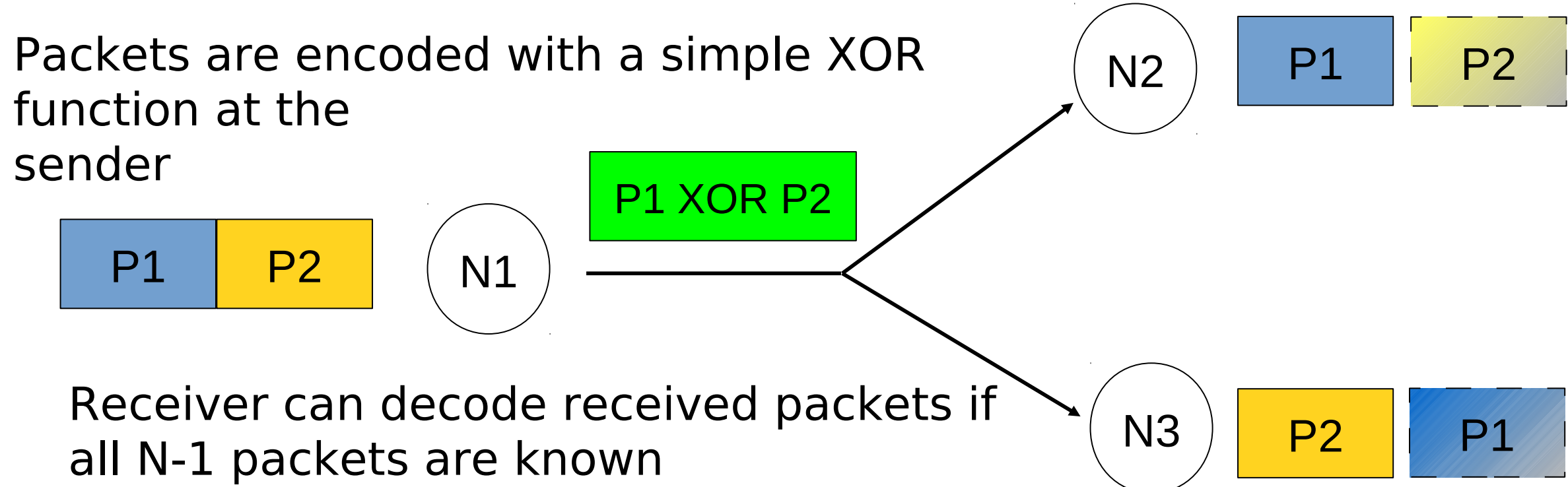


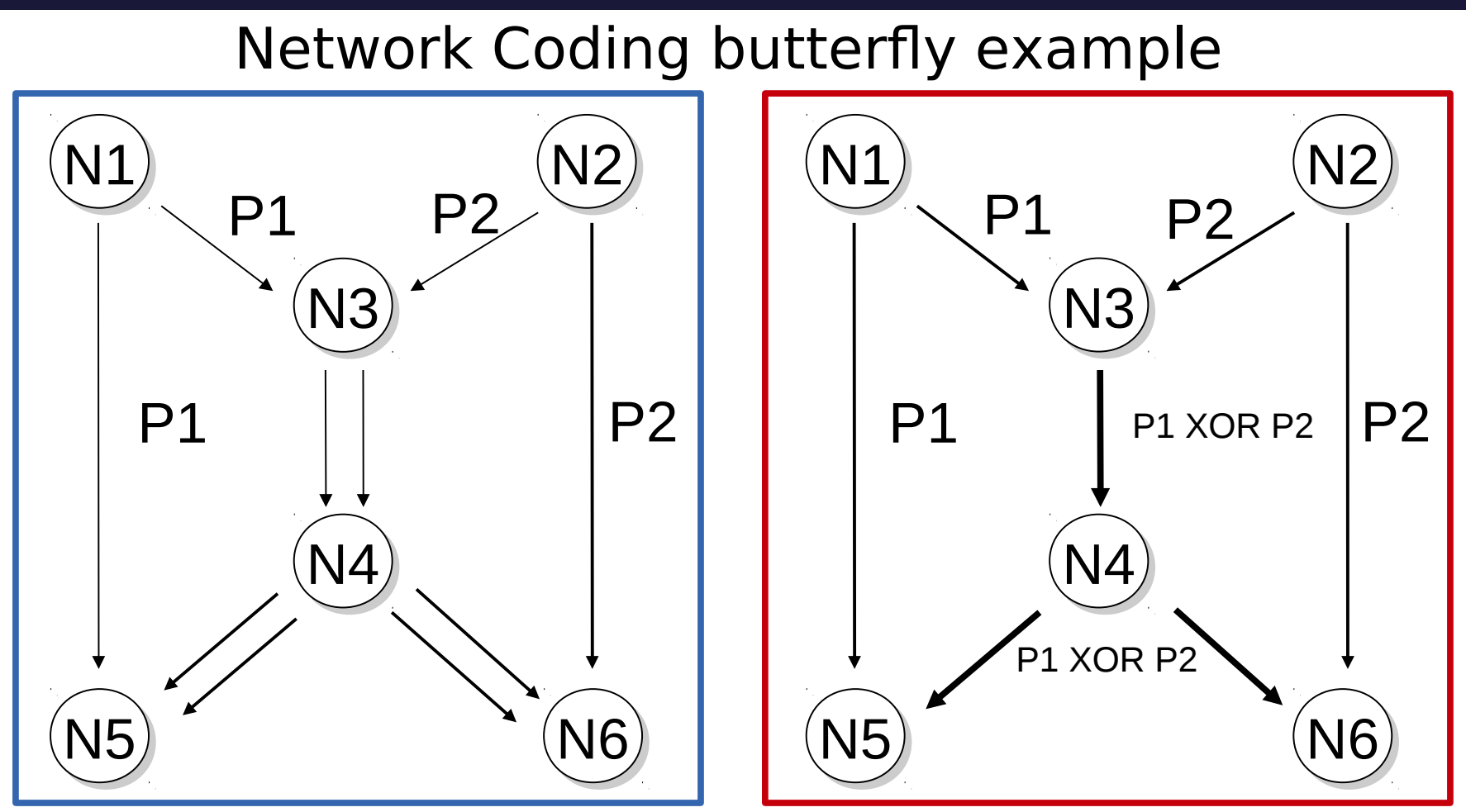
Network coding is a way to transmit the information content of multiple packets within a single packet. To achieve this, a bitwise XOR is performed between a certain number of N packets. This encoded packet is then broadcast to N neighbor nodes. The receiving nodes are able to decode the packet if all

N-1 packets are already present at the receiver. This method reduces the number of required transmissions for data delivery, which helps to avoid network congestion, decrease delay and make data transmission more energy efficient.

