

# On the Optimal Scheduling of Streaming Applications in Unstructured Meshes

*Networking 09*

Luca Abeni, Csaba Kiraly, and Renato Lo Cigno

# Overview of the Talk

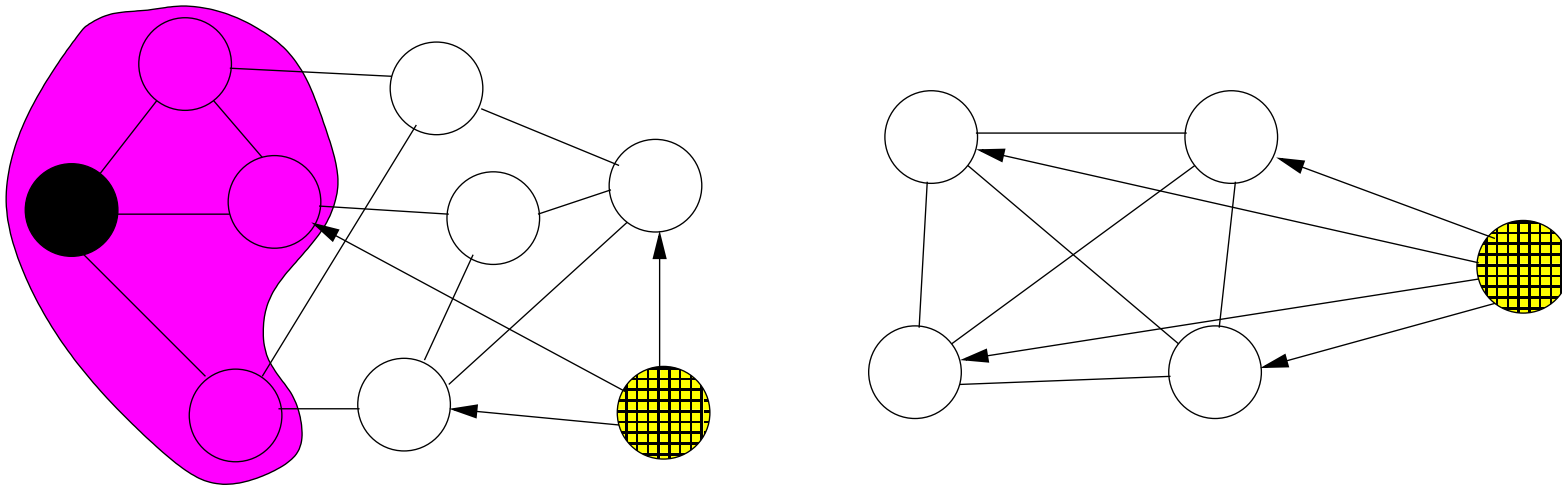
- Introduction / Definitions
  - P2P Streaming Systems
  - Unstructured systems / Neighbourhood / ...
  - Diffusion Delay, optimality
- Scheduling Chunks & Peers
- Optimal Schedulers:
  - LUC/ELP
  - DI/ELP
- Restricting the Neighbourhood (robustness)
- Reducing the chunk buffer size (chunk loss)

# P2P Streaming Systems

- A **Source** generates encoded audio/video
- Various **Peers** receive the encoded media and contribute to the diffusion (by forwarding the received media)
- The encoded media is characterised by *implicit temporal constraints*
  - No file distribution...
- The perceived QoS depends on how the constraints are respected
  - Affected by the decisions taken by each peer

# Definitions

- The media stream is divided in **chunks**
- Unstructured system



- Each peer is connected to a subset of the other peers (**neighbourhood**)
  - Source → only sends chunks (directed links)
  - Other peers → bidirectional links

# Chunks & Peers Scheduling

- Each peer
  - Receives chunks from the other peers, and store them in a local buffer
  - Periodically (with period  $T$ ) sends a chunk to a neighbour
- Scheduling:
  - Which chunk is sent? (**chunk scheduling**)
  - To which peer is the chunk sent? (**peer scheduling**)
- Assumptions:
  - $T$  = chunk size (each peer has an upload bandwidth equal to the stream bitrate  $\rightarrow 1$ )
  - Unlimited download bandwidth

