# Cooperative packet recovery over heterogeneous wireless networks

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## Introduction

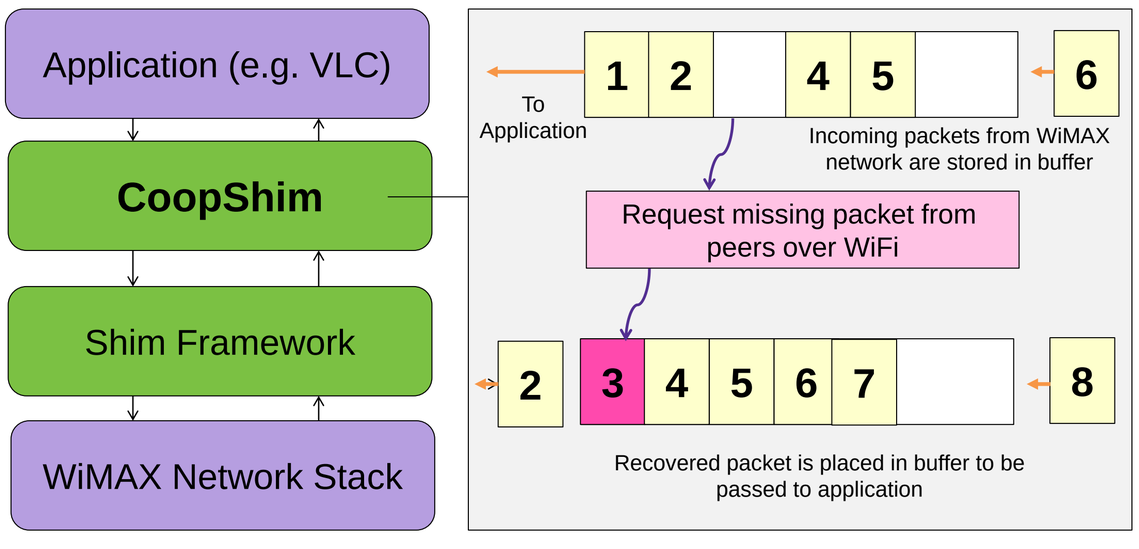
**Challenge:** It is difficult to guarantee the reception reliability of multiple wireless multicast/broadcast receivers because each receiver experiences different channel conditions.

**Solution:** We take advantage of the multiplicity of radios on modern devices to allow cooperative packet recovery over a secondary network. *

- Wireless devices are connected to the principal network (e.g. WiMAX) to receive multicast or broadcast data.
- A wireless device may lose some of the data sent over the principal network.
- The wireless devices form an assistant network over WiFi to recover the lost data cooperatively from their peers.

## Implementation

- Built on *shims*, a framework that was developed as part of the Seattle project.
- Shims add or modify network functionality in a way that is transparent to the application.




## Evaluation

- With no cooperative recovery, we see packet loss over the WiMAX link when testing with *iperf*:

```
[ ID] Interval       Transfer     Bandwidth        Jitter   Lost/Total Datagrams
[  3]  0.0- 1.0 sec  47.9 KBytes   392 Kbits/sec   3.465 ms    0/   35 (0%)
[  3]  1.0- 2.0 sec  47.9 KBytes   392 Kbits/sec   4.310 ms    1/   36 (2.8%)
[  3]  2.0- 3.0 sec  47.9 KBytes   392 Kbits/sec   3.354 ms    1/   36 (2.8%)
[  3]  3.0- 4.0 sec  46.5 KBytes   381 Kbits/sec   4.023 ms    1/   35 (2.9%)
[  3]  4.0- 5.0 sec  49.2 KBytes   403 Kbits/sec   5.180 ms    0/   36 (0%)
[  3]  5.0- 6.0 sec  47.9 KBytes   392 Kbits/sec   3.941 ms    1/   36 (2.8%)
[  3]  6.0- 7.0 sec  49.2 KBytes   403 Kbits/sec   4.573 ms    0/   36 (0%)
[  3]  7.0- 8.0 sec  46.5 KBytes   381 Kbits/sec   3.912 ms    1/   35 (2.9%)
[  3]  8.0- 9.0 sec  47.9 KBytes   392 Kbits/sec   3.981 ms    1/   36 (2.8%)
[  3]  9.0-10.0 sec  49.2 KBytes   403 Kbits/sec   4.238 ms    0/   36 (0%)
[  3] 10.0-11.0 sec  47.9 KBytes   392 Kbits/sec   4.269 ms    0/   35 (0%)
[  3] 11.0-12.0 sec  47.9 KBytes   392 Kbits/sec   4.531 ms    1/   36 (2.8%)
[  3] 12.0-13.0 sec  49.2 KBytes   403 Kbits/sec   3.405 ms    0/   36 (0%)
[  3] 13.0-14.0 sec  49.2 KBytes   403 Kbits/sec   2.759 ms    0/   36 (0%)
[  3] 14.0-15.0 sec  46.5 KBytes   381 Kbits/sec   2.337 ms    1/   35 (2.9%)
```

