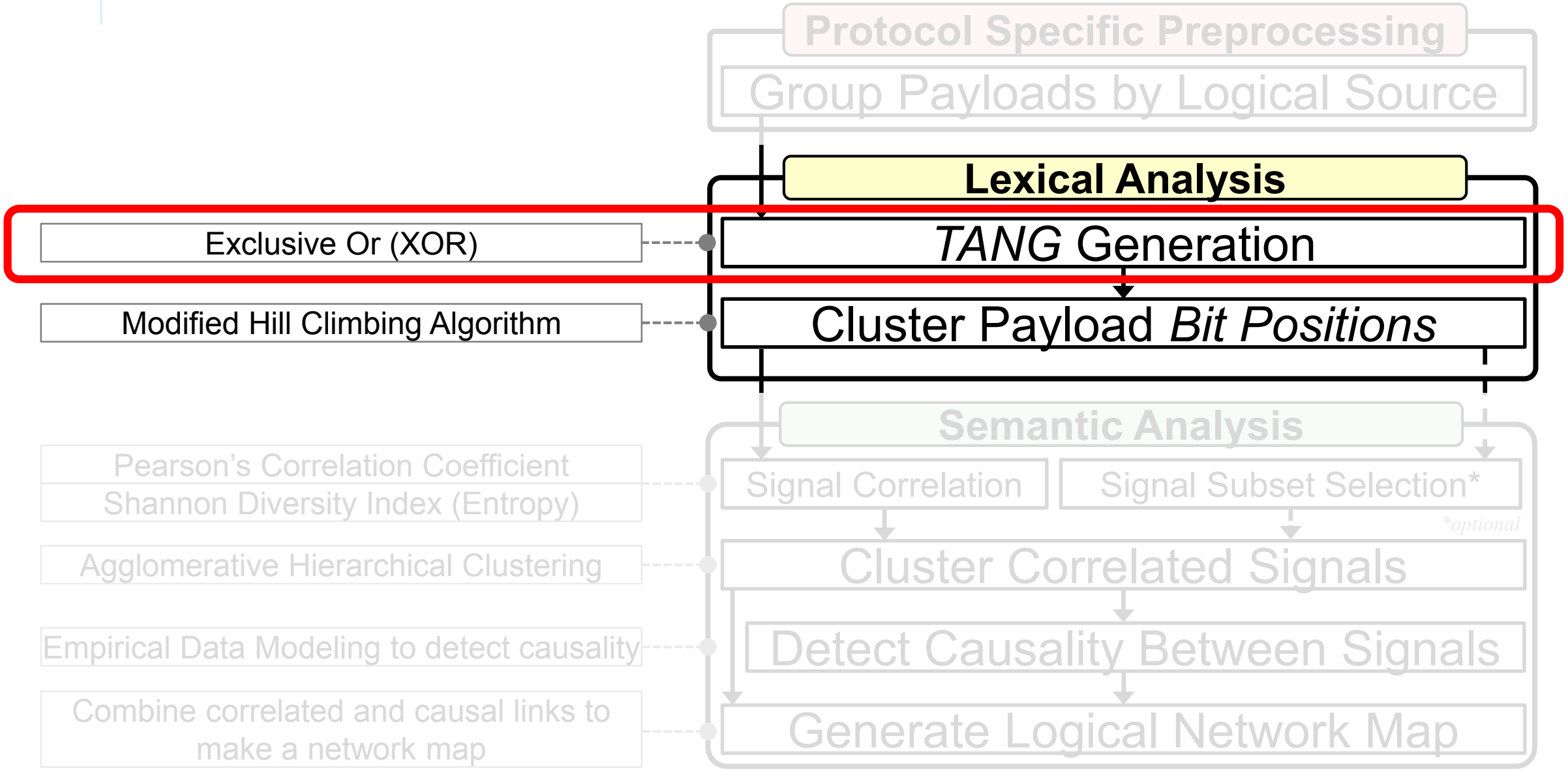
Bit Position:	0	1	2	3	4	5	6	7	8	9
	1	1	1	1	0	0	0	0	0	1
	0	0	0	1	0	0	0	0	1	1
	0	0	1	1	0	0	0	0	0	1
	0	0	0	1	0	0	0	1	1	1
	0	1	1	1	0	0	0	0	0	1
	0	0	0	1	0	0	0	0	1	1
+	0	0	1	1	0	0	0	0	0	1
	1	2	4	7	0	0	0	1	3	7