# Optimal Streaming

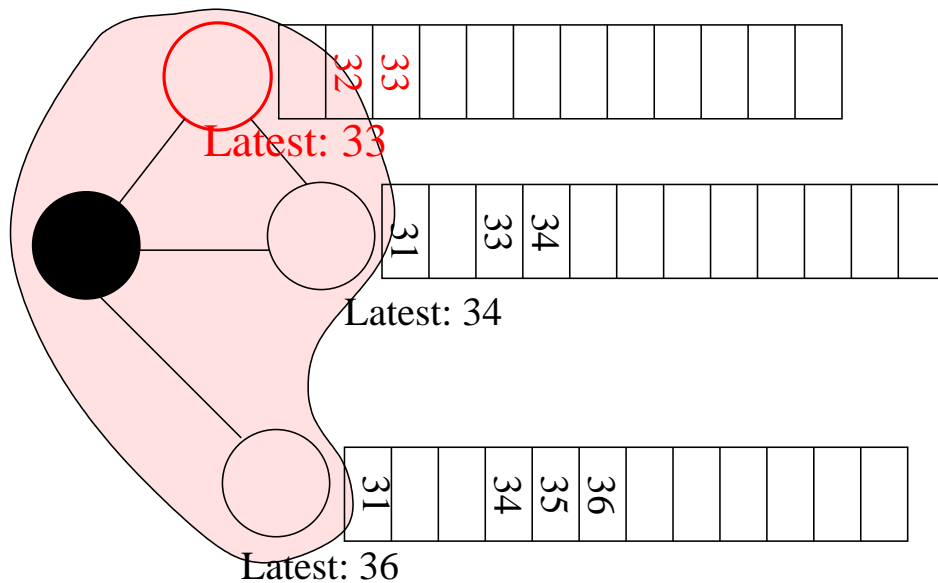
- **Diffusion Delay**  $\delta$ : if a chunk is generated at time  $t$  and diffused to all peers at time  $t'$ ,  $\delta = t' - t$
- The diffusion delay  $\delta$  is affected by the chunk and peer schedulers
- On a full mesh,  $\delta \geq \lceil \log_2(N) \rceil + 1$ 
  - Can this bound be achieved with a **distributed chunk/peer scheduler**?
  - The bound is valid for specific overlays (full mesh, hypercubes, ...); what happens with a generic overlay with **reduced neighbourhood size**?
- First, we develop a scheduler which is optimal on full meshes, then we check its robustness with realistic overlays (reduced neighbourhood size)

# Schedulers' Properties

- Chunk Schedulers:
  - LUC, RUC, Random chunk, Latest Blind chunk
- Peer Schedulers:
  - RUp, ...
- Optimal scheduling on full meshes
  - Select the chunk first, and the target peer after
  - New peer scheduler: ELp
    - We will show that **LUC/ELp is optimal**
  - New chunk scheduler DI: **DI/ELp is optimal too**
- Scheduler Robustness:
  - Reducing the neighbourhood size, **LUC/ELp is quite bad; DI/ELp is still good**