## The principle of Network Coding



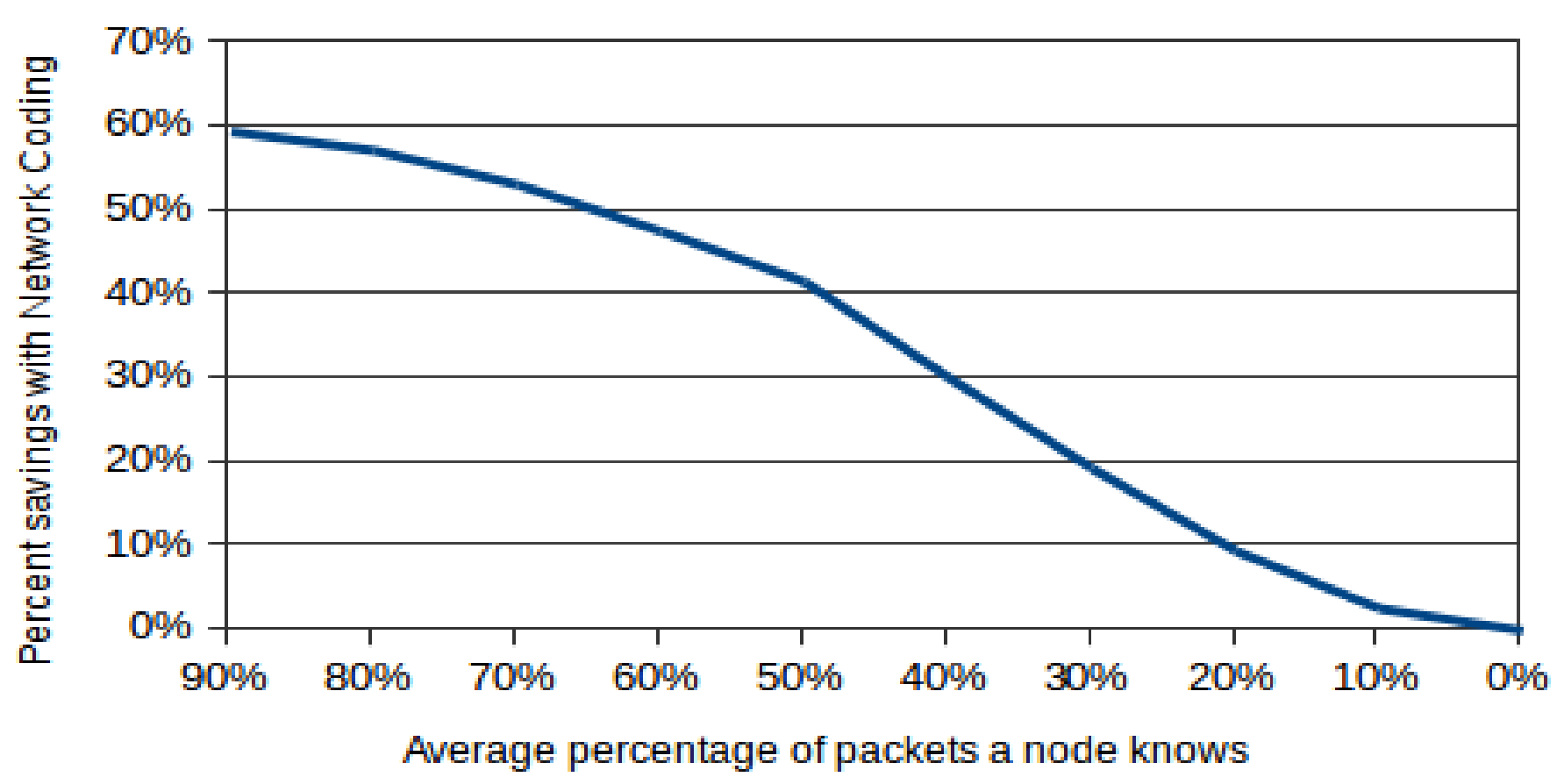
Number of transmissions is reduced



## Benefits of Network Coding

- Increase network throughput**  
by reducing the number of required transmissions
- Reduce delay**  
by transmitting data within a minimized number of transmissions
- Increase energy efficiency**  
by minimizing the number of sent and received packets

