

Exposing Congestion Attack on Emerging Connected Vehicle based Traffic Signal Control¹

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AI Security and Practice

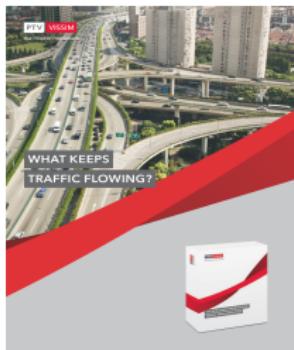
November 1, 2021

¹Chen Q A, Yin Y, Feng Y, et al. Exposing Congestion Attack on Emerging Connected Vehicle based Traffic Signal Control[C]//NDSS. 2018.

Content

- ▶ Simulation software for traffic simulation
- ▶ Infrastructure parameters
- ▶ Development and evaluation
- ▶ Attack demonstration
- ▶ Discussion

Simulation Software



PTV Vissim



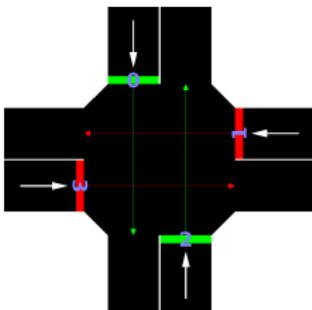
Eclipse Sumo

- ▶ Adv. Visualization(2D/3D)
- ▶ COM Interface(C++, Python)
- ▶ Premium Software
- ▶ Easy to Use
- ▶ Traci Interface(Python, C++)
- ▶ Open-source Software

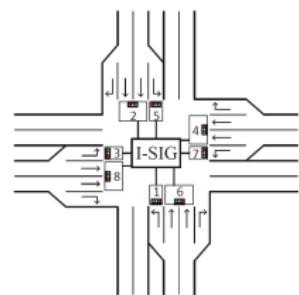
Some Tips About SUMO

- ▶ phase is not phase
- ▶ set/get attributes through specific static methods
- ▶ GUI mode and CLI mode

```
<tlLogic id="center" type="static" programID="0" offset="0">
  <phase duration="31" state="GGGgrrrrrrGGgrrrrrr"/>
  <phase duration="4" state="yygyrrrrrryygyrrrrr"/>
  <phase duration="6" state="rrrGrrrrrrrrGrrrrrr"/>
  <phase duration="4" state="rrryrrrrrrrryrrrrr"/>
  <phase duration="31" state="rrrrGGGGggrrrrGGGGgg"/>
  <phase duration="4" state="rrrryygygrrrryygg"/>
  <phase duration="6" state="rrrrrrrrGrrrrrrrGG"/>
  <phase duration="4" state="rrrrrrrryyrrrrrryy"/>
</tlLogic>
```



SUMO traffic light



I-SIG traffic light

Infrastructure Parameters(Traffic Light)



Signal Timing Manual
Second Edition

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
In Cooperation with
American Association of State Highway and Transportation Officials

- ▶ Speed Limit: 40mph
- ▶ Yellow: 4s
- ▶ Red: 2s
- ▶ Min-Green: 10s
- ▶ Max-Green: 50s

Approach Speed (MPH)	Minimum Yellow Change ¹ (Seconds)
25	3.0*
30	3.2
35	3.6
40	3.9
45	4.3
50	4.7
55	5.0
60	5.4

Approach Speed (MPH)	Red Clearance ¹ (Seconds)				
	30	50	70	90	110
25	0.4	0.9	1.5	2.0	2.5
30	0.1	0.6	1.0	1.5	2.0
35	0.0	0.4	0.8	1.1	1.5
40	0.0	0.2	0.5	0.9	1.2
45	0.0	0.1	0.4	0.7	1.0
50	0.0	0.0	0.2	0.5	0.8
55	0.0	0.0	0.1	0.4	0.6
60	0.0	0.0	0.0	0.2	0.5

Phase Type	Facility Type	Minimum Green (Seconds)
Through	Major Arterial (> 40 mph)	10 to 15
	Major Arterial (\leq 40 mph)	7 to 15
	Minor Arterial	4 to 10
Left Turn	Collector, Local, or Driveway	2 to 10
	Any	2 to 5

Phase Type	Facility Type	Maximum Green (Seconds)
Through	Major Arterial (> 40 mph)	50 to 70
	Major Arterial (\leq 40 mph)	40 to 60
	Minor Arterial	30 to 50
Left Turn	Collector, Local, or Driveway	20 to 40
	Any	15 to 30

