recursive algorithm

dir= 1 or -1
dir=-dir

```
algorithm new_name(x, first, dir):
        % x (n ≥ x ≥ 1) is the recursion parameter %
(01)  SM[x, first, dir][i] ← old_name_i;
(02)  competing_i ← SM[x, first, dir].collect();
(03)  if |competing_i| = x
(04)     then last ← first + dir(2x − 2);
(05)          if old_name_i = max(competing_i)
(06)             then res_i ← last
(07)             else  res_i ← new_name(x − 1, last + dir̄, dir̄)
(08)          end if
(09)     else  res_i ← new_name(x − 1, first, dir)
(10)  end if;
(11)  return(res_i).
```

new_name(n,1,1)

- For a pair (first, dir); the Algo ensures at most x processes invoke new_name(x, first, dir)
- These processes compete for new names in space name of size 2x-1
- Initial space New_name (n,1,1)—> 1, 2n-1

- if k processes participate in the renaming, their main call new_name(n, 1, 1) will systematically entail the call new_name(n – 1, 1, 1), etc., until the call new_name(k, 1, 1).

- If k processes participate to new_name(k, 1, 1) at least one (the last process that writes) find k processes in competing

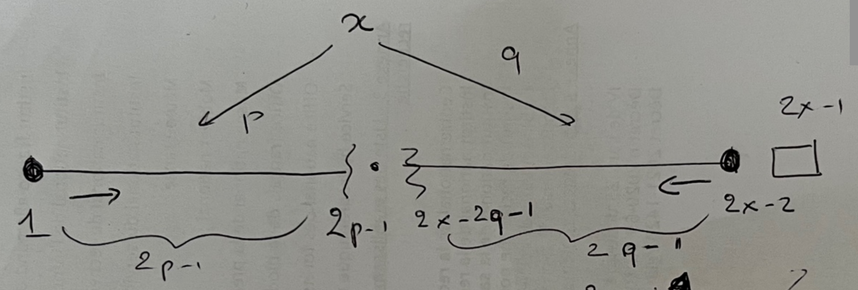
- In space 1..X, (dir=1) if k processes compete they get a name in 1..2k-1

- In space 1..X, (dir=-1) if k processes compete they get a name in X-(2k-2)..X

- **Splitter behavior** associated with the array of atomic registers SM [x, first, dir] is defined by the following properties: (let $x' = x - 1$):
  - At most $x' = x-1$ processes invoke new_name(x–1, first, dir) (line 9). Hence, these processes will obtain new names in an interval of size $(2x' - 1)$ as follows:
    - If dir = 1, the new names will be in the "going up" interval [first..first + (2x'– 2)],
    - if dir = -1, the new names will be in the "going down" interval [first – (2x'– 2)..first].
  - At most $x' = x - 1$ processes invoke new_name(x – 1, last + $\overline{dir}$, $\overline{dir}$) (line 7), where last = first + dir(2x – 2) (line 7). Hence, these $x' = x - 1$ processes will obtain their new names in a renaming space of size $(2x' - 1)$ starting at last + 1 and going from left to right if $\overline{dir} = 1$, or starting at last – 1 and going from right to left if $\overline{dir} = -1$.

- At most one process “stops”, i.e., defines its new name as last = first + dir(2x – 2) (lines 4,5,6). Let us observe that the only process that can stop is the one such that id has the greatest value in the array SM [x, first, dir] [1..n] which contains then exactly x identities.

$p \neq 0 \quad q \neq 0$



$x = p + q + 1$

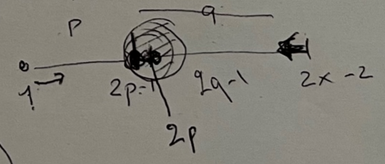
$2x - 2q - 1 = 2p + 1$

$x = p + q$

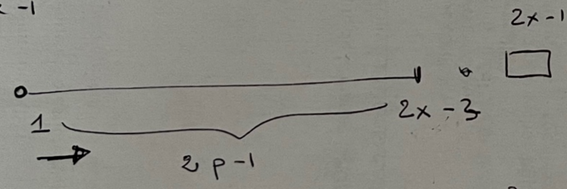
$1 \ldots 2p-1$

$2x-2q = 2p$

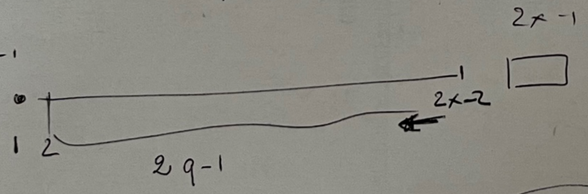
$2x-2$

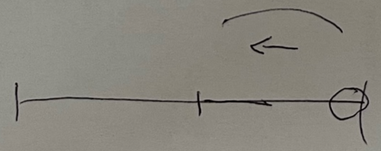


$p = x - 1$



$q = x - 1$





- With objects cons for 2 processes we can achieve strong adaptive renaming
- (strong = space of new name are in 1..n)
- Adaptive : if k processes compete they gets a name in 1..k

- With strong adaptive renaming we can achieve consensus for 2 processes

Byzantine failures

- A correct process is a process that follow its code
- A byzantine process might fail by exhibiting arbitrary behavior (e.g send bogus message)
- (but it can’t pretend to be another process)(or no message)

