

# Quantum Leader Election

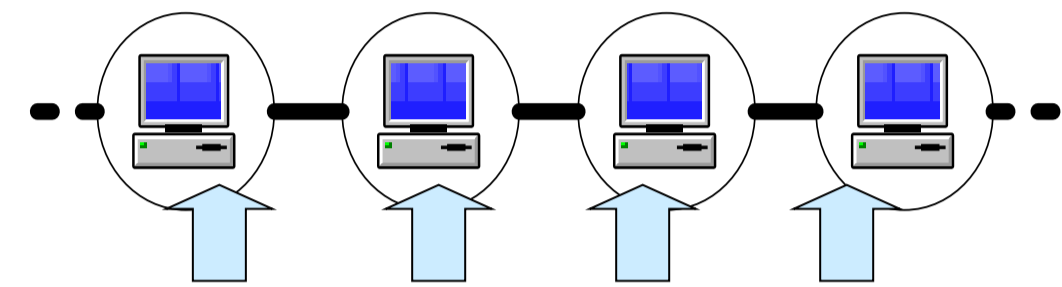
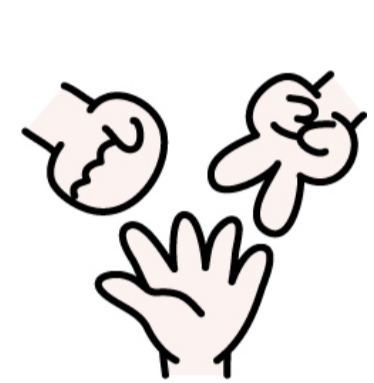