Payload Tokenization

By Least Significant Bit

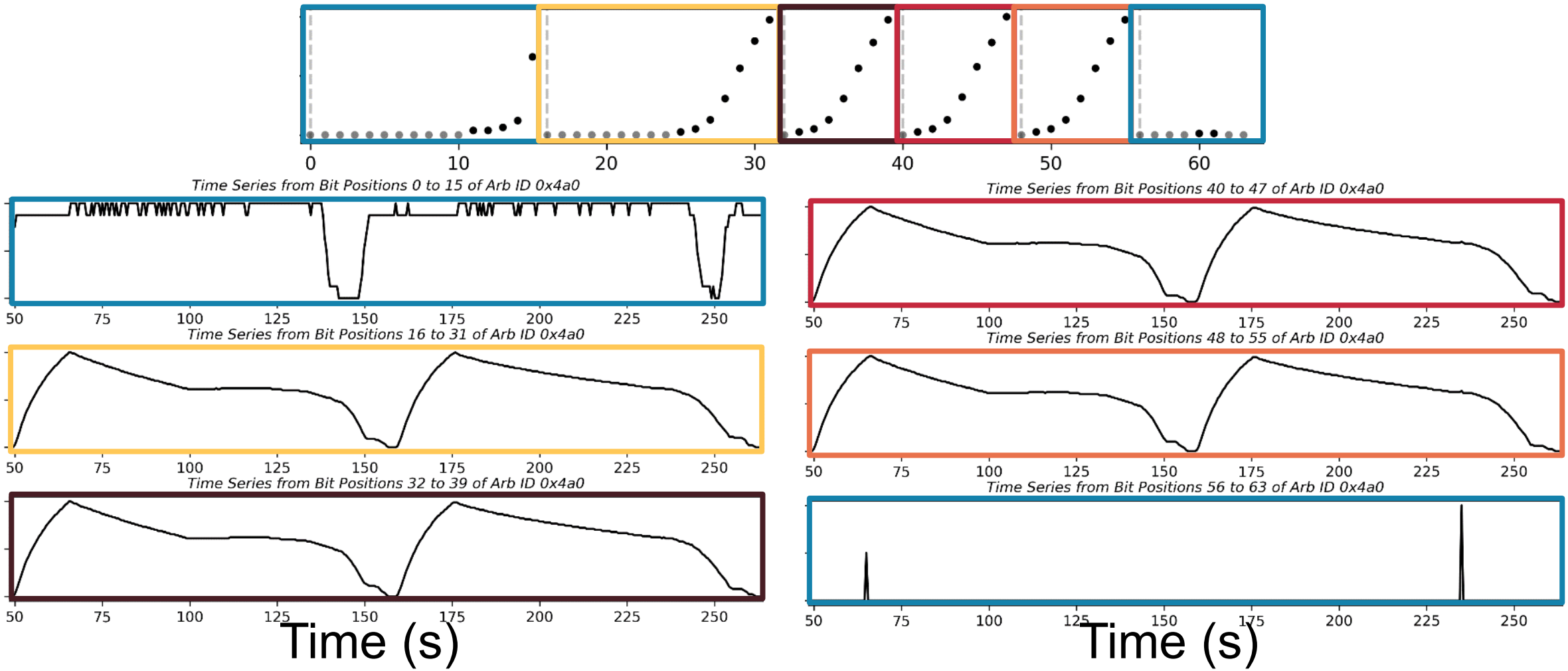


Unsupervised Reverse Engineering

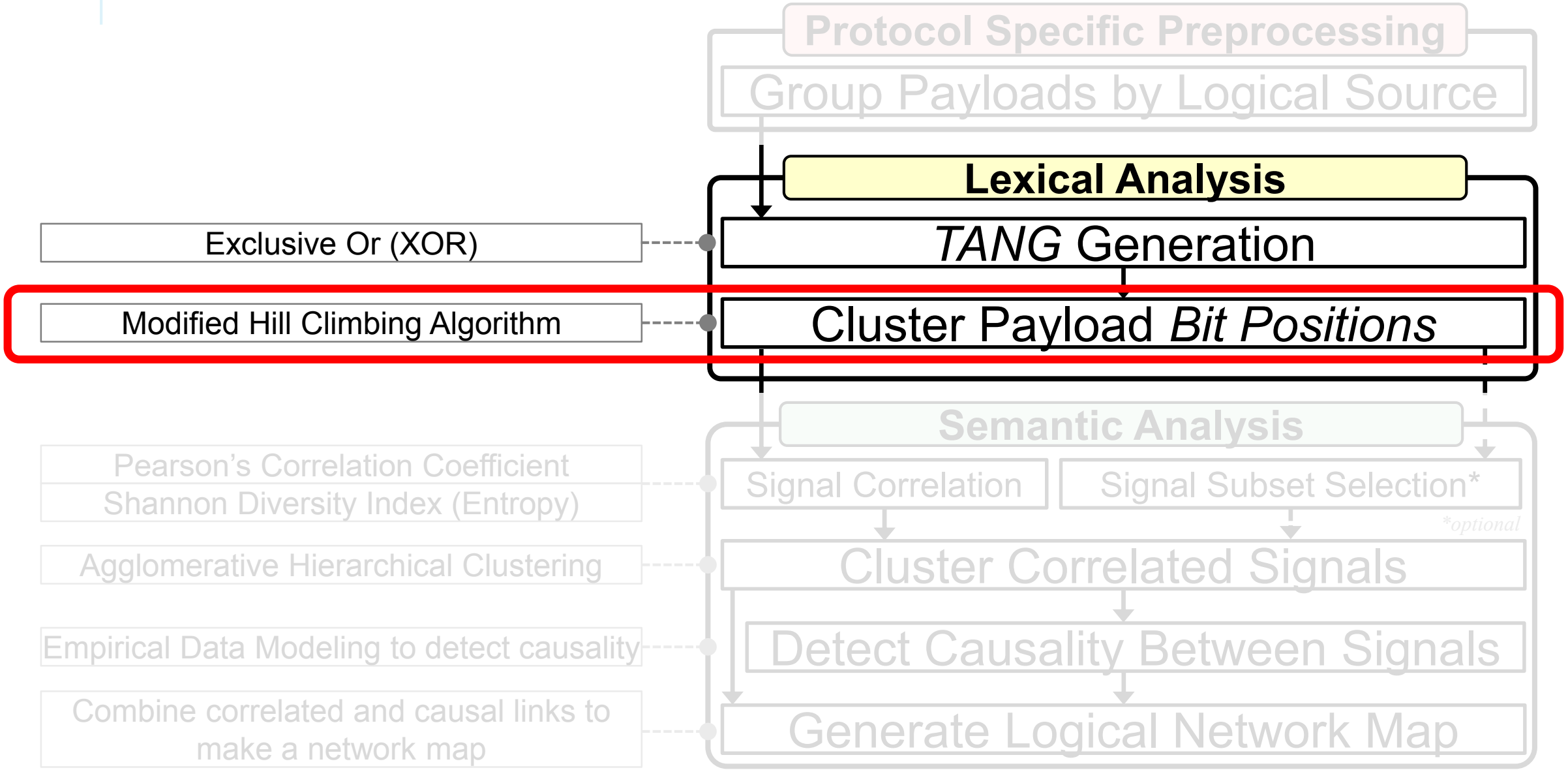


Payload Tokenization

By Least Significant Bit

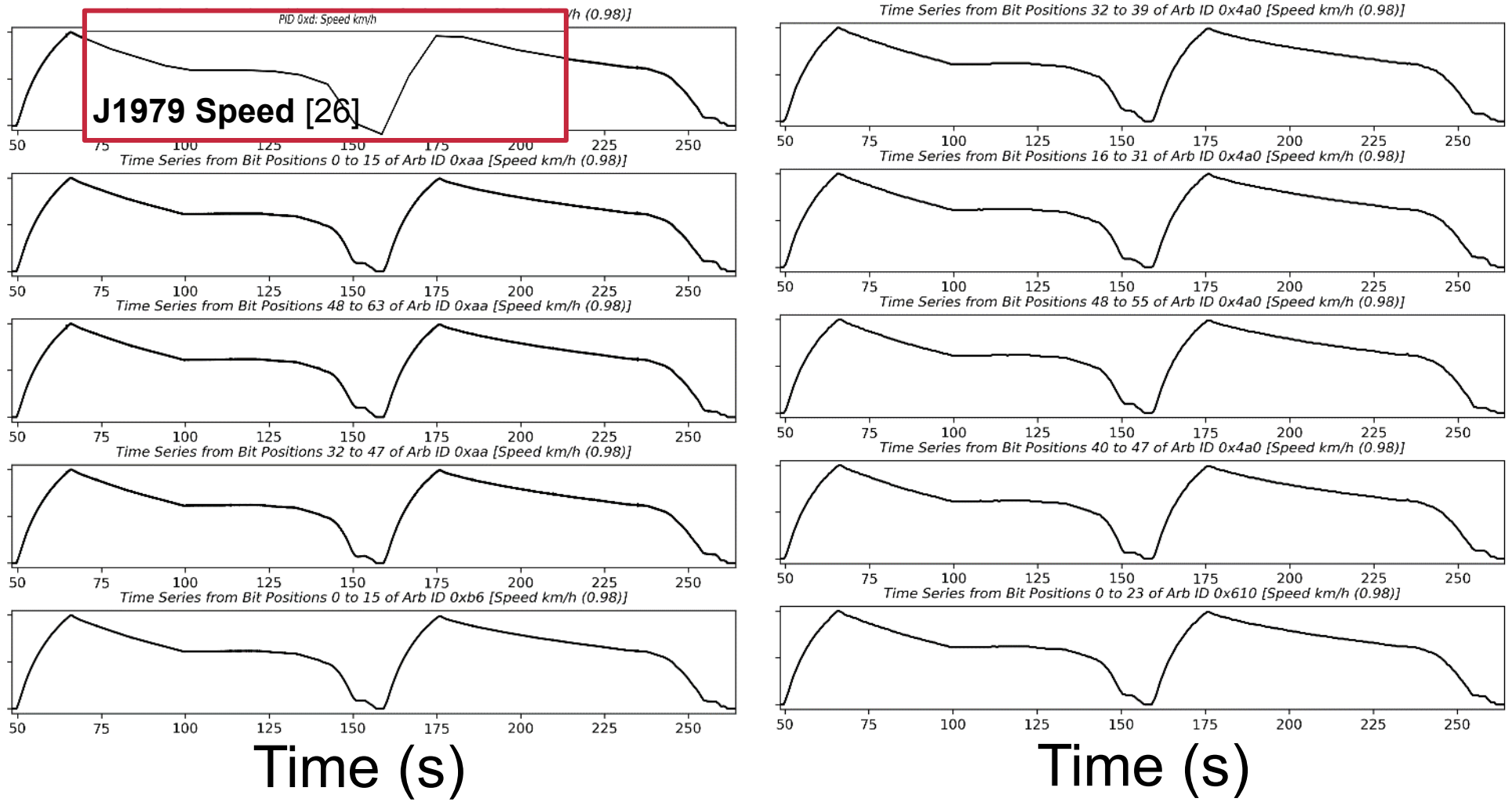


Unsupervised Reverse Engineering



Semantic Analysis

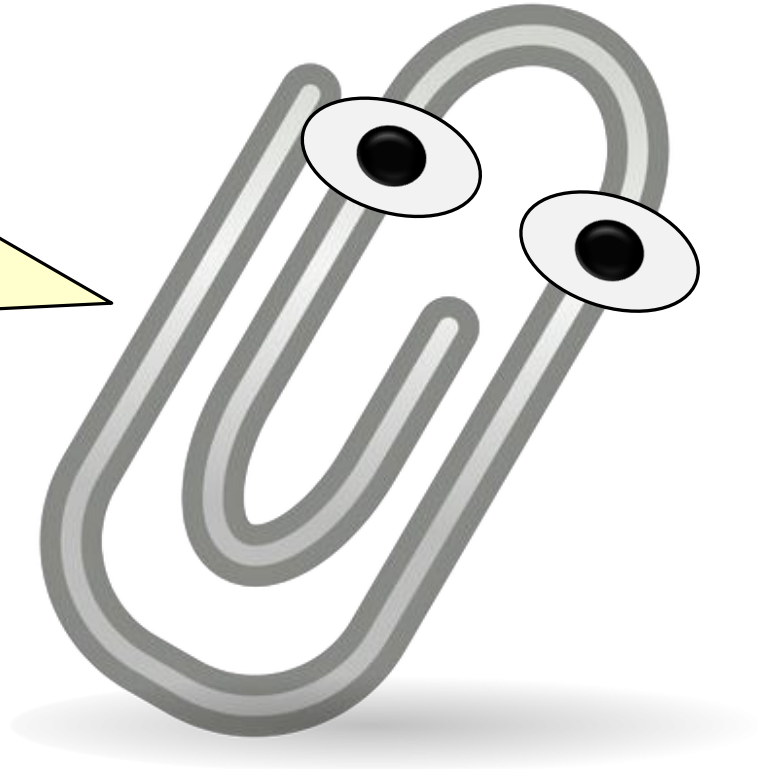
Correlated and Causal Relationships



[26] SAE International, “SAE J1979: E/E Diagnostic Test Modes,” 2017.

SHOW ME WHAT YOU GOT!

Let’s reverse engineer some cars!