- With at most t crash failures , in synchronous system we can solve consensus
- This is not true with Byzantine failure
- First define « byzantine agreement » : the previous definition of validity « the decided value is a value proposed by some process » doesn’t work

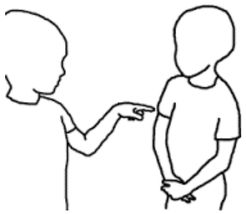
Byzantine agreement

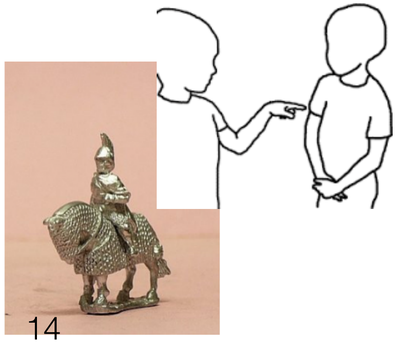
- **Agreement**: No two correct processes decide on different values
- **Validity** : if all correct processes propose the same value v then v is the only possible decision for correct processes
- **Termination** : All correct processes eventually decide

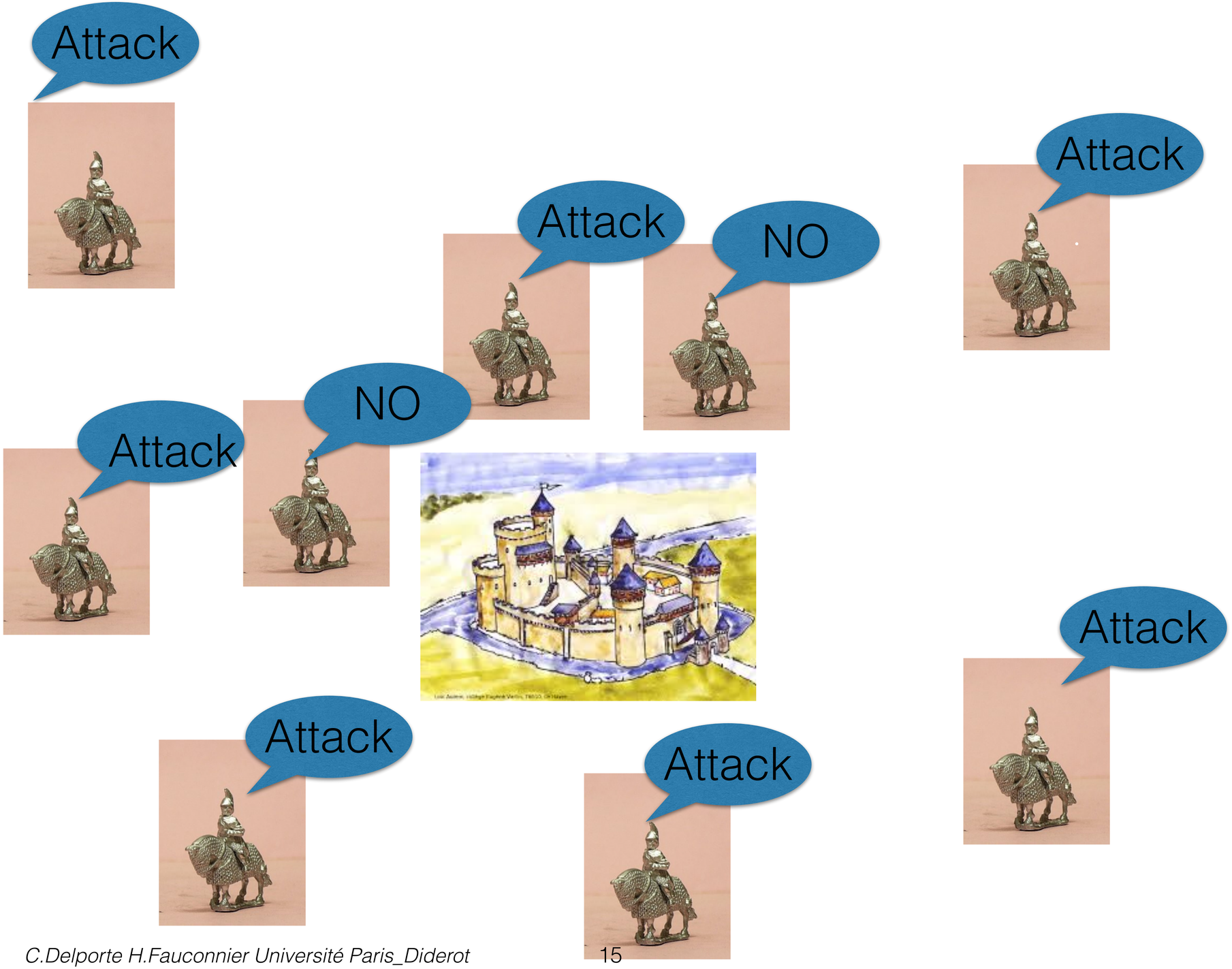




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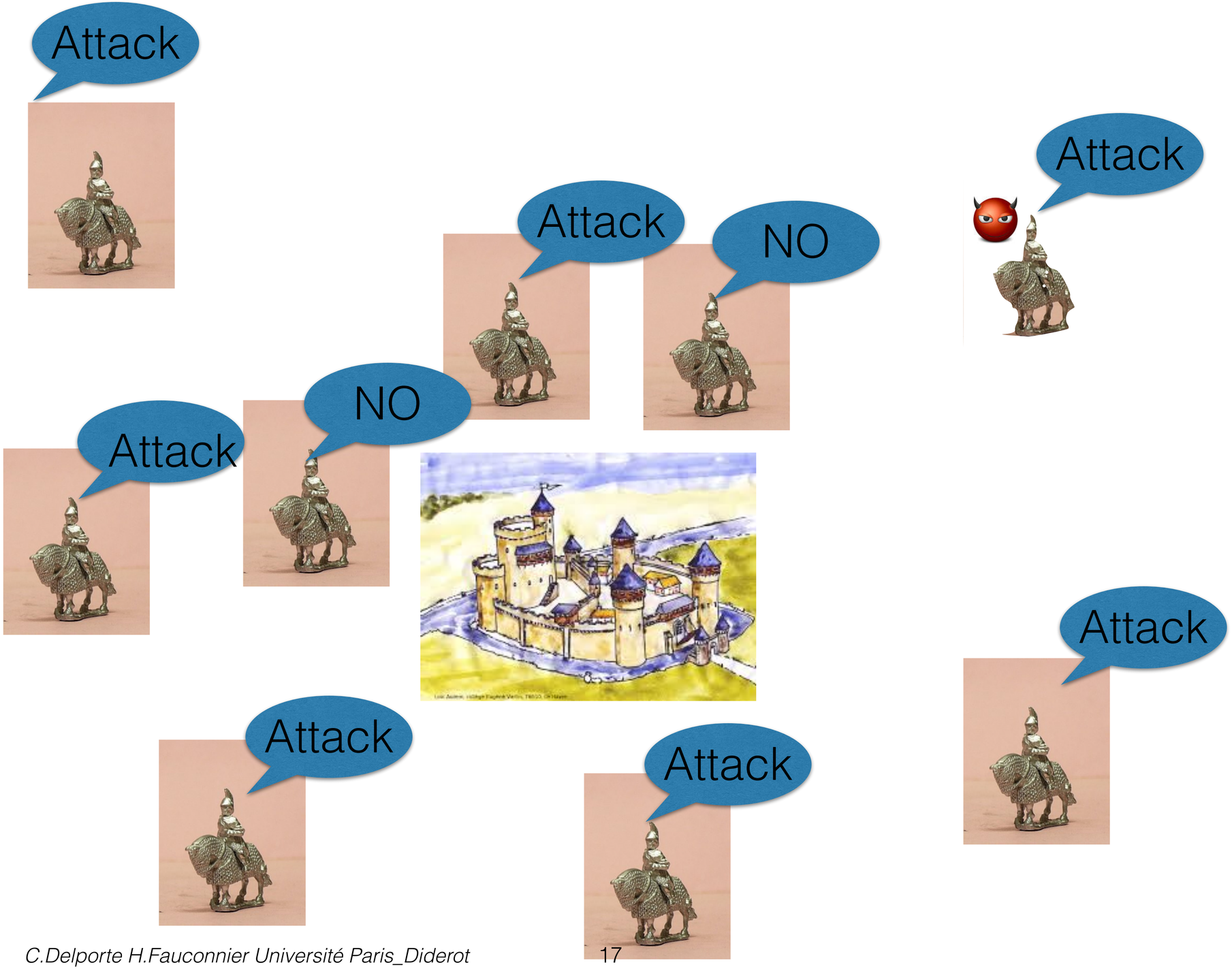