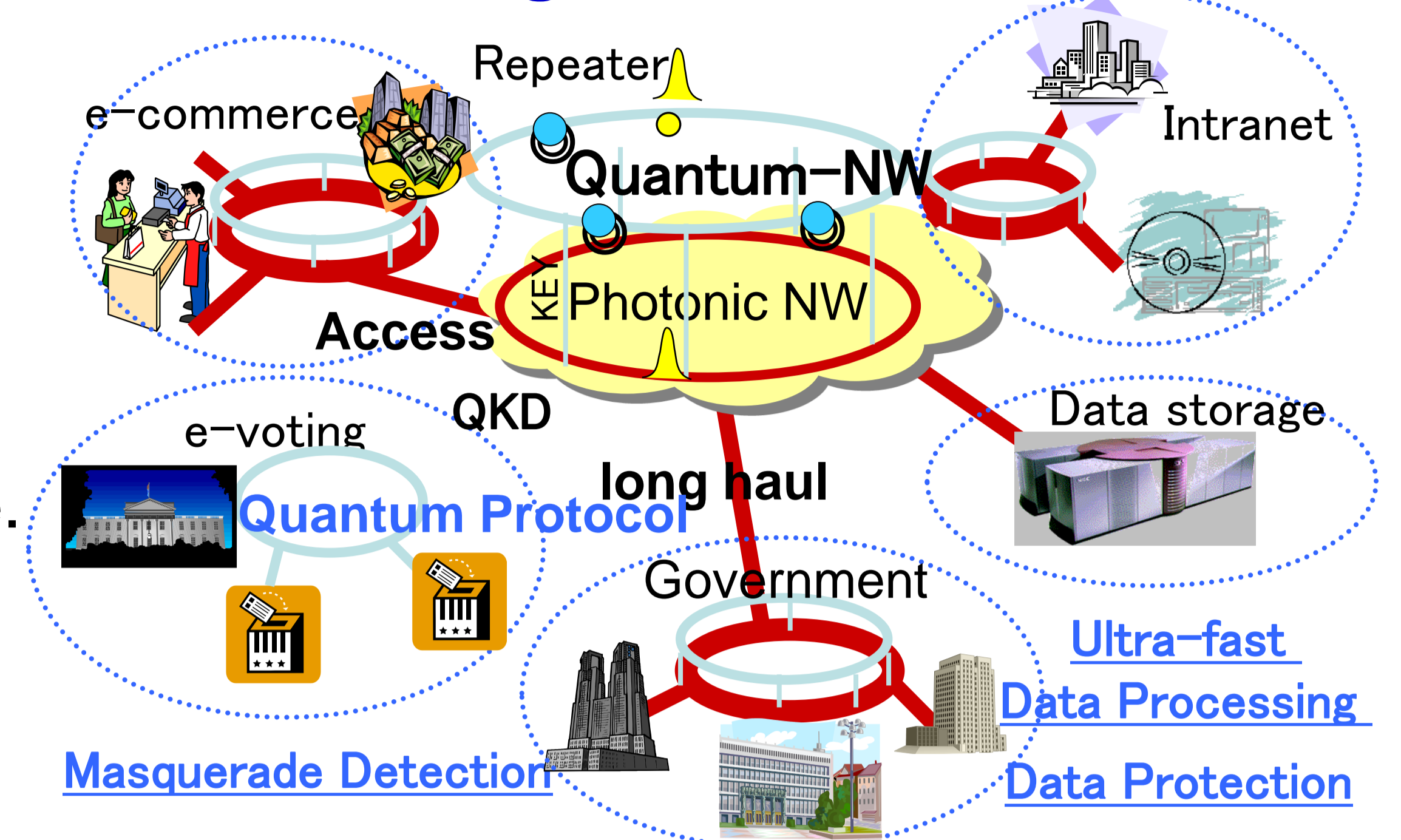
S. Tani, H. Kobayashi, K. Matsumoto, Y. Okubo, X.-B. Wang, Y.-K. Jiang, A. Tomita