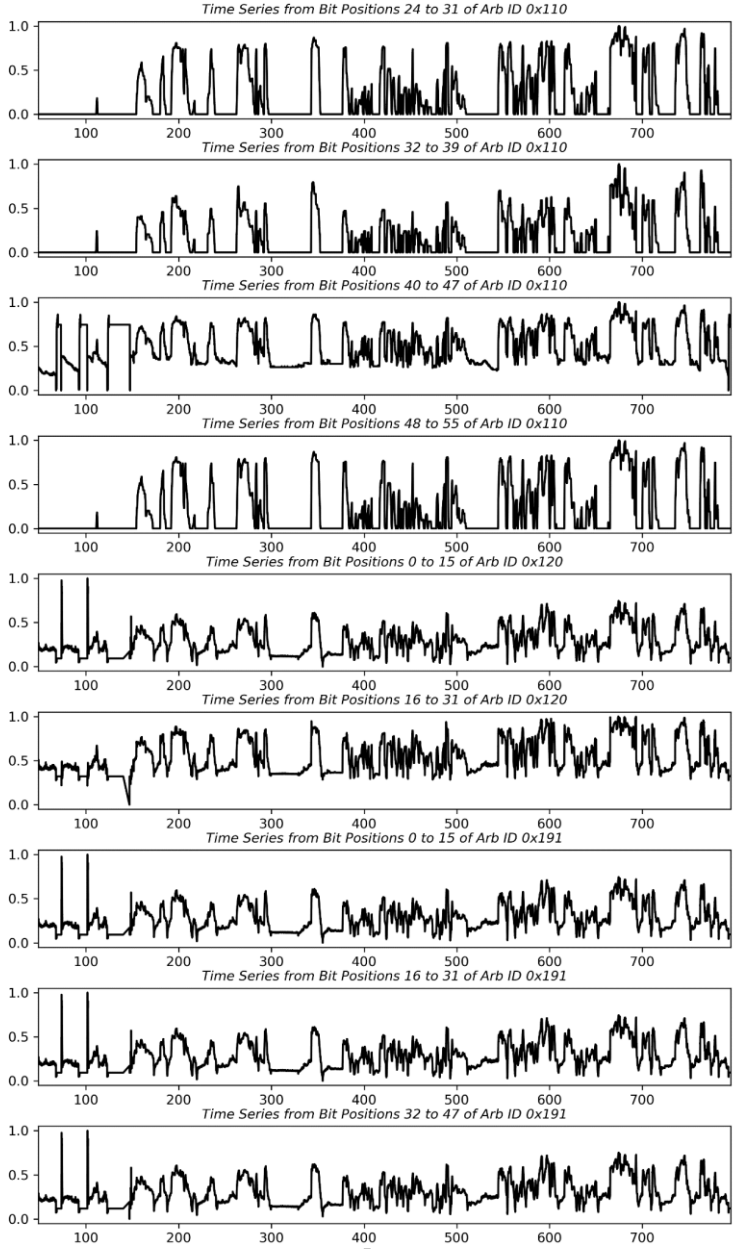


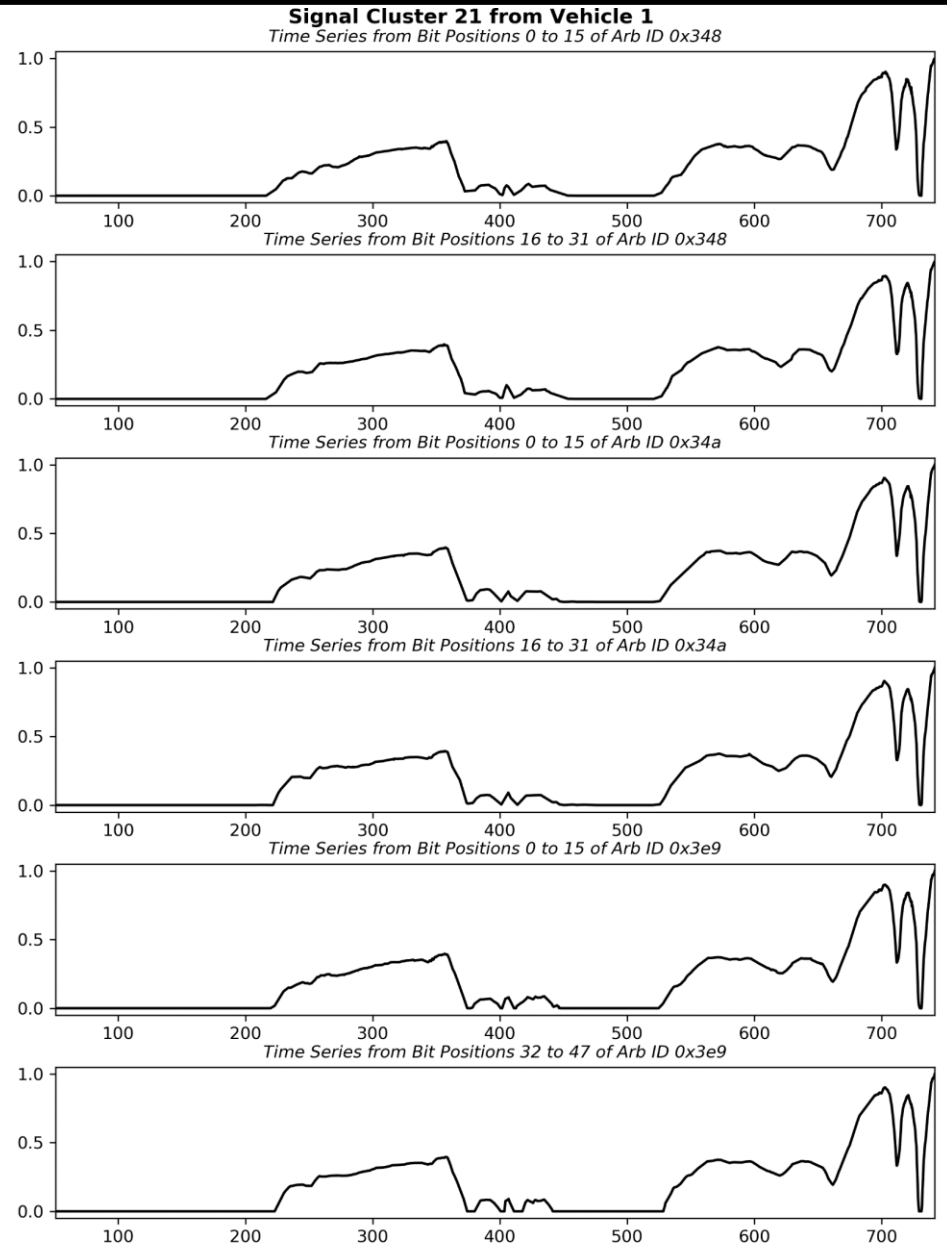
https://github.com/brent-stone/CAN_Reverse_Engineering

VEHICLE 1

VEHICLE 2

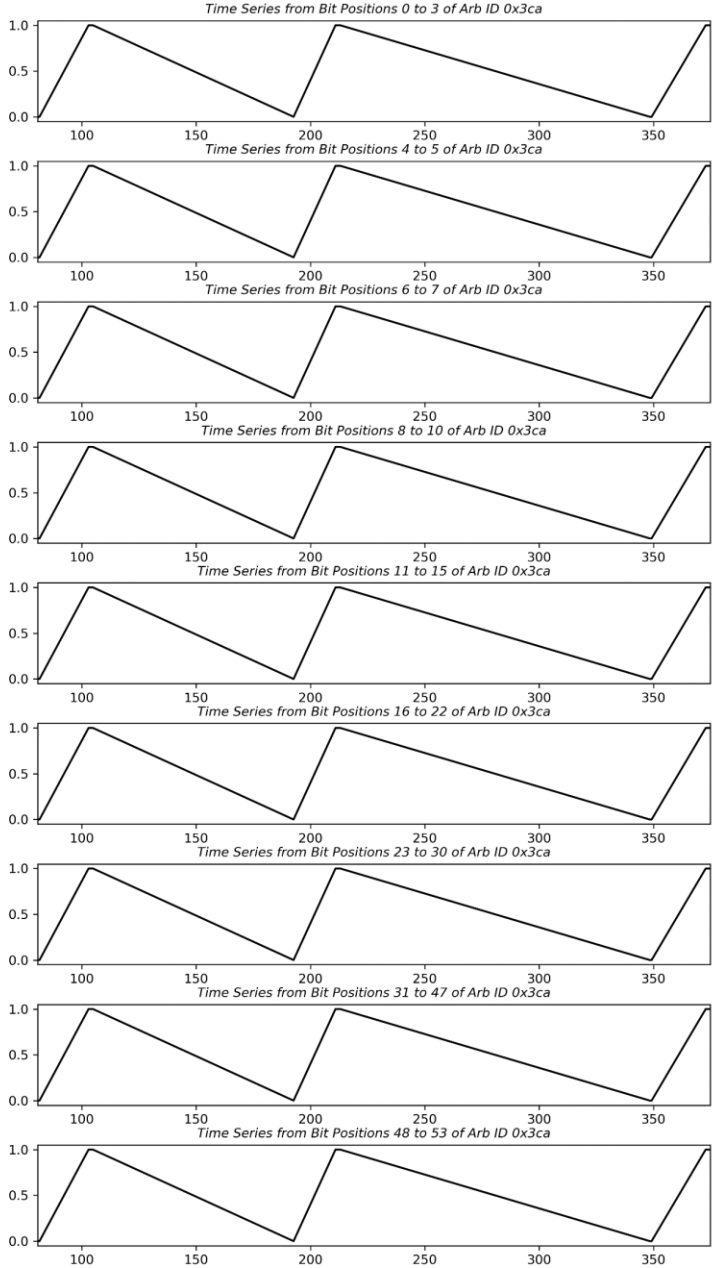
CROPPED TO FIT ON SLIDE





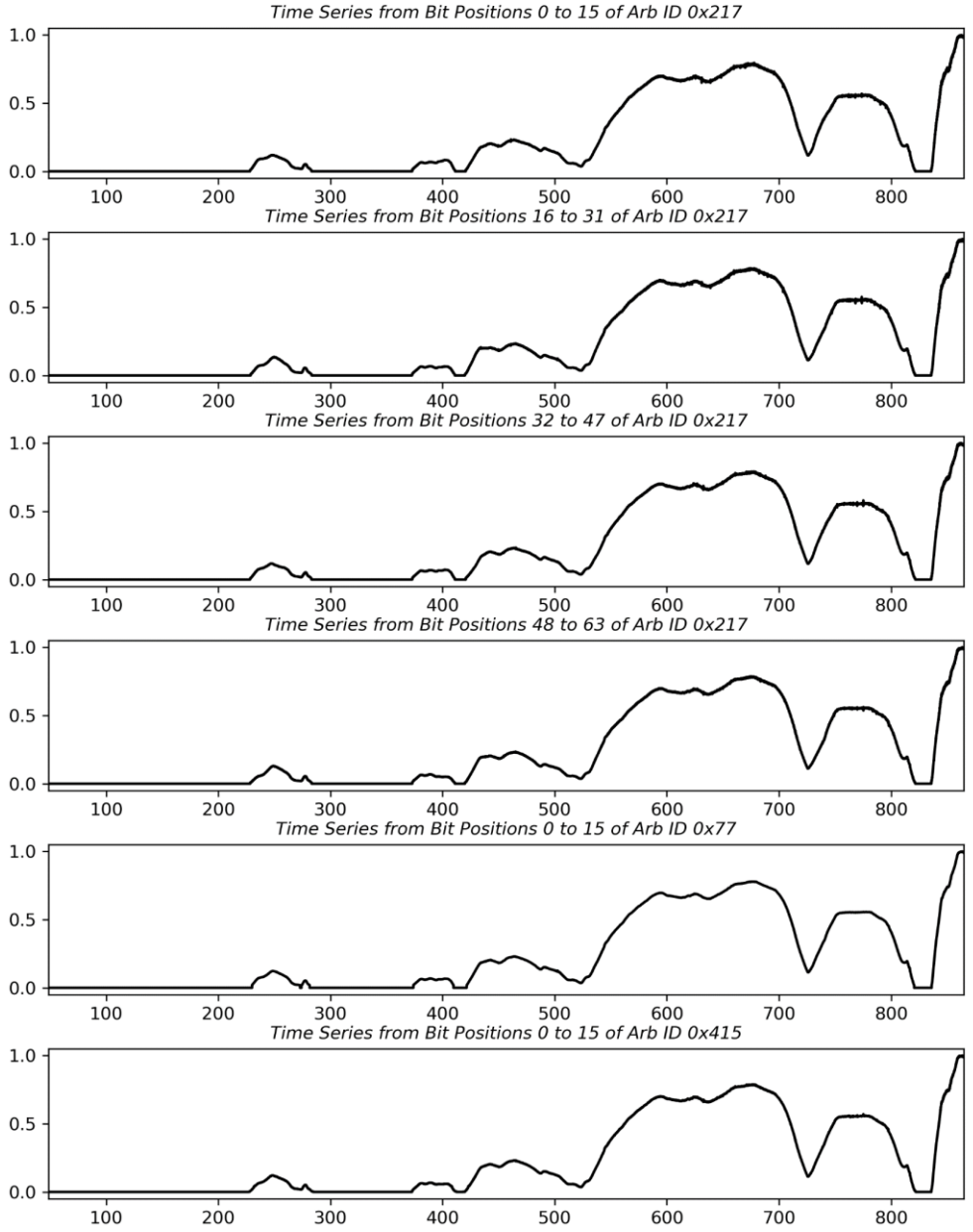
https://github.com/brent-stone/CAN_Reverse_Engineering