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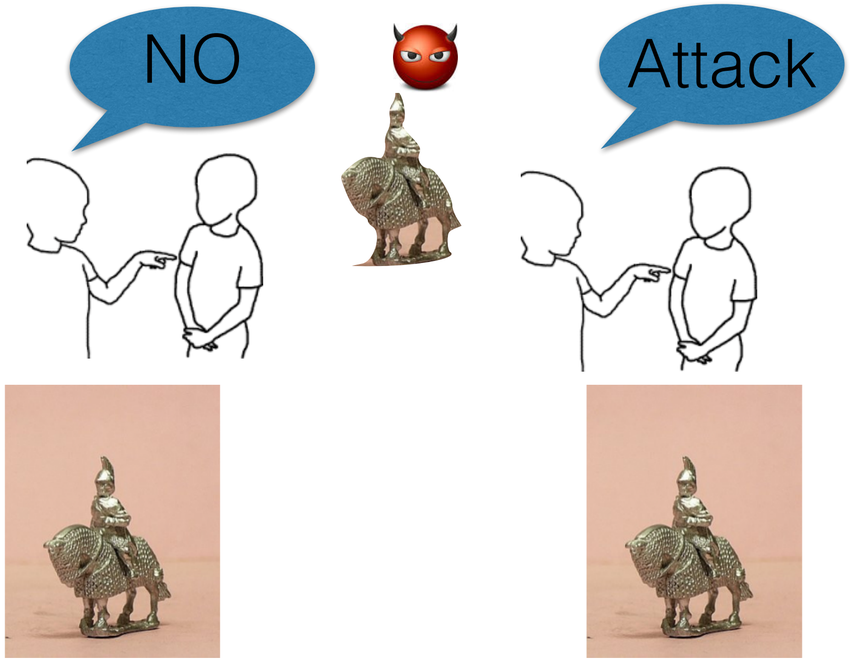
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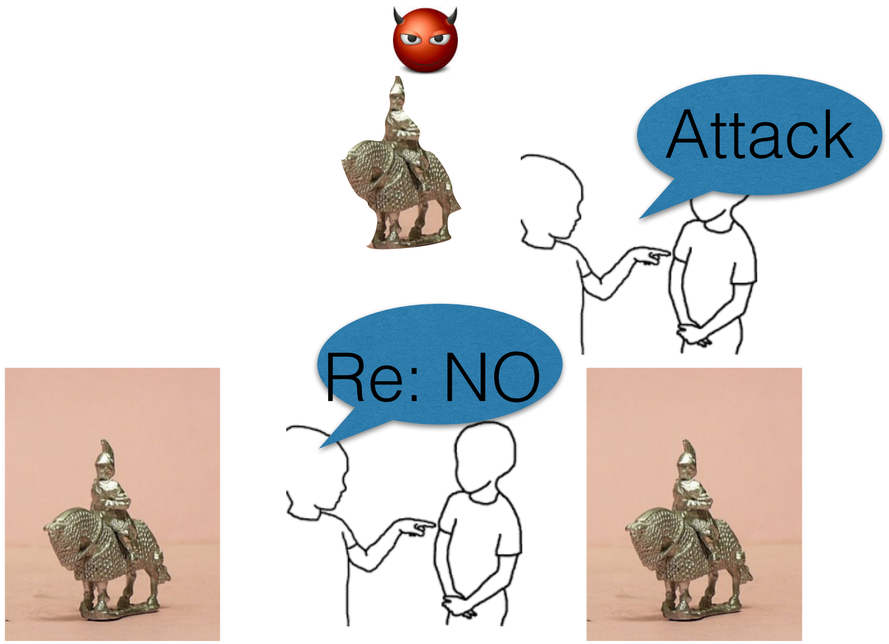
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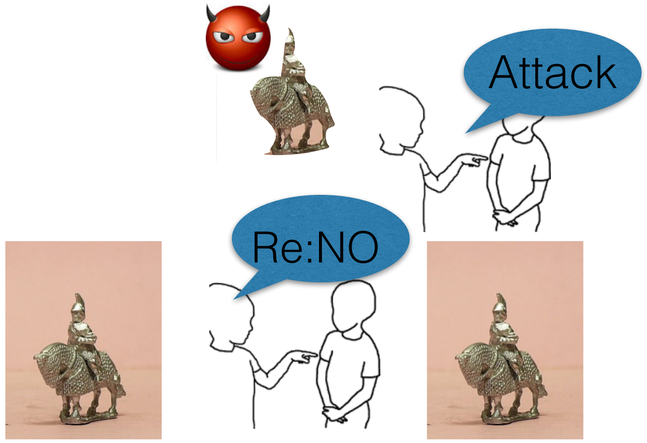
Re: NO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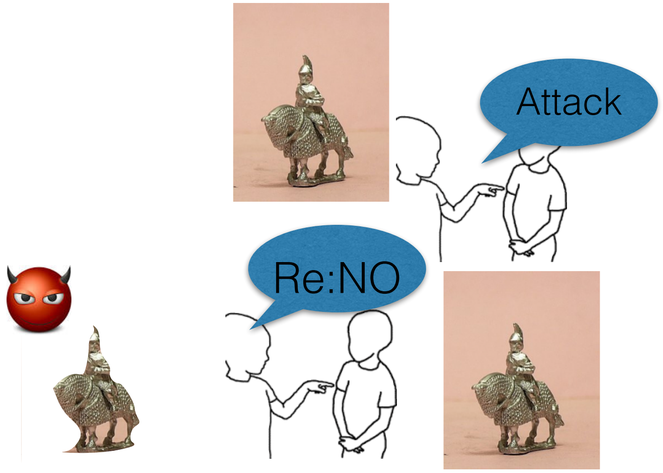
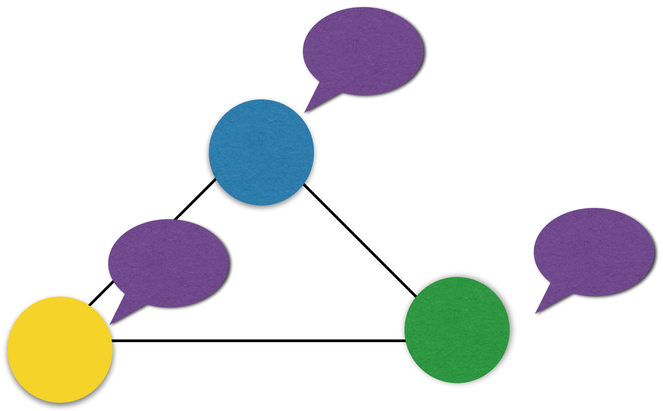
Re:NO