LNCS3404, 581 (2005); arXiv:1001.5307; PRA77, 032343 (2008).

## Quantum Leader Election

- Distributed computing increases its importance in integrated networks
- Leader Election
  - Election of a unique leader from distributed parties **without identifier**
  - A fundamental problem in distributed computing: the leader can locally solve distributed computing problems.
  - Proved that **no classical algorithm** can solve it without fail in bounded time.
- Quantum Leader Election
  - can **exactly** solved on anonymous networks of any unknown topology.

### • Future integrated Network



**identical operation**

## Algorithm of Quantum Leader Election

### • Algorithm I

- for  $n$  party, exactly elects a unique leader in  $O(n^2)$  rounds and  $O(n^4)$  time.
- requires  $O(n^4)$ -qubit communication for each party connected, and total communication complexity  $O(n^4)$  over all parties

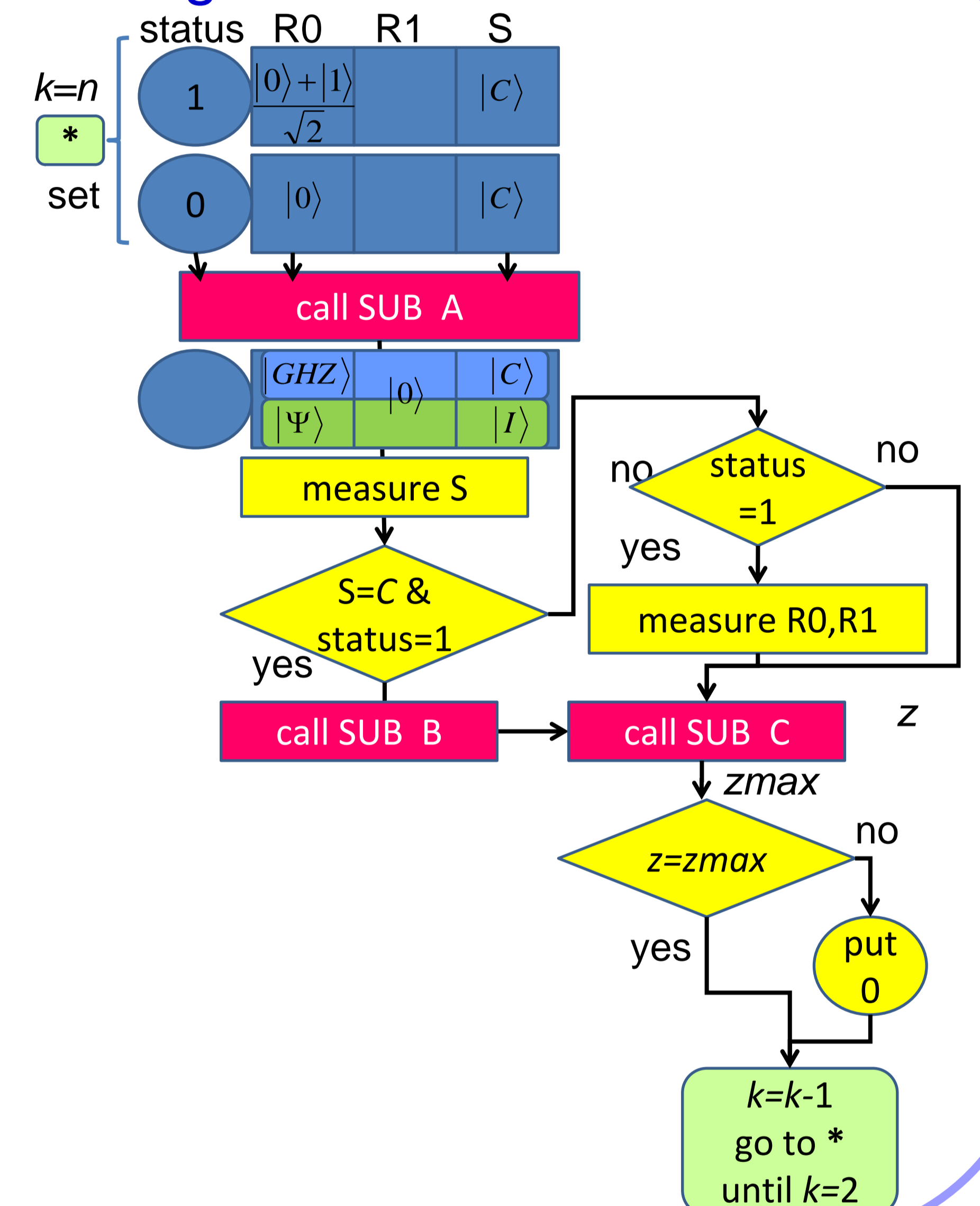
### • Algorithm II

- for  $n$  party, exactly elects a unique leader in  $O(n \log n)$  rounds and  $O(n^6 (\log n)^2)$  time.
- requires  $O(n^2)$ -qubit communication for each party connected, and total communication complexity  $O(n^6 (\log n)^2)$  over all parties
- can be used to compute any Boolean function in  $O(n)$  rounds of  $O(n^6 (\log n))$  bits classical communication