VEHICLE 3



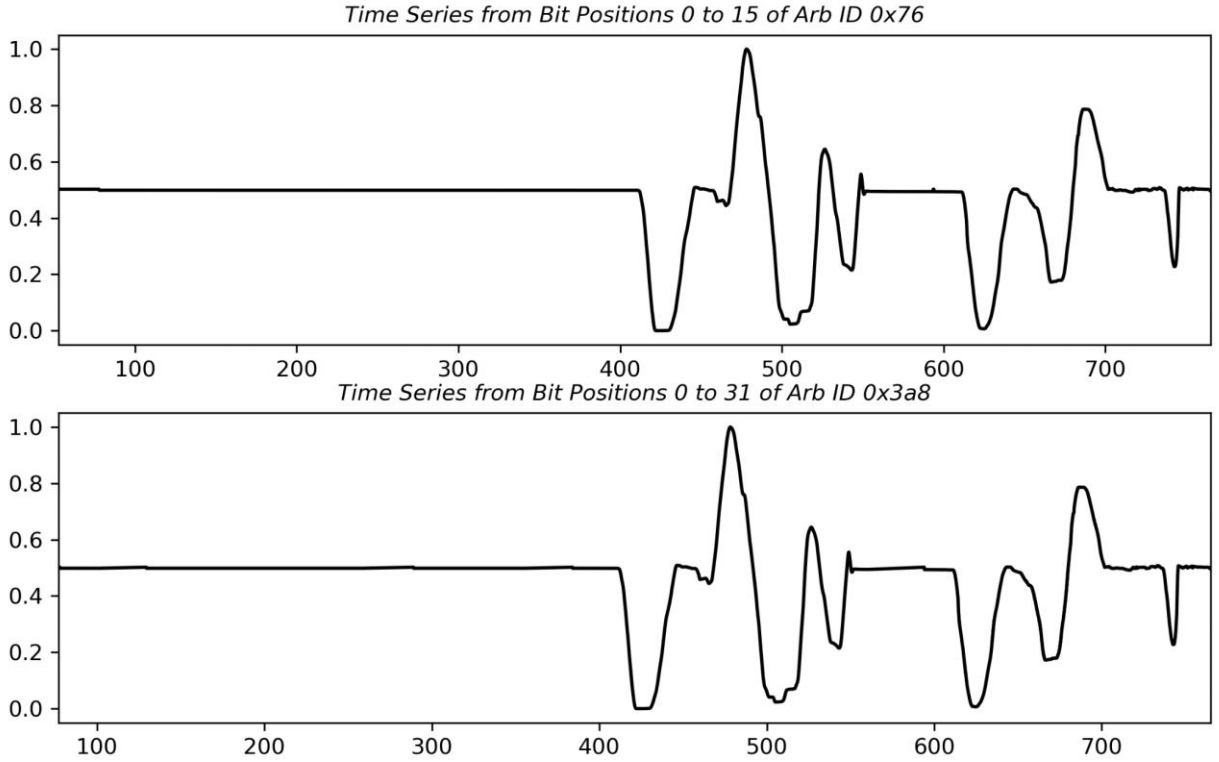
CROPPED TO FIT ON SLIDE

VEHICLE 4

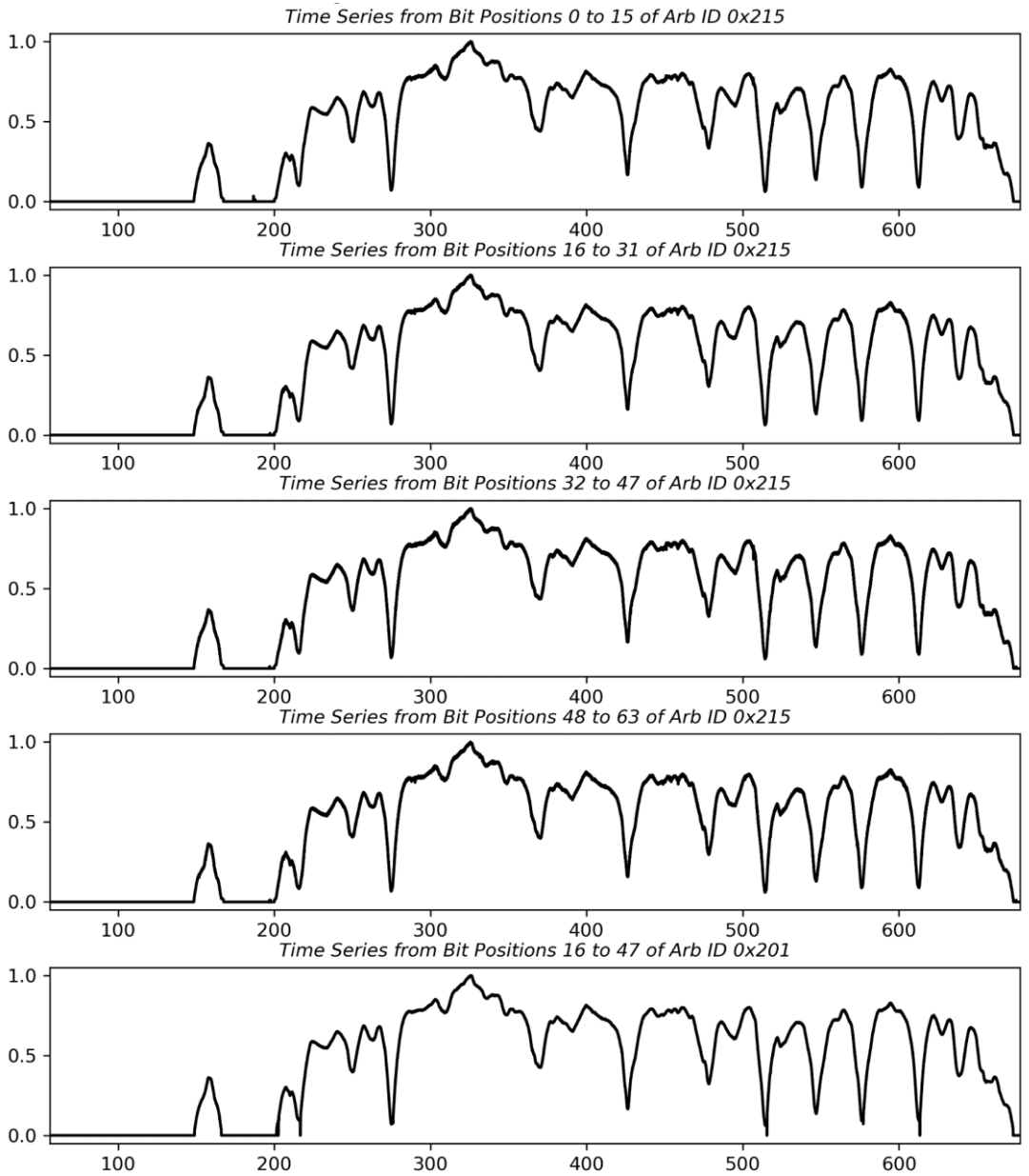


https://github.com/brent-stone/CAN_Reverse_Engineering

VEHICLE 5

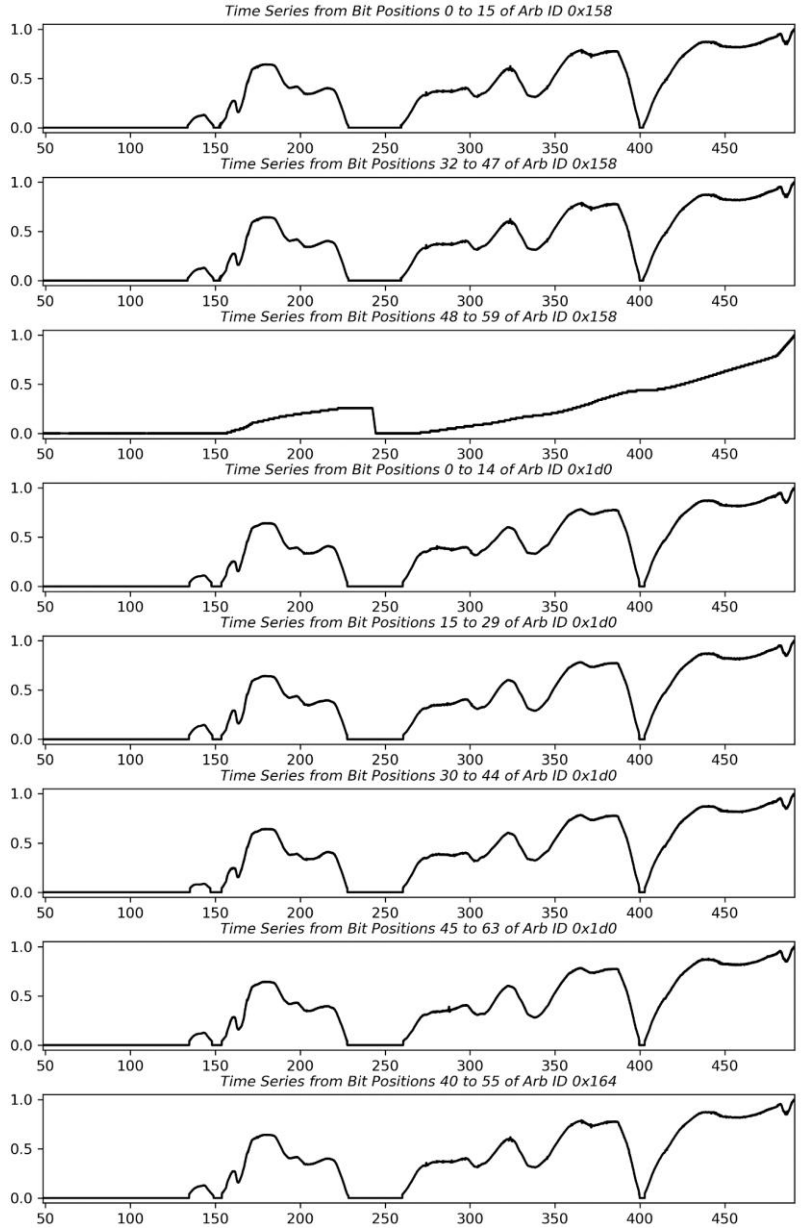


VEHICLE 6



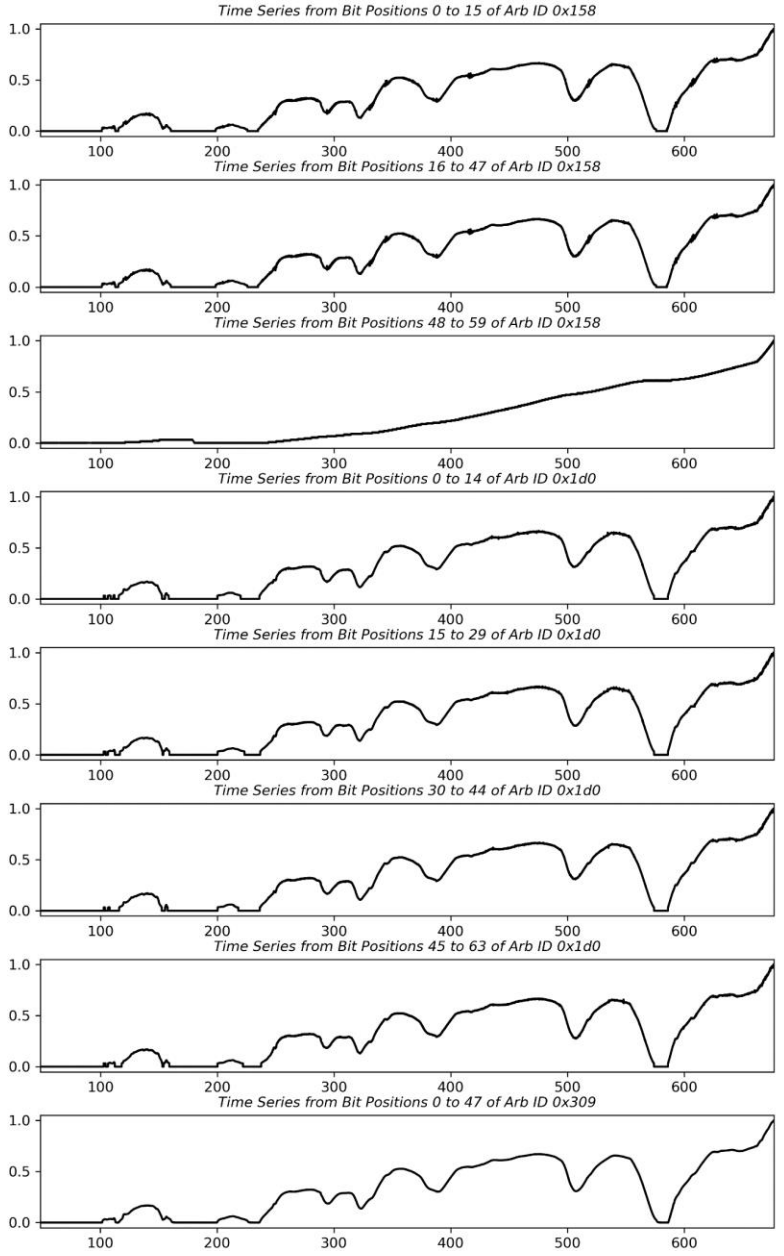
https://github.com/brent-stone/CAN_Reverse_Engineering