- With *coopshim*, we observe that the lost packets are effectively recovered:

```
[ ID] Interval       Transfer     Bandwidth        Jitter   Lost/Total Datagrams
[  3]  0.0- 1.0 sec  46.5 KBytes   381 Kbits/sec   5.943 ms    0/   34 (0%)
[  3]  1.0- 2.0 sec  47.9 KBytes   392 Kbits/sec   8.135 ms    0/   35 (0%)
[  3]  2.0- 3.0 sec  49.2 KBytes   403 Kbits/sec   5.063 ms    0/   36 (0%)
[  3]  3.0- 4.0 sec  47.9 KBytes   392 Kbits/sec   4.724 ms    0/   35 (0%)
[  3]  4.0- 5.0 sec  50.6 KBytes   414 Kbits/sec   6.504 ms    0/   37 (0%)
[  3]  5.0- 6.0 sec  46.5 KBytes   381 Kbits/sec   6.343 ms    0/   34 (0%)
[  3]  6.0- 7.0 sec  47.9 KBytes   392 Kbits/sec   6.472 ms    0/   35 (0%)
[  3]  7.0- 8.0 sec  49.2 KBytes   403 Kbits/sec   4.866 ms    0/   36 (0%)
[  3]  8.0- 9.0 sec  47.9 KBytes   392 Kbits/sec   5.877 ms    0/   35 (0%)
[  3]  9.0-10.0 sec  47.9 KBytes   392 Kbits/sec  32.814 ms    0/   19 (0%)
[  3]  9.0-10.0 sec  16 datagrams received out-of-order
[  3] 10.0-11.0 sec  47.9 KBytes   392 Kbits/sec   9.115 ms    0/   35 (0%)
[  3] 11.0-12.0 sec  49.2 KBytes   403 Kbits/sec   6.566 ms    0/   36 (0%)
[  3] 12.0-13.0 sec  47.9 KBytes   392 Kbits/sec   5.574 ms    0/   35 (0%)
[  3] 13.0-14.0 sec  49.2 KBytes   403 Kbits/sec   5.861 ms    0/   36 (0%)
[  3] 14.0-15.0 sec  47.9 KBytes   392 Kbits/sec   4.832 ms    0/   35 (0%)
[  3] 15.0-16.0 sec  49.2 KBytes   403 Kbits/sec   4.835 ms    0/   36 (0%)
```

## Conclusions

- The cooperative recovery scheme is an effective way to ensure more reliable delivery of multicast/broadcast traffic over a wireless link.
- The scheme does not place any additional burden on the multicast service, and uses the WiFi hardware that is already present on most modern wireless devices.

## References

* Sinkar, K.; Jagirdar, A.; Korakis, T.; Liu, H.; Mathur, S.; Panwar, S.; , "Cooperative Recovery in Heterogeneous Mobile Networks," *Sensor, Mesh and Ad Hoc Communications and Networks, 2008. SECON '08. 5th Annual IEEE Communications Society Conference on* , vol., no., pp.395-403, 16-20 June 2008

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