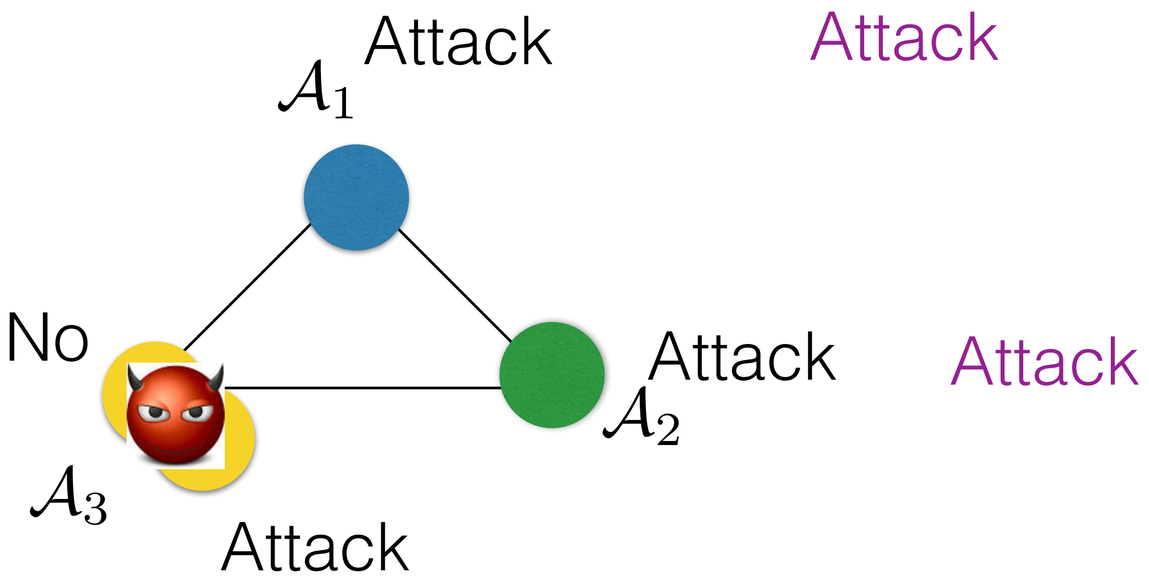

Attack
Re:NO

Impossibility result

- Theorem: If $n \leq 3t$ then it is impossible to solve byzantine agreement
- proof n=3 t =1