# Optimal Schedulers - ELP

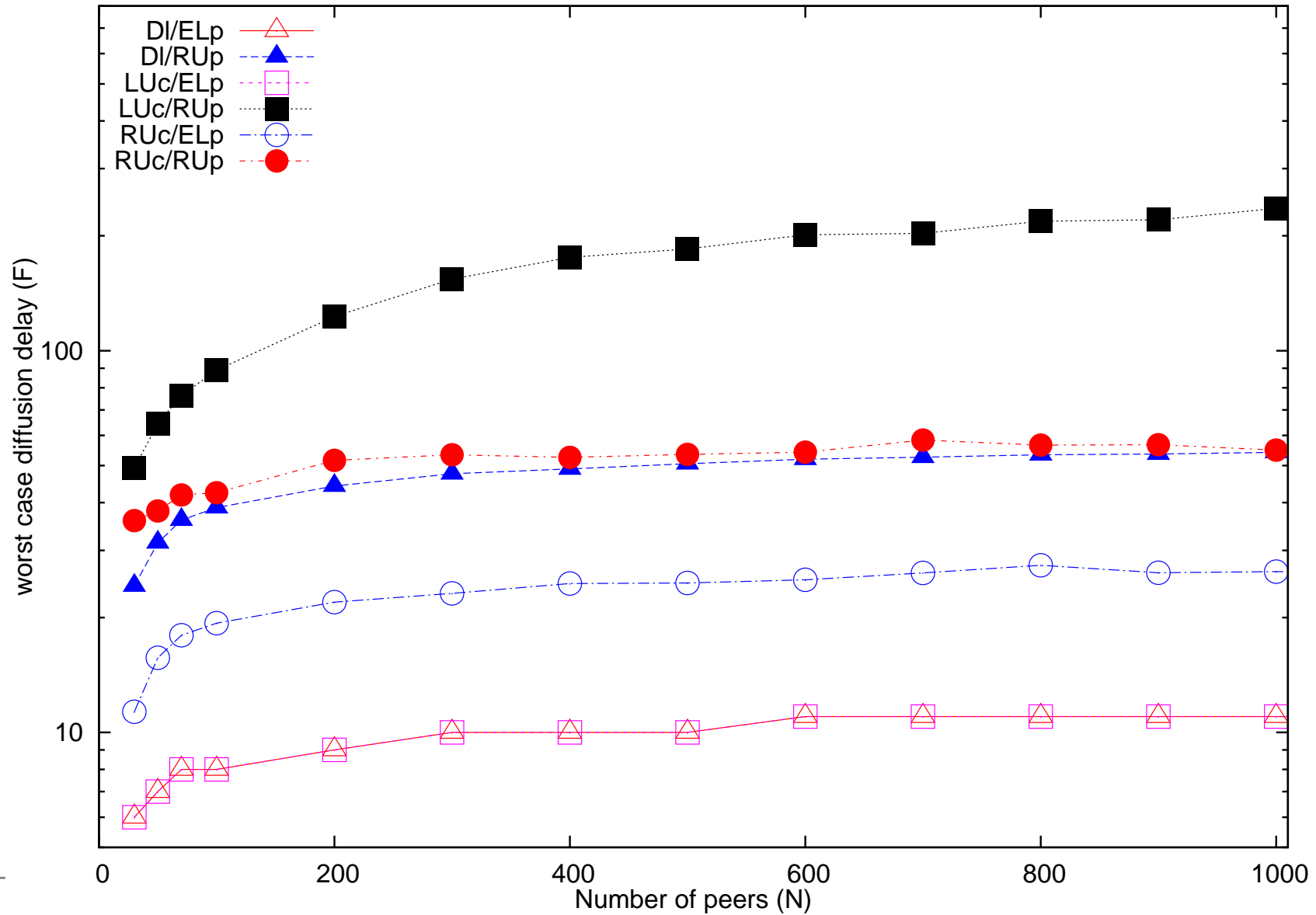
- Earliest Latest peer Scheduler (ELP):
  - When a peer  $P_i$  must select a target...
    - Check the latest chunk owned by each peer
    - And select as a target the peer with the earliest latest chunk