Depending on the information distribution, the number of required transmissions can be reduced significantly. The following graph shows the savings with network coding on a random distribution of packets in a network with 1 sender and 3 receivers.



The upper bound for potential savings depends on the number of receiving nodes N.

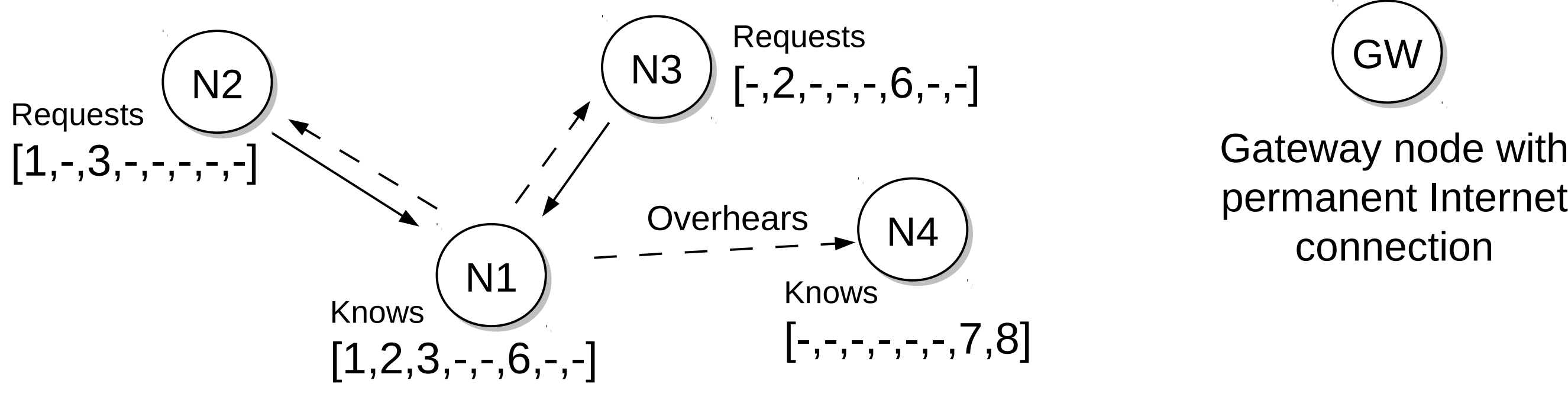
$$\text{Potential savings} = 1 - \left(\frac{1}{N}\right)$$

$$1 - \left(\frac{1}{3}\right) = 0.67 \rightarrow 3 \text{ receivers can achieve 67\% savings}$$