VEHICLE 7



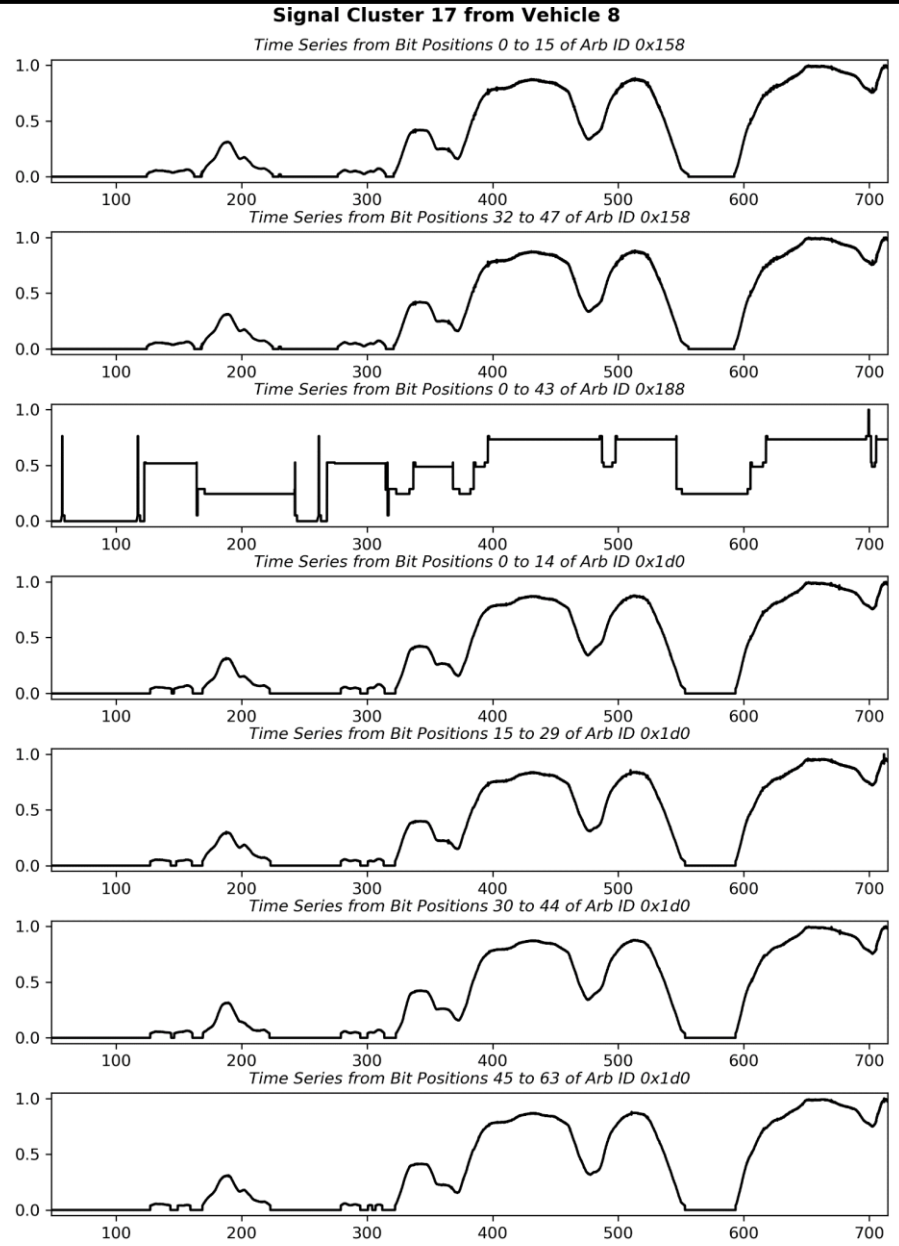
CROPPED TO FIT ON SLIDE

VEHICLE 8



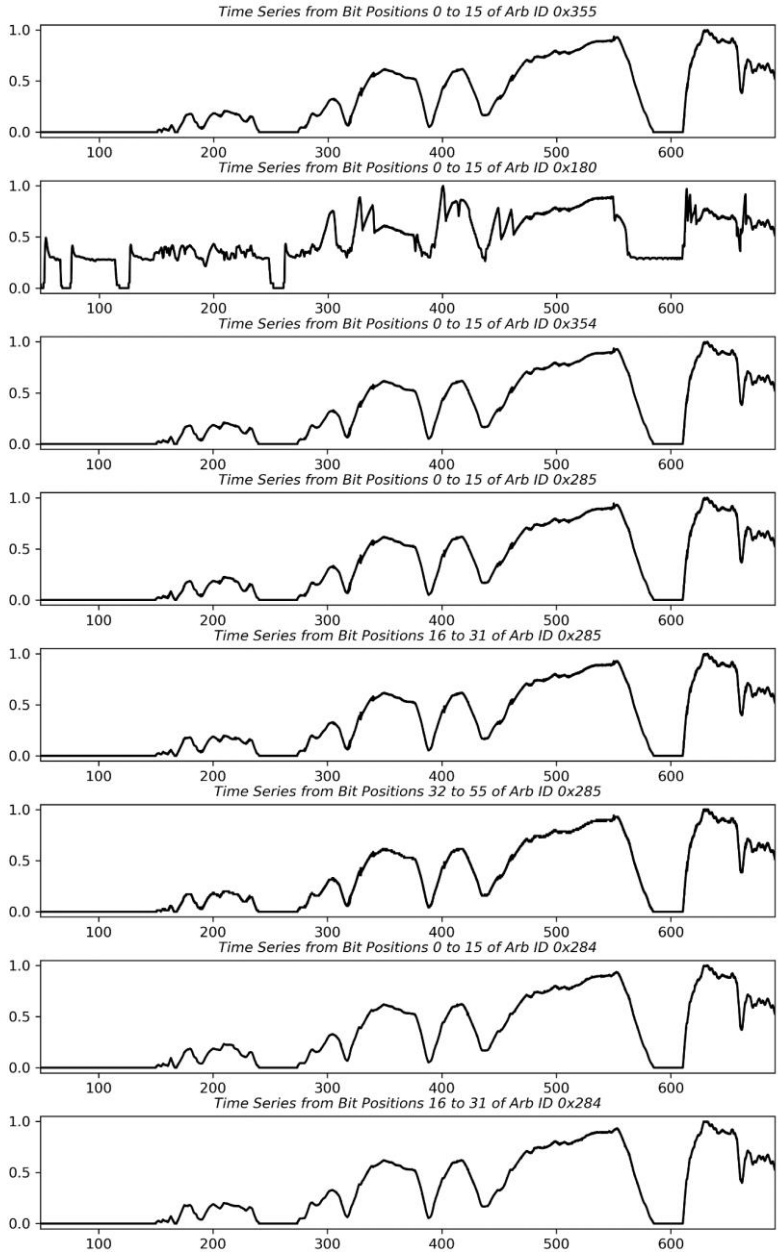
https://github.com/brent-stone/CAN_Reverse_Engineering

VEHICLE 9



CROPPED TO FIT ON SLIDE

VEHICLE 10



https://github.com/brent-stone/CAN_Reverse_Engineering

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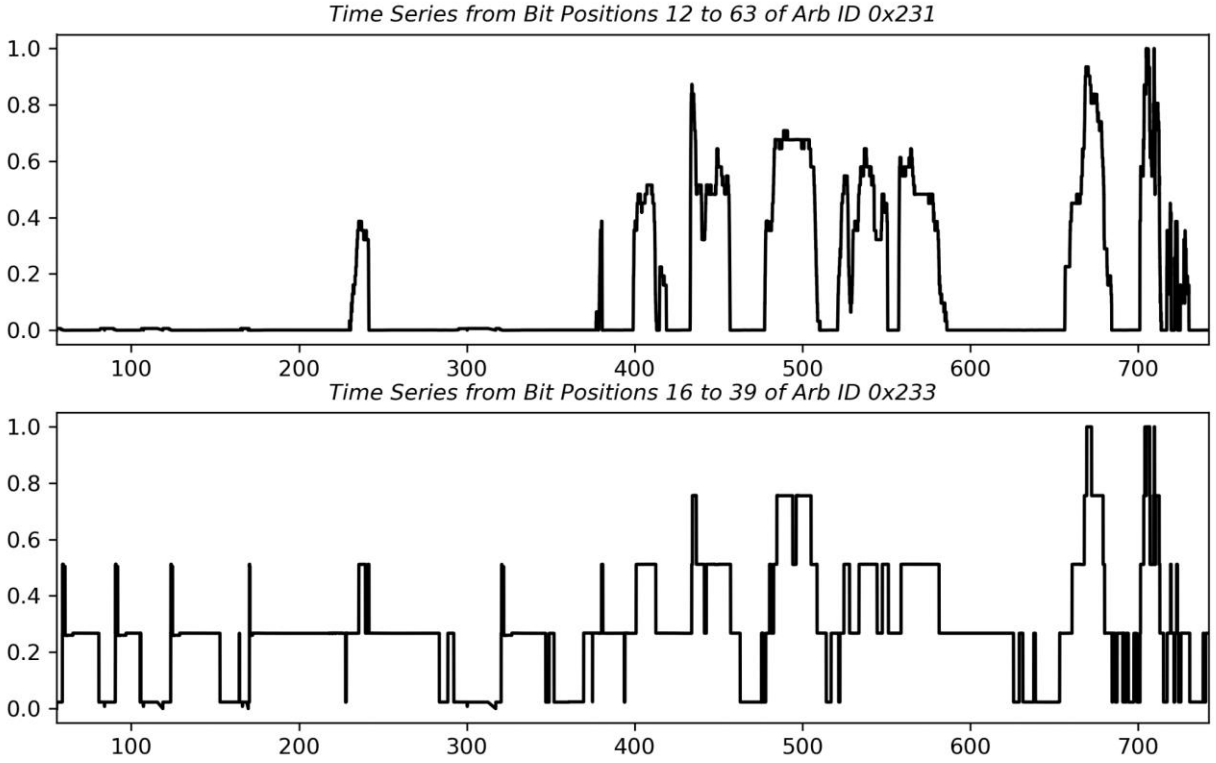