### • Further improvement

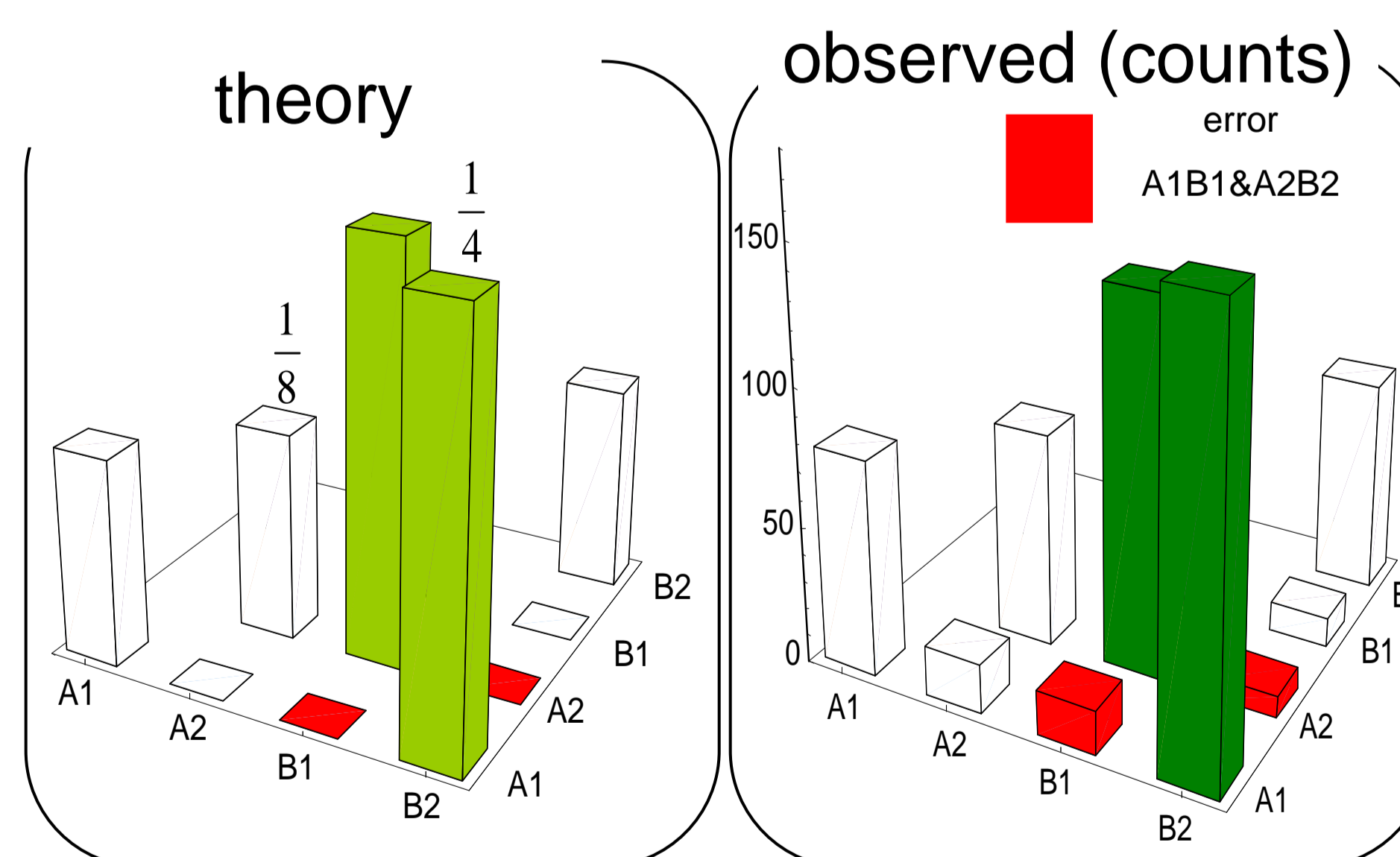
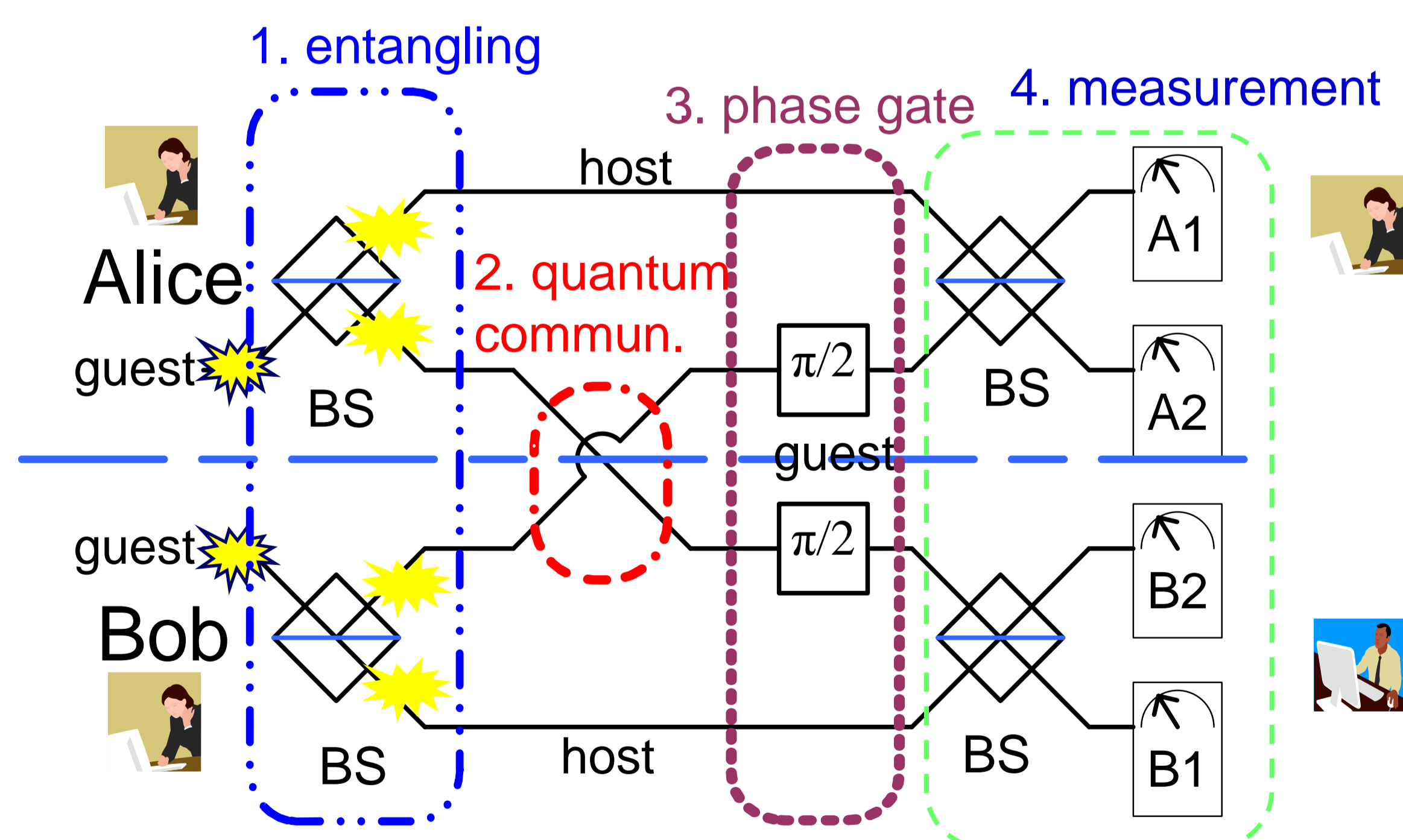
- for  $n$  party, and  $m$  edges, exactly elects a unique leader in  $O(n)$  rounds with  $O(mn^2)$  bit complexity, if  $n$  is known to every party.
- utilizes exact amplitude amplification