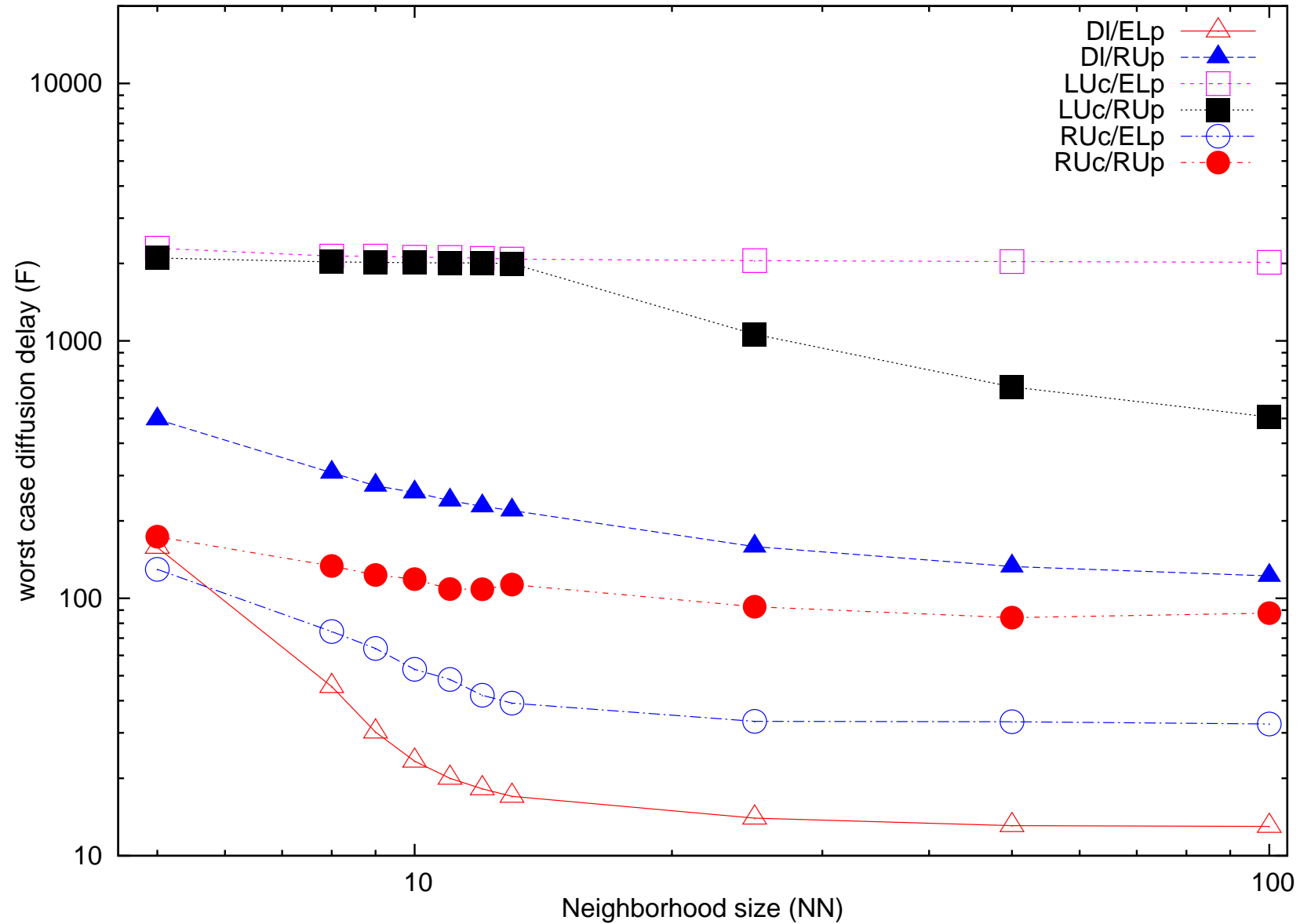
# Optimal Schedulers - DI

- Deadline-Based chunk Scheduler (DI):
  - Each copy of each chunk is associated a **scheduling deadline**
  - initialised to the chunk generation time
    - $d = t$
  - postponed each time that the chunk instance is sent
    - $d = d + P$
  - The chunk with the earliest deadline is selected
- On full meshes, DI/ELp is equivalent to LUC/ELp if  $P > 1$ 
  - $P$  is a **parameter** of the scheduling algorithm, which can be used to adapt it to the network conditions