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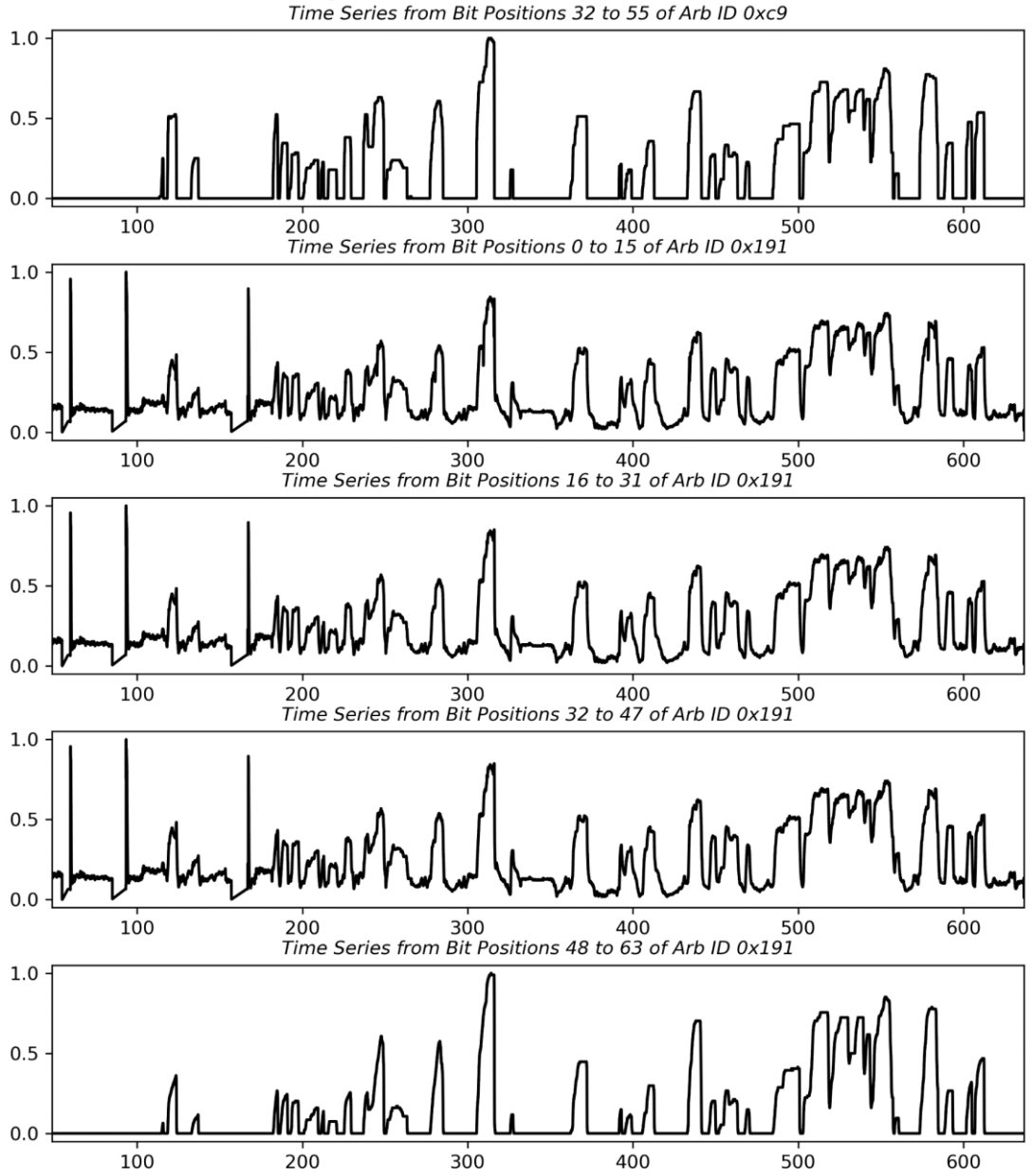
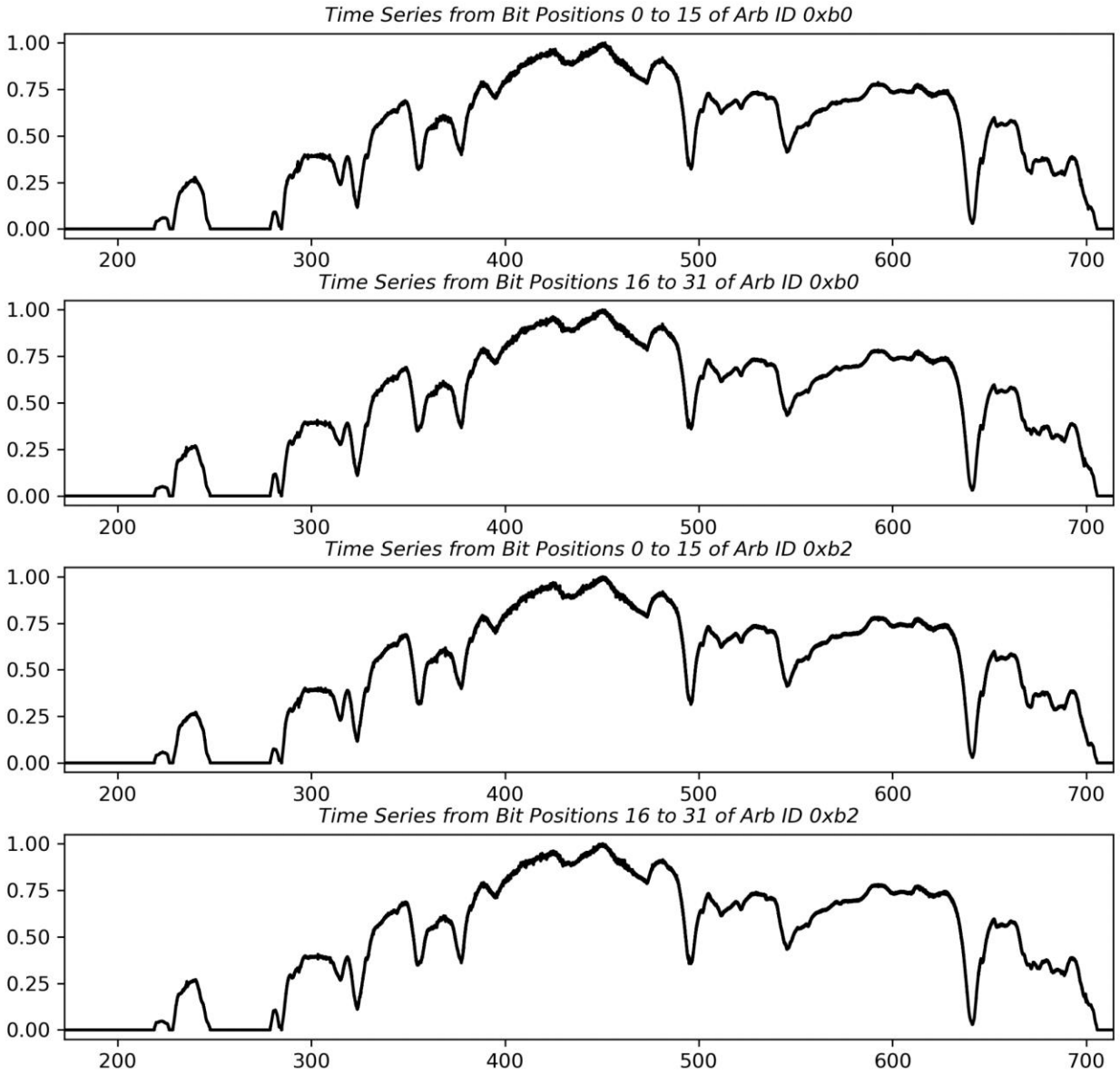
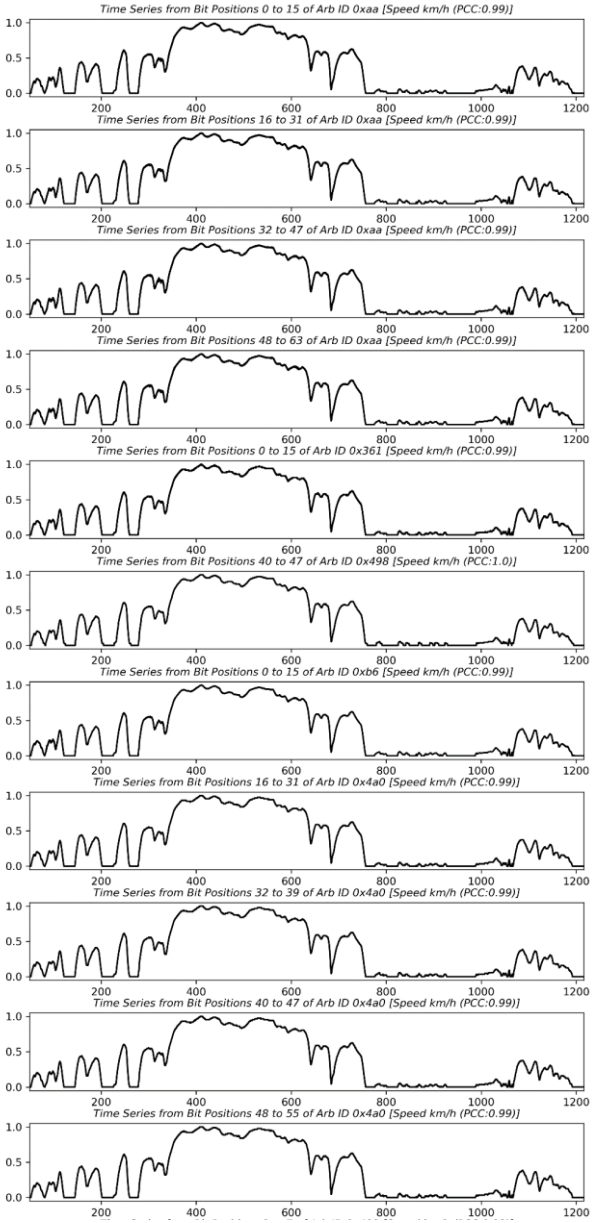