### • Algorithm I

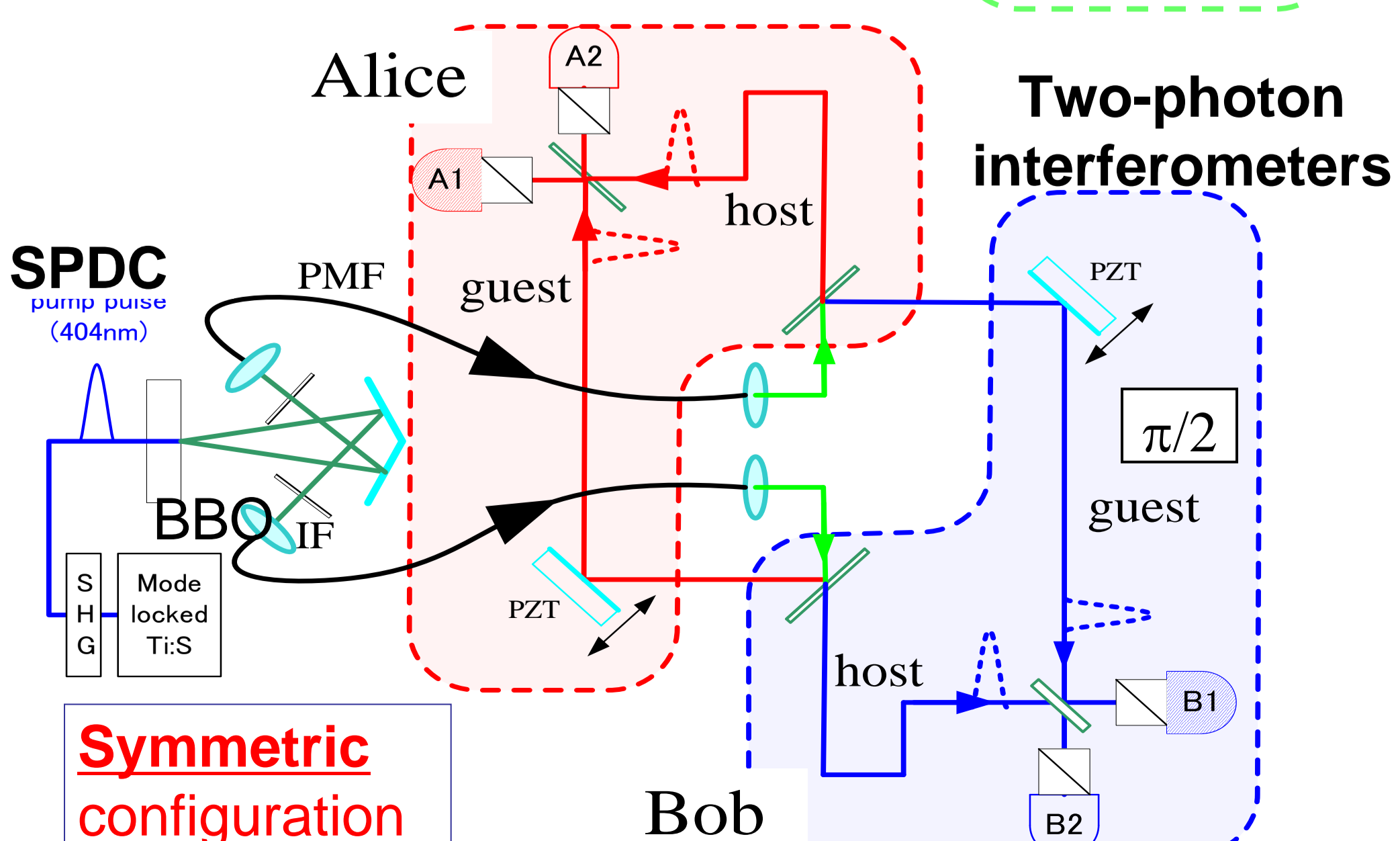


## Photonic Implementation

Photon number state implementation of two-party QLE (algorithm I)



A1	A2	B1	B2	Leader
1	-	-	1	Alice
-	1	1	-	Bob
2	-	-	-	Alice
-	2	-	-	Alice
-	-	2	-	Bob
-	-	-	2	Bob



### • Leader Election:

- Create asymmetric states from a symmetric state only with symmetric operations.
- as a Practical photonic implementation
  - Appropriate definition on success events result in deterministic operation with linear optics
  - even loss helps the successful leader election!