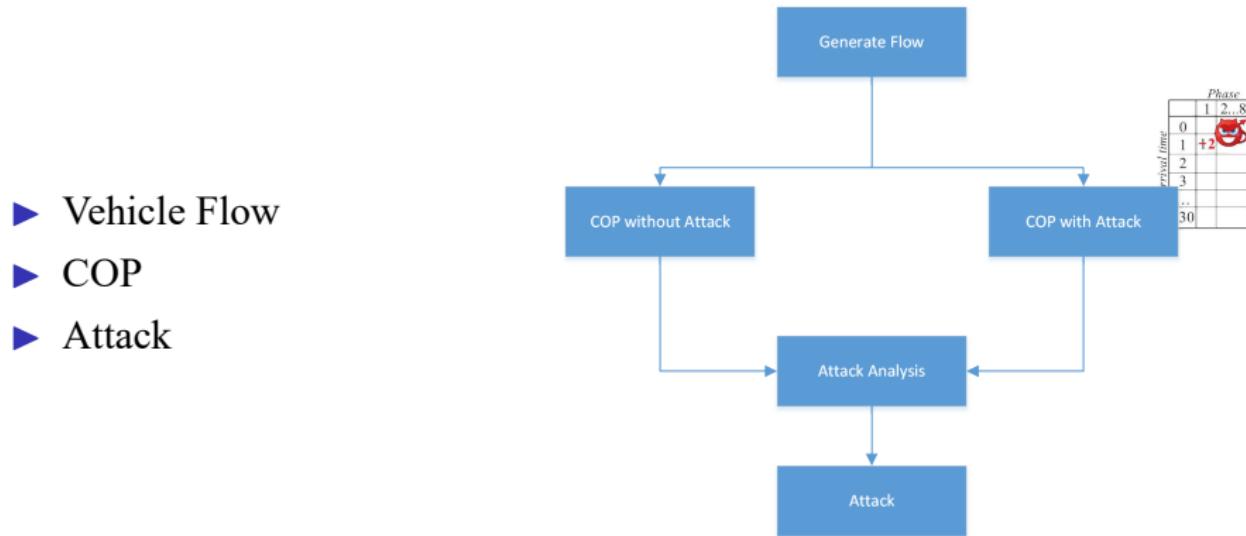
Infrastructure Parameters(Vehicle Flow)

0.7 vehicle / capacity?

- ▶ Possion Distribution: $22 * 6$ per 2 minutes
- ▶ Uniform Distribution: step into the scene

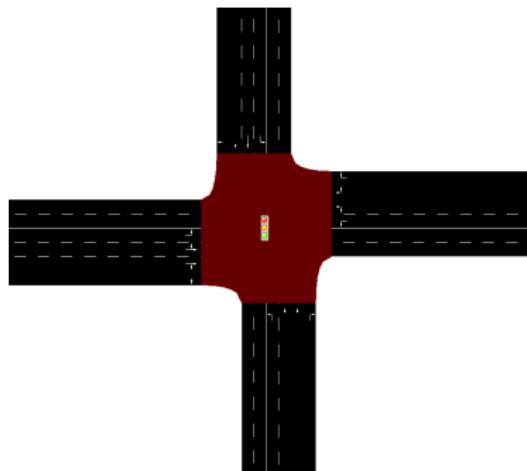
Development and Evaluation-Development

Modules⁸



⁸ <https://github.com/ZeroWalker10/Exposing-Congestion-Attack-on-Emerging-Connected-Vehicle-based-Traffic-Signal-Control>

Development and Evaluation-Vehicle Flow



```
flow
├── flow_generator.py
├── main_flow.py
├── route_mgt.py
├── route.py
├── utility.py
└── vehicle_flow.py
    ├── vehicle_mgt.py
    ├── vehicle.py
    ├── vehicle_type_mgt.py
    └── vehicle_type.py
```

- ▶ Vehicle Type: bus, car, truck
- ▶ 16 Routes: random dist.

