

# 1. MILP Linearization

1. Given  $\alpha, \beta, r$  which are binary variables. and

prove that  $\alpha + \beta + r \neq 2 \iff \alpha + \beta - r \leq 1 \wedge \alpha - \beta + r \leq 1 \wedge -\alpha + \beta + r \leq 1$

$\alpha$	$\beta$	$r$	LHS	$\alpha + \beta - r \leq 1$	$\alpha - \beta + r \leq 1$	$-\alpha + \beta + r \leq 1$	RHS	LHS = RHS?
0	0	0	T	T	T	T	T	T
0	0	1	T	T	T	T	T	T
0	1	0	T	T	T	T	T	T
0	1	1	F	T	T	F	F	T
1	0	0	T	T	T	T	T	T
1	0	1	F	T	F	T	F	T
1	1	0	F	F	T	T	F	T
1	1	1	T	T	T	T	T	T

2.

prove  $\alpha\beta = r \iff \alpha + \beta - 1 \leq r \wedge r \leq \alpha \wedge r \leq \beta$

$\alpha$	$\beta$	$r$	LHS	$\alpha + \beta - 1 \leq r$	$r \leq \alpha$	$r \leq \beta$	RHS	LHS = RHS?
0	0	0	T	T	T	T	T	T
0	0	1	F	T	F	F	F	T
0	1	0	T	T	T	T	T	T
0	1	1	F	T	F	T	F	T
1	0	0	T	T	T	T	T	T
1	0	1	F	T	T	F	F	T
1	1	0	F	F	T	T	F	T
1	1	1	T	T	T	T	T	T

3. select  $M$  to guarantee

$$\beta x = y \iff 0 \leq y \leq x \wedge x - M(1 - \beta) \leq y \wedge y \leq M\beta, \quad x \leq 2021$$

$\beta$	LHS	$0 \leq y \leq x$	$x - M(1 - \beta) \leq y$	$y \leq M\beta$
0	$0 = y$	$0 \leq y \leq x$	$x - M \leq y$	$y \leq 0 \Rightarrow x - M \leq y = 0 \leq x$
1	$x = y$	$0 \leq y \leq x$	$x \leq y$	$y \leq M \Rightarrow 0 \leq x = y \leq M$

In case  $\beta = 1$  LHS  $x = y$   $x - M \leq 0$  and  $x \leq 2021$   $M \geq x$

$$M \geq 2021 \quad \#$$

## 2. Signal Packing

1. New design is better due to enhance the data efficiency, packing signal can reduce header and other bits message, so packing same period signal is better

2. we can know  $M_1$  sender is  $E_0$  and receiver is  $E_1$  but  $M_2$  sender is  $E_1$  and Receiver is  $E_2, E_3$ , above two message have different sender and receiver so can't merge them.

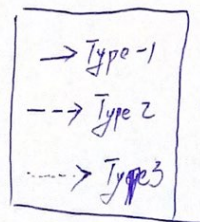
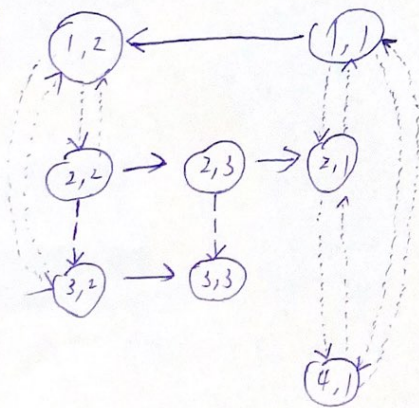
3.

If we can separate  $M_3$  messages' sender and receiver to two part ( $E_0 \rightarrow E_3$  to  $E_0 \rightarrow E_1$  and  $E_1 \rightarrow E_3$ ), then we can

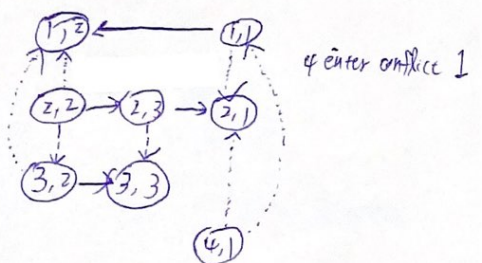
~~merge~~ packing  $M_3$  signal into  $M_1$  and  $M_2$  messages signal. Above

action can enhance data efficiency and have more frequent messages to replace period time 100 msec  $M_3$  message.

4. (1)



(2)



When vehicle 1 in conflict zone 1  
vehicle 2 in conflict zone 3  
vehicle 3 in conflict zone 2  
it will become dead lock