Decide



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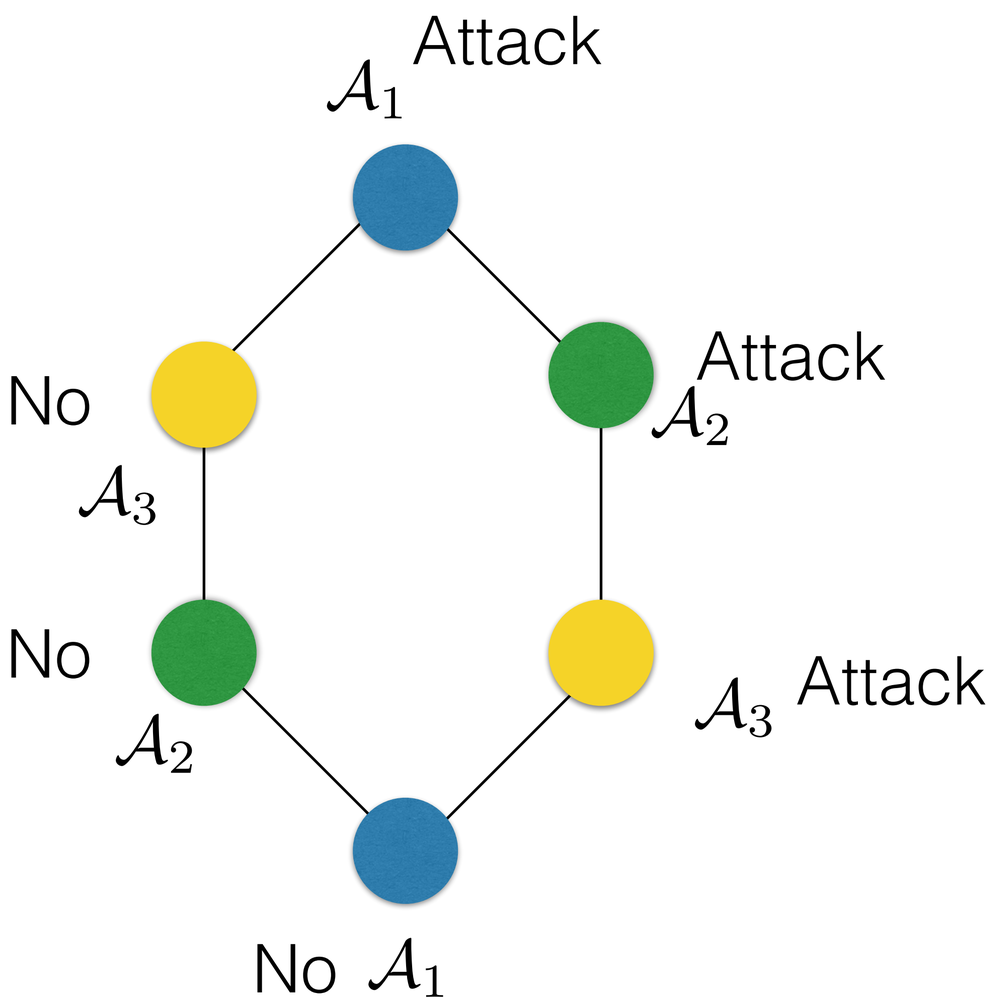
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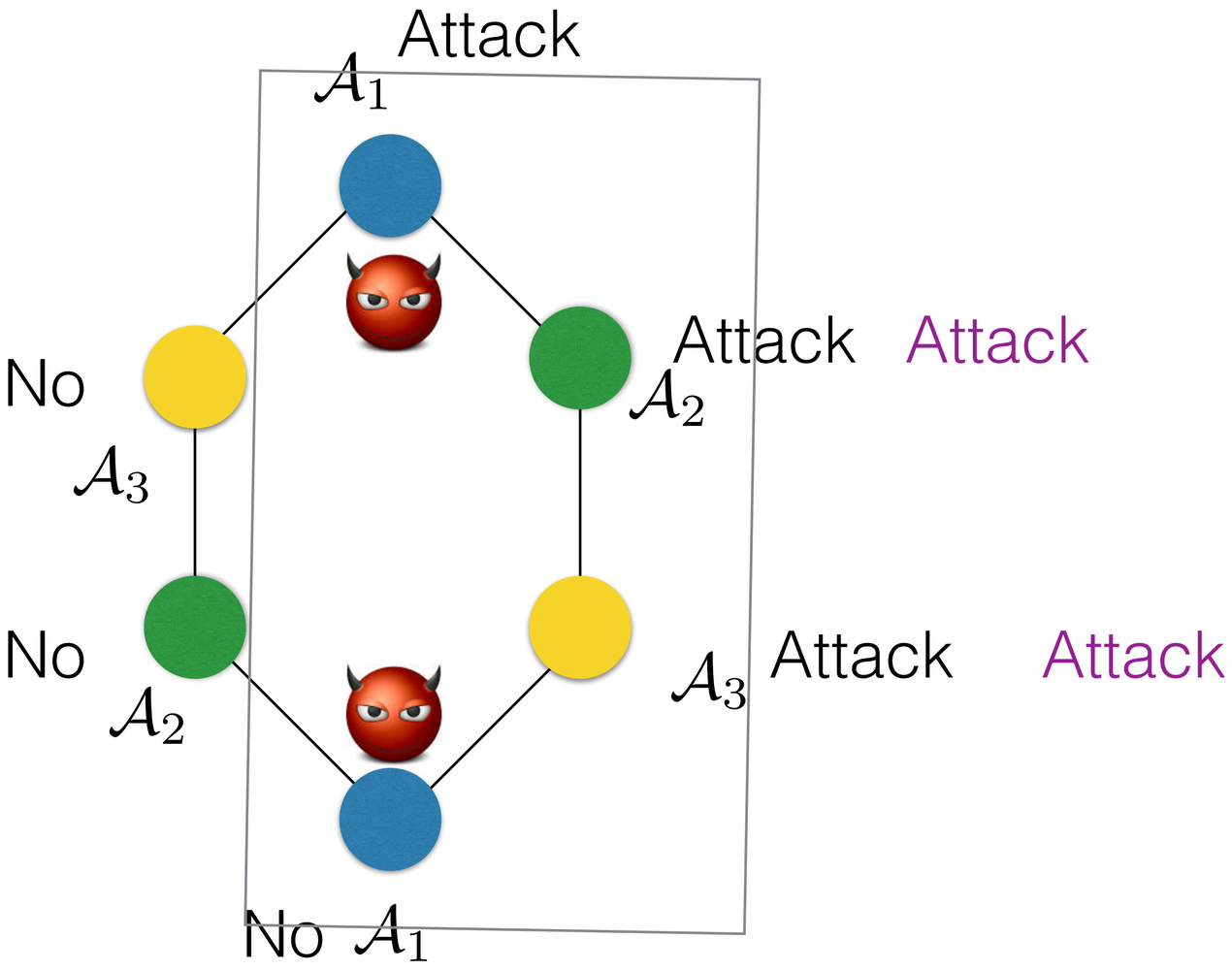