https://github.com/brent-stone/CAN_Reverse_Engineering

VEHICLE 13



VEHICLE 14



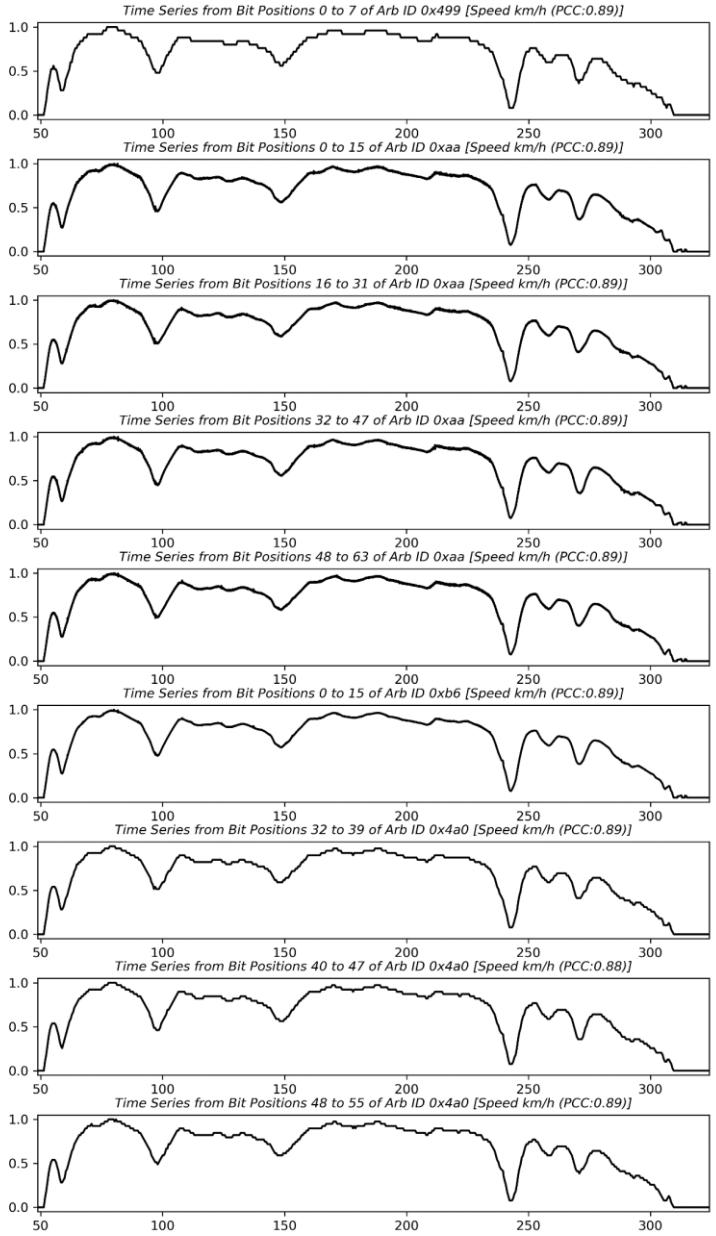
CROPPED TO FIT ON SLIDE

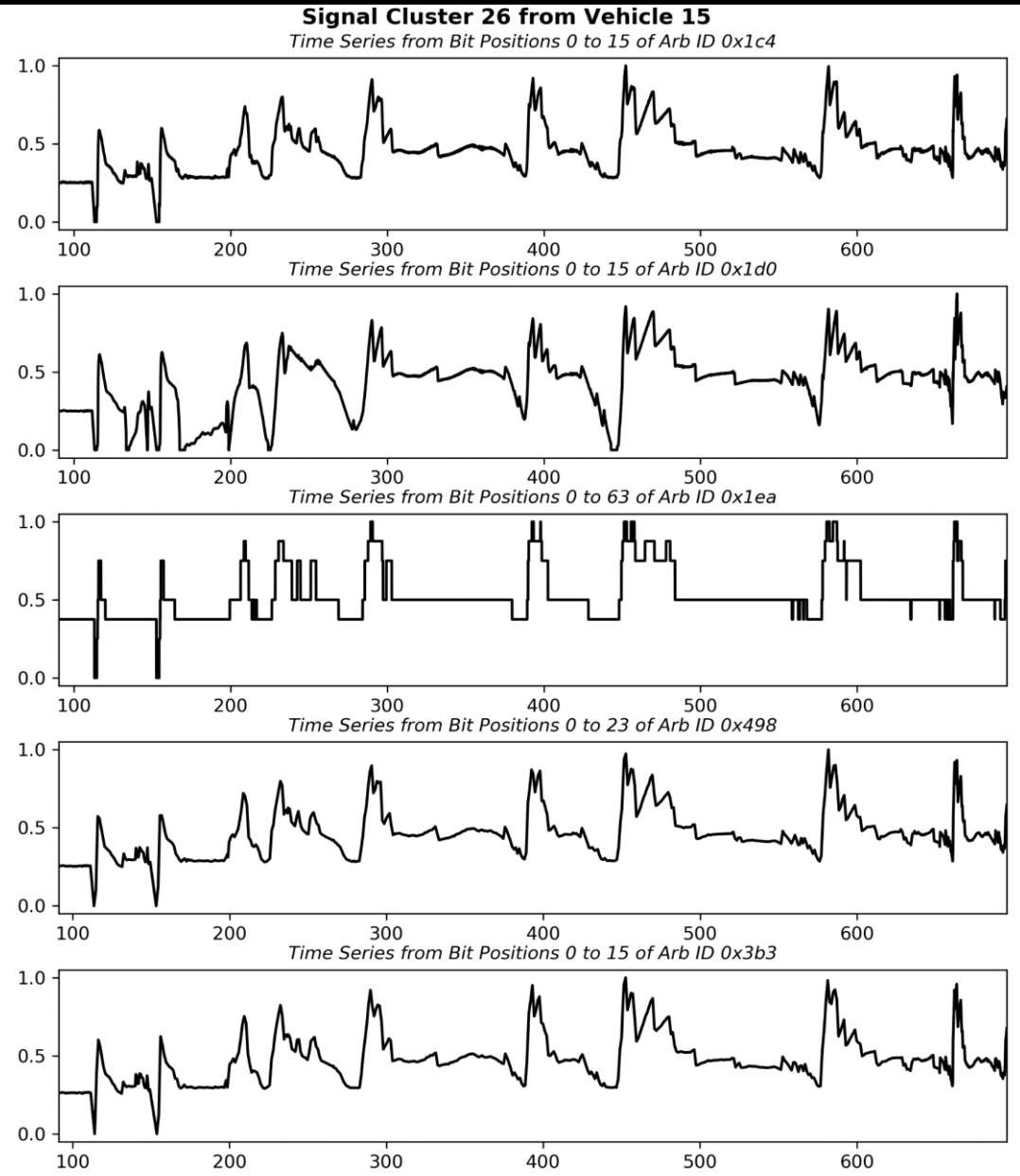
https://github.com/brent-stone/CAN_Reverse_Engineering

VEHICLE 15

VEHICLE 16

