Beyond Listen-before-Talk: Collective Primary User Protection with Inherent System Feedback

Xin Liu
Computer Science Department
University of California, Davis

Joint work with Zhi Ding, Senhua Huang, and Fabio Lapiccirella

Interference Protection Criteria

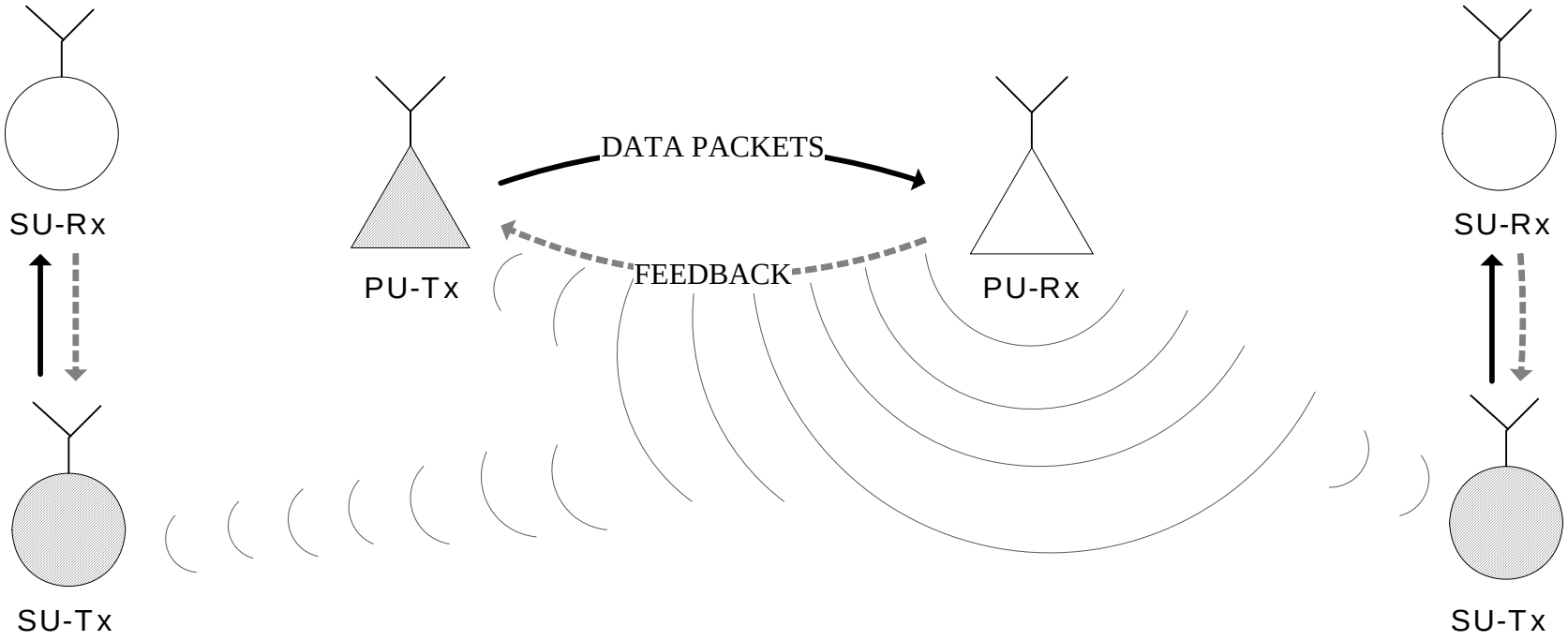
- Impact of SU transmissions on PU receiver:
  - PHY layer, e.g., interference power
  - Link layer, e.g., outage, collision
  - Network layer, e.g., rate assurance
  - Transport layer, e.g., TCP throughput
  - Application layer, e.g., user experience

Listen-before-talk

- Early approach for PU protection
- Significant amount of research and good progress

- Ultra conservative to provide PU protection
  - Worst case fading environment
  - Multiple SUs
  - Not counting for interference-resistant systems