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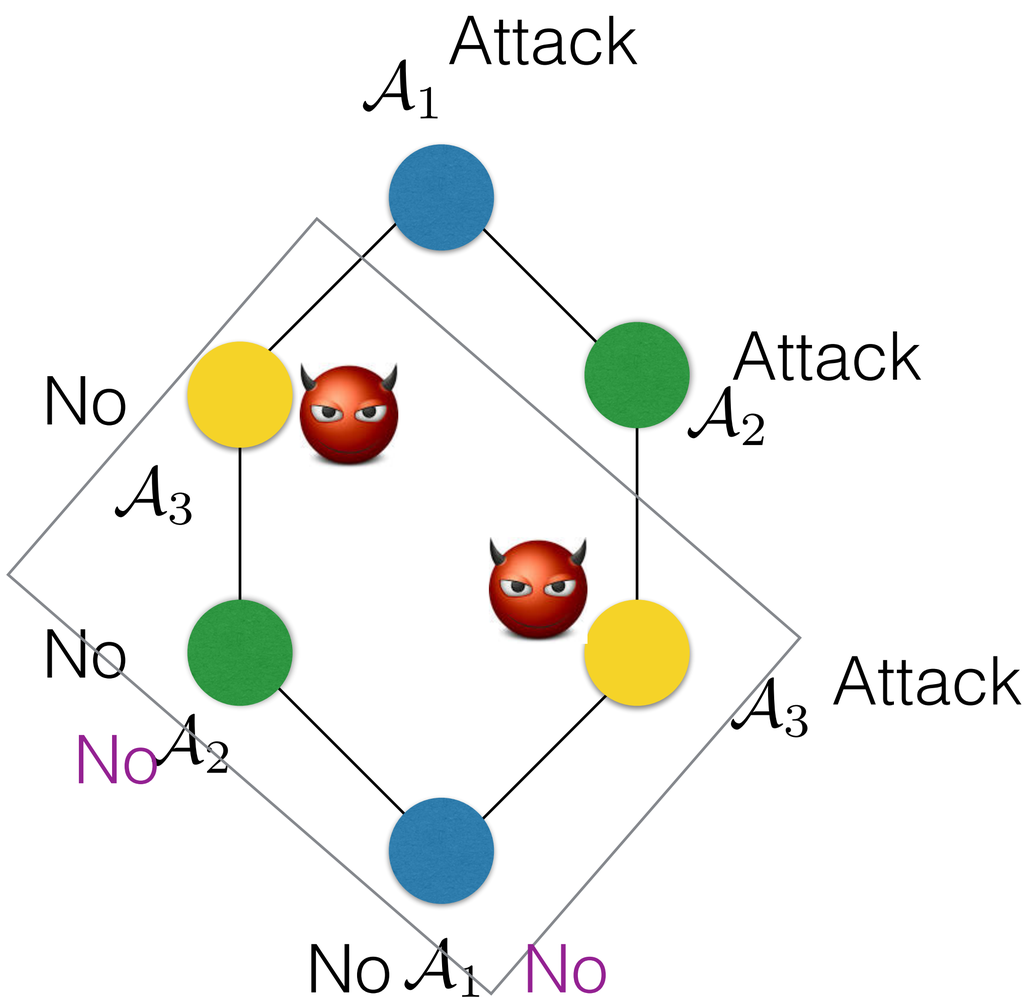
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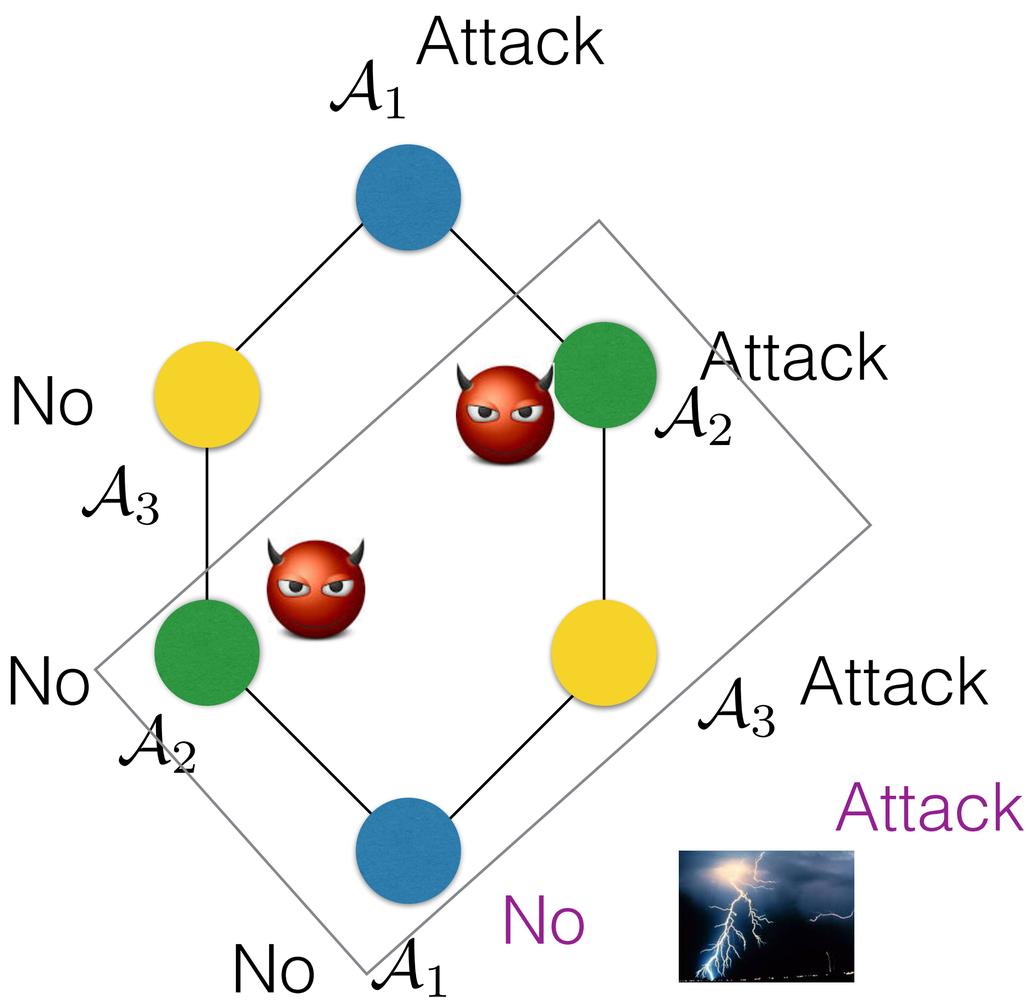
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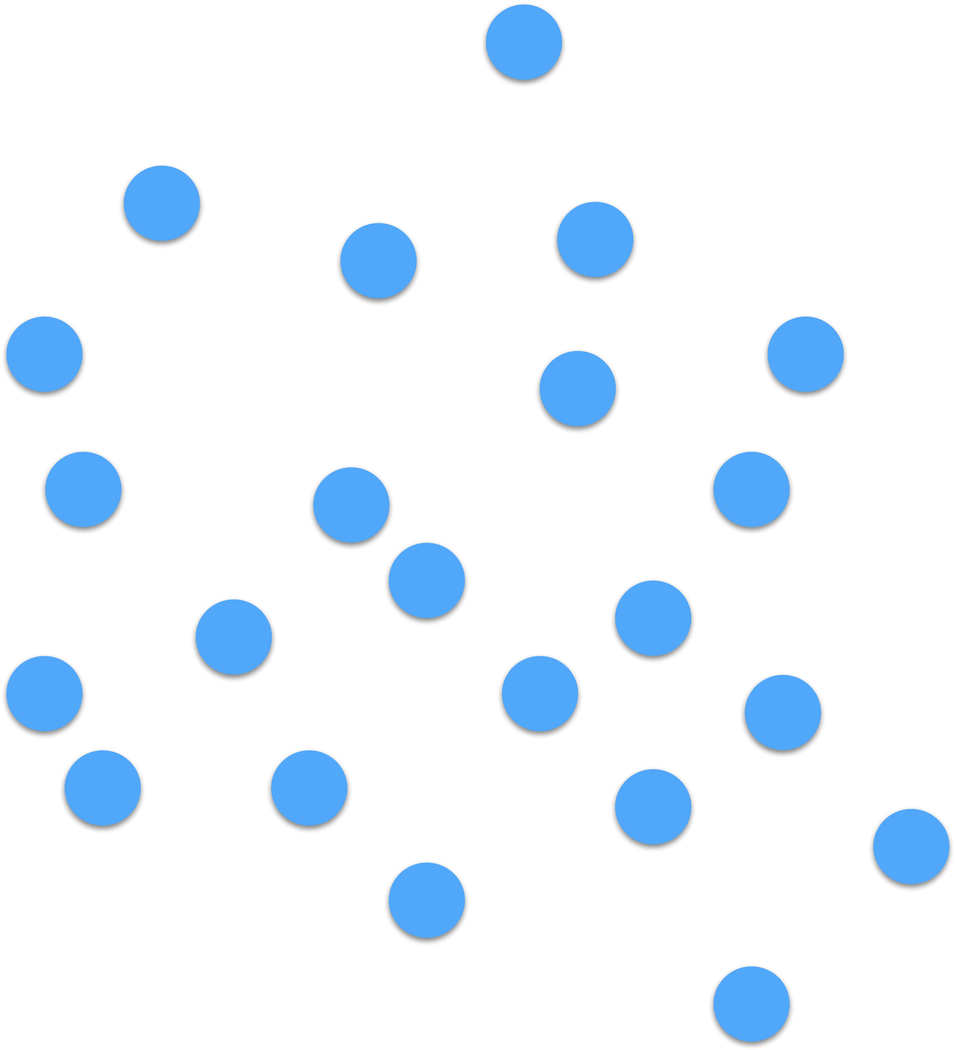