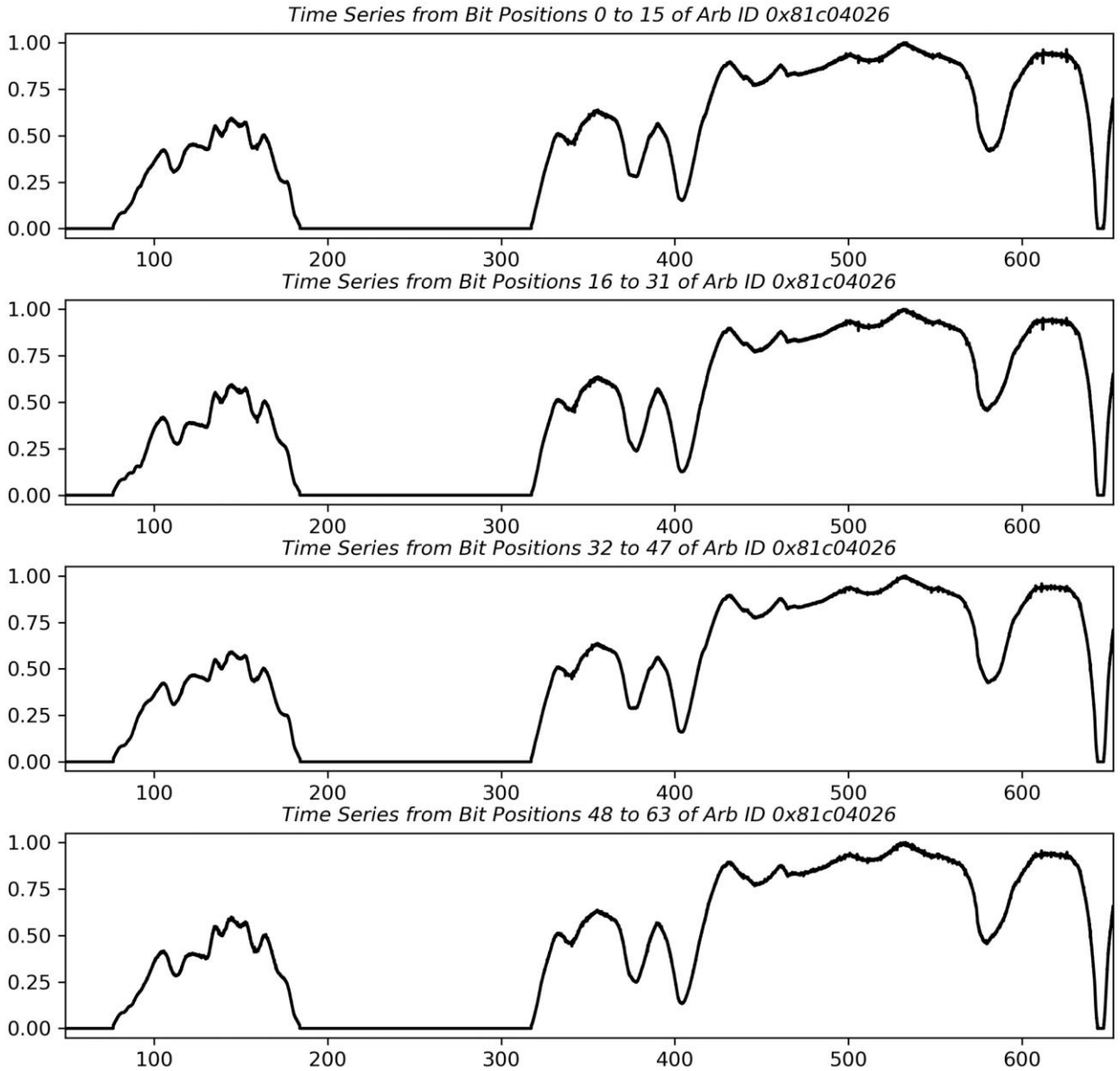
CROPPED TO FIT ON SLIDE



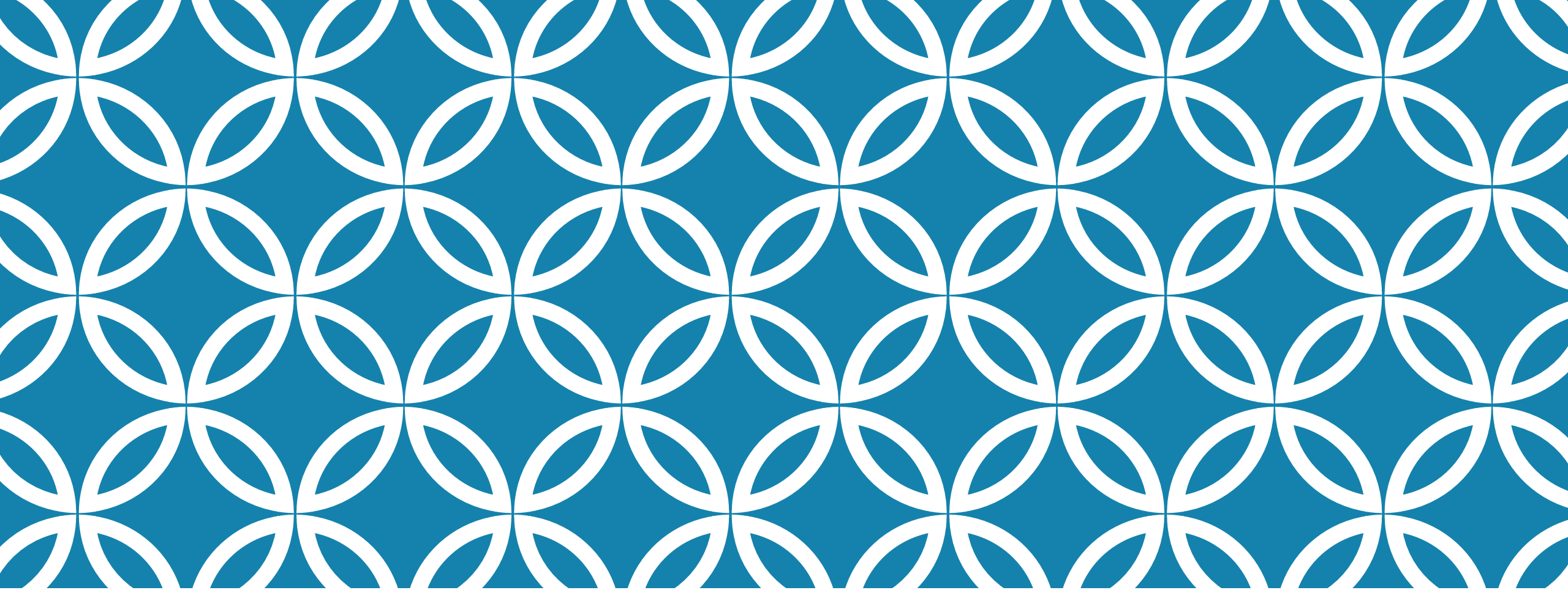


https://github.com/brent-stone/CAN_Reverse_Engineering

VEHICLE 17



https://github.com/brent-stone/CAN_Reverse_Engineering



QUESTIONS

BRENT STONE