Feedback-based SU Access



Feedback-based SU Access

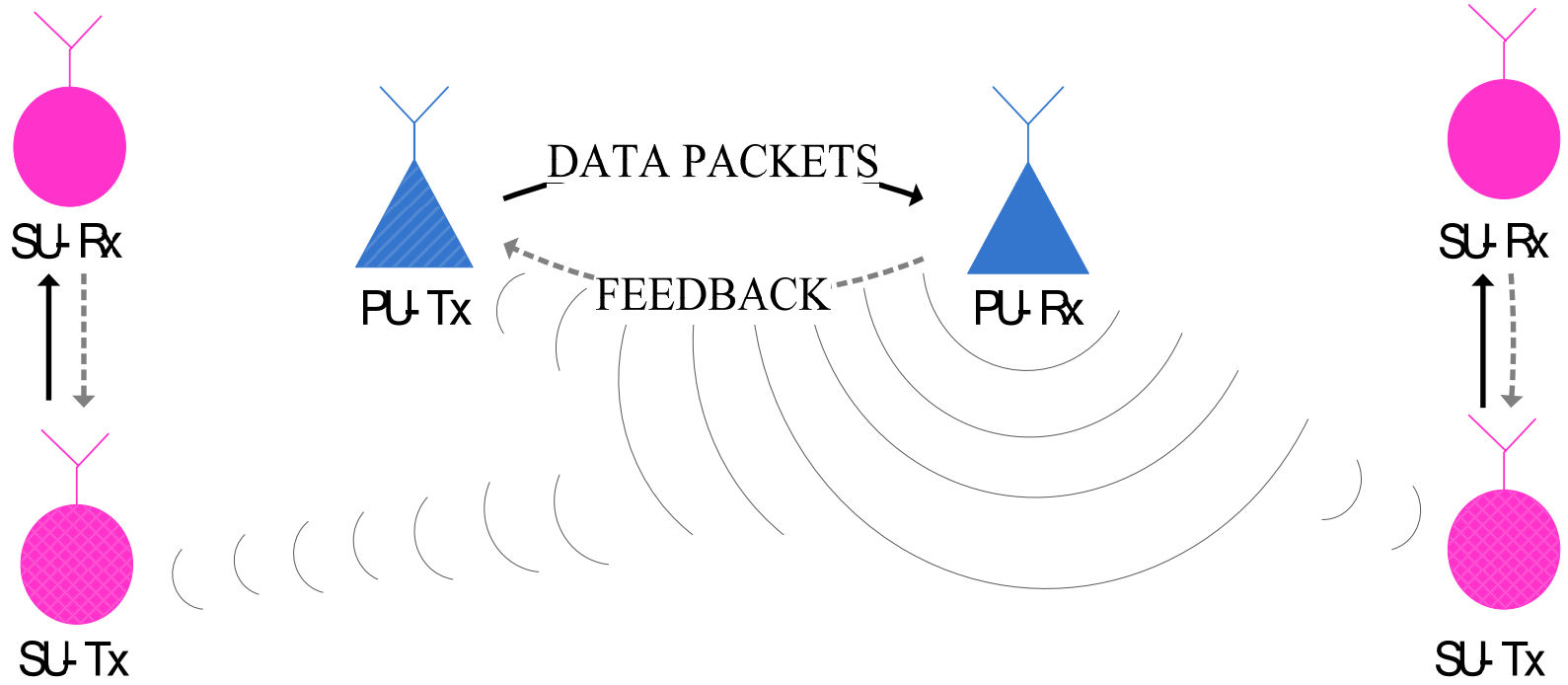
- Primary users: two-way communication
  - Cellular, WiFi, etc.
- SUs are able to decode the primary link control feedback
  - Often simple, unencrypted
  - Same interest group
  - Contract
- SUs learn channel condition from PU-Rx feedback information
- Adjust policy based on (imperfect) feedback

Advantages

- Explicit protection on PU RECEIVER PERFORMANCE
- Enables joint SU protection
- More efficient spectrum utilization

Case 1: Protecting PU Outage through Distributed Power Control

Feedback



PU-Rx broadcasts its 1-bit outage information

Objective

- Collective interference protection on PU
  - PU outage probability
- Performance maximization at SUs
  - Distance and time
- Distributed SU power control
  - Adjust SU transmission power based on overhearing PU receiver performance
  - No information exchange among SUs
    - Geographically distributed
    - Come and go as wish

Case 2: PU Queue Stability

Objective

- To quantify the interference impact from a network-layer perspective
- PU protection criteria:
  - PU traffic demand is satisfied
  - PU rate assurance
  - PU queue stability
- Indication of PU stability:
  - PU channel idle
- Distributed SU access and power control

Take-Home Messages

- Impact of SU transmissions on PU receiver:
  - PHY layer, e.g., interference power
  - Link layer, e.g., outage, ACK/NACK
  - Network layer, e.g., queue stability
  - User perspective, e.g., user experience
- Inherent PU feedback information provides important indication on the impact of aggregated SU transmissions
  - Enables distributed SU control and joint PU protection