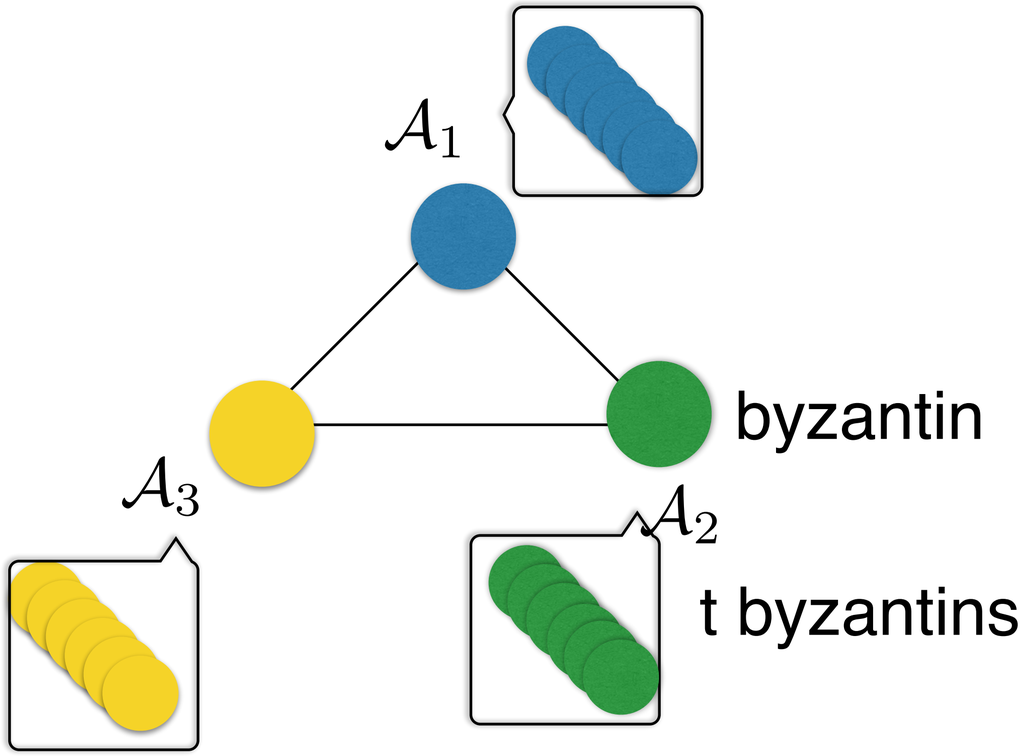
No $\mathcal{A}_1$

- The proof may be easily extends to any value of n

$n \geq 3t$



$n \geq 3t$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