Development and Evaluation-COP

```
cop
├── ConnectedVehicle.h
├── COP_DUAL_RING.h
├── COP.h
├── EVLS.h
├── IDMSGcnt.h
├── LinkedList.h
├── ListHandle.h
└── PositionLocal3D.h
    └── ReqNode.h
```

MMITSS-AZ 1.0¹

- ▶ Dual ring COP
- ▶ EVLS

¹ <https://github.com/mmitss/mmitss-az>

Development and Evaluation-Evaluation

Evaluation: total delay

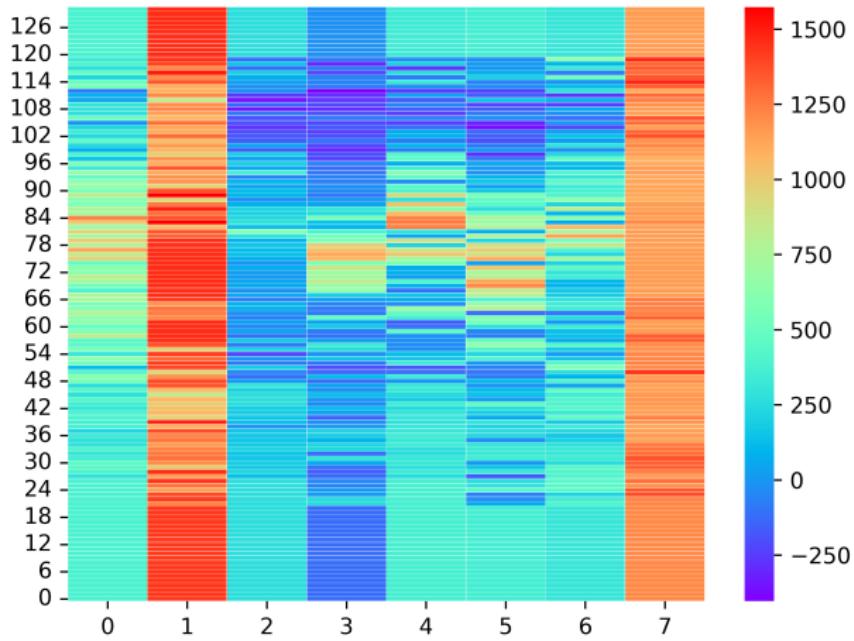
Steps:

- ▶ normal COP schedule
- ▶ COP with different attack options
- ▶ attack

```
src
└── arrival_table_diy.cpp
    ├── attacker.cpp
    ├── main_analysis.cpp
    ├── main_attack.cpp
    ├── main_baseline.cpp
    ├── main_cop.cpp
    └── phase_diy.cpp
        ├── time_schedule.cpp
        └── traffic_light_diy.cpp
            └── vehicle_diy.cpp
```

```
include/
└── arrival_table_diy.h
    ├── attacker.h
    ├── phase_diy.h
    ├── time_schedule.h
    └── traffic_light_diy.h
        └── vehicle_diy.h
```

Development and Evaluation-Evaluation



Development and Evaluation-Some regret

full employment, but transition period is lost

```
if(m_pene_ratio < 0.95) {
    // pest employment
    // TODO: EVLS
}

COP_DUAL_RING(init_phases, green_elapse, passed_phases, real_skip);
if(opt_sig_seq[0][0] == 0 && opt_sig_seq[0][1] == 0) {
    if(opt_sig_plan[0][0] > 0) {
        opt_sig_seq[0][0] = init_phases[0];
    } else {
        opt_sig_seq[0][1] = init_phases[0];
    }
}
```

Attack Demonstration

It is show time...

Discussion-Parallel

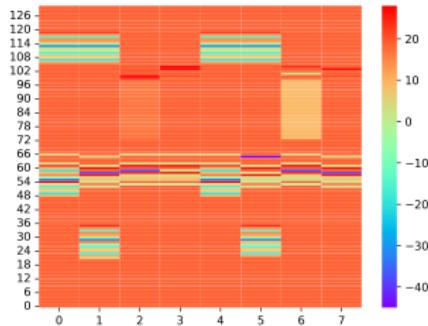
OpenMP[®]

Discussion-with and without COP

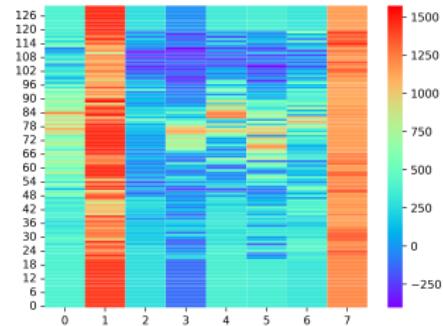
- ▶ highlight COP effect
- ▶ whether COP algorithm is right

Discussion-flow and attack effect

- ▶ flow threshold
- ▶ flow distribution



uniform distribution



concentrated distribution

Thank you!