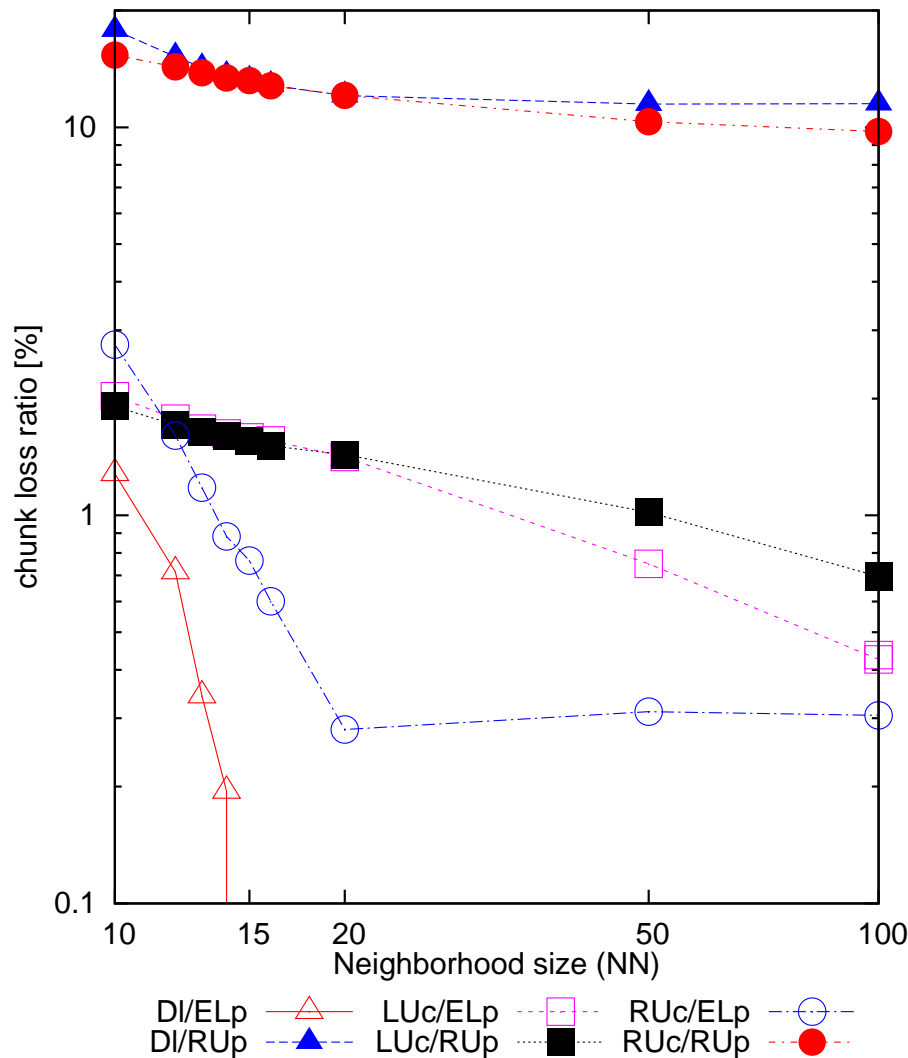
# Optimality



# Robustness



# Reducing the Chunk Buffer Size



- Neighbourhood size  $< \log_2(N)$   $\rightarrow$  Chunk loss for all the algorithms
- Neighbourhood size  $\geq \log_2(N)$   $\rightarrow$  DI/ELp can reduce the chunk loss
- RUC/ELp does not perform too badly, but increasing the neighbourhood size over 20 does not seem to help

# Conclusions

- Optimal scheduling in P2P streaming systems
  - $\delta \geq \lceil \log_2(N) \rceil + 1$
- Optimal Schedulers:
  - Chunk first / Peer later
  - ELp peer scheduler
  - LUc/ELp and DI/ELp are optimal on full meshes
- Robust Schedulers:
  - Reducing the neighbourhood size, LUc/ELp does not perform well...
  - DI/ELp is still good!
- Future work:
  - Removing even more assumptions