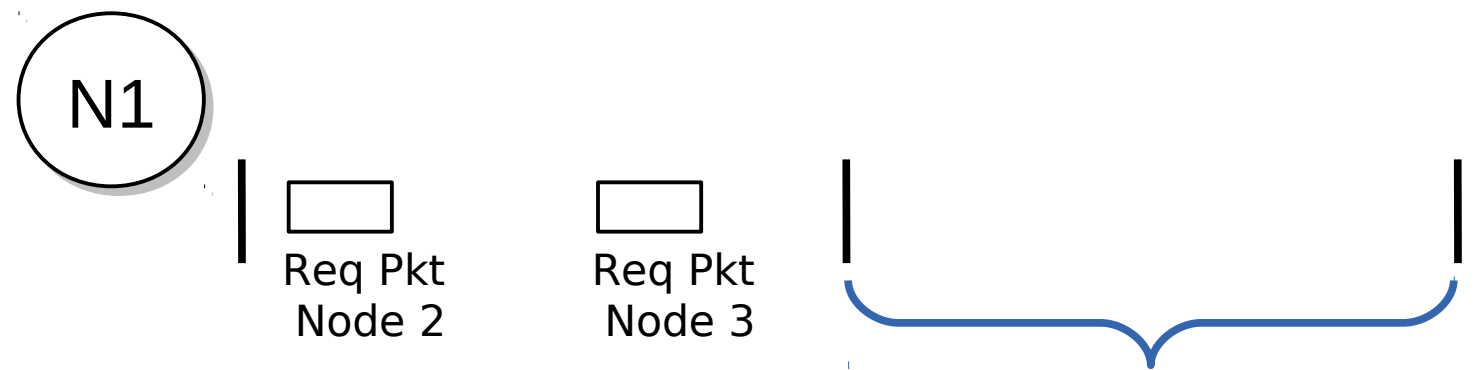
References:  
 Sachin Katti, Hariharan Rahul, Wenjun Hu, Dina Katabi, Muriel Medard, Jon Crowcroft "XORs in the Air: Practical Wireless Network Coding", SIGCOMM'06  
 Xuejun Zhuo, Qinghua Li, Wei Gao, Guohong Cao, Yiqi Dai "Contact Duration Aware Data Replication in Delay Tolerant Networks", ICNP'11

## Network Coding in DTN

1. Step – Nodes meet and broadcast packet requests



2. Step – Node receives request packets within a specified time



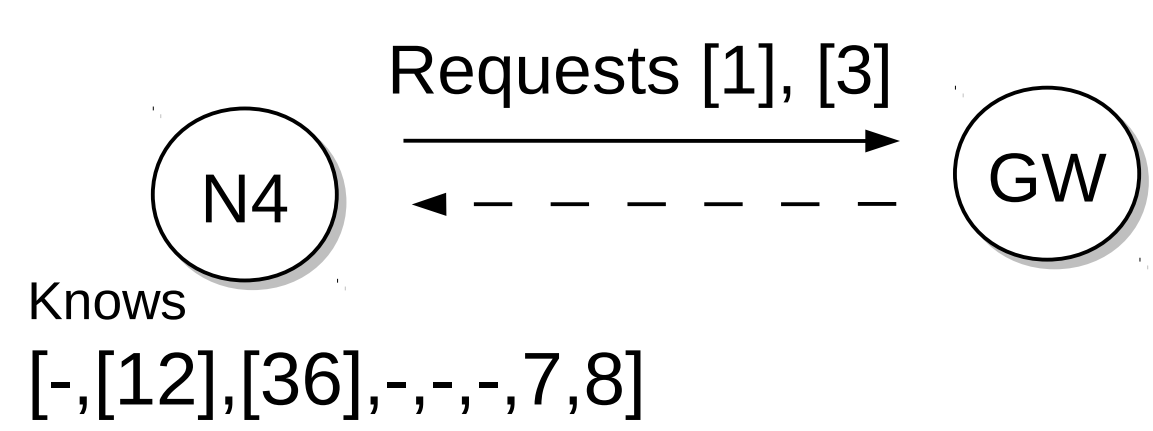
What is the optimal time frame to wait for requests?

3. Step – Node 1 determines optimal combination to encode packets

	1	2	3	4	5	6	7	8
N2	1		1					
N3		1				1		
N4								

→ Transmissions are reduced by **50%**

4. Step – Node 4 resolves encoded packets with gateway node



→ Transmissions are reduced by **50%**

What is the best strategy to save the maximum number of transmissions?