

Rural Area Wireless Mesh Networks

Major Area Examination Reading List

Veljko Pejovic
Department of Computer Science
University of California, Santa Barbara
veljko@cs.ucsb.edu

1 Text Books

- [1] R. Flickenger, C. Aichele, C. Fonda, J. Forster, I. Howard, T. Krag, and M. Zennaro. *Wireless Networking in the Developing World*. Limehouse Book Sprint Team, first edition, January 2006.
- [2] J. F. Kurose and K. W. Ross. *Computer Networking: A Top-Down Approach*. Addison Wesley Publishing Company, fourth edition, March 2007.
- [3] A. Tanenbaum. *Computer Networks*. Prentice Hall, August 2002.

2 Rural Networks

- [1] A. Sharma, C. E. Perkins, and E. M. Belding. Rural Mesh Networks: Challenges and Future Directions. Submitted to IEEE Wireless Communications Magazine on Wireless Technologies Advances for Emergency and Rural Communications, 2008.
- [2] L. Subramanian, S. Surana, R. Patra, S. Nedeveschi, M. Ho, E. Brewer, and A. Sheth. Rethinking Wireless for the Developing World. In *Fifth Workshop on Hot Topics in Networks (HotNets-V)*, Irvine, CA, USA, November 2006.

2.1 Network Planning

- [1] K. Chebroly and B. Raman. FRACTEL: A Fresh Perspective on (Rural) Mesh Networks. In *NSDR '07: Proceedings of the 2007 workshop on Networked systems for developing regions*, Kyoto, Japan, August 2007.
- [2] S. Guo, M. Falaki, E. Oliver, S. U. Rahman, A. Seth, M. Zaharia, U. Ismail, and S. Keshav. Design and Implementation of the KioskNet System (Extended Version). Technical Report CS-2007-40, University of Waterloo, November 2007.
- [3] A. Lele, M. Raj, and D. Das. Providing Voice Connectivity to Rural India Using WiMAX: Issues and Solution. In *NSDR '07: Proceedings of the 2007 workshop on Networked systems for developing regions*, Kyoto, Japan, August 2007.
- [4] B. Raman. Channel Allocation in 802.11-based Mesh Networks. In *The 25th Annual Conference on Computer Communications (IEEE INFOCOM)*, Barcelona, Spain, April 2006.

- [5] S. Sen and B. Raman. Long Distance Wireless Mesh Network Planning: Problem Formulation and Solution. In *The 16th Annual International World Wide Web Conference (WWW 2007)*, Banff, Canada, May 2007.

2.2 Deployment Experiences

- [1] D. Johnson. Evaluation of a Single Radio Rural Mesh Network in South Africa. In *IEEE/ACM International Conference on Information and Communication Technologies and Development (ICTD2007)*, Bangalore, India, December 2007.
- [2] S. Sen, S. Kole, and B. Raman. Rural Telephony: A Socio-Economic Case Study. In *International Conference on Information and Communication Technologies and Development (ICTD-2006)*, Berkeley, CA, USA, May 2006.
- [3] S. Surana, R. Patra, S. Nedeveschi, M. Ramos, L. Subramanian, Y. Ben-David, and E. Brewer. Beyond Pilots: Keeping Rural Wireless Networks Alive. In *ACM USENIX NSDI*, San Francisco, CA, USA, April 2008.

3 MAC Layer

3.1 Long Distance MAC Layer Solutions

- [1] M. Balakrishnan, P. Zhou, and R. Rao. On Adding Link Dimensional Dynamism to CSMA/CA based MAC Protocols. Technical Report 767, School of Electrical and Computer Engineering, UCSD, March 2007.
- [2] P. Bhagwat, B. Raman, and D. Sanghi. Turning 802.11 Inside-Out. In *Second Workshop on Hot Topics in Networks (HotNets-II)*, Cambridge, MA, USA, November 2003.
- [3] A. Das and T. Zhu. A Reservation-Based TDMA MAC Protocol Using Directional Antennas (RTDMA-DA) For Wireless Mesh Networks. In *Global Telecommunications Conference, 2007. GLOBECOM '07. IEEE*, Washington, DC, USA, November 2007.
- [4] P. Kumar. Design, Implementation, and Evaluation of new MAC Protocols for Long Distance 802.11 Networks. Master's thesis, Indian Institute of Technology, Kanpur, May 2006.
- [5] R. Patra, S. Nedeveschi, S. Surana, A. Sheth, L. Subramanian, and E. Brewer. WiLDNet: Design and Implementation of High Performance WiFi Based Long Distance Networks. In *USENIX NSDI*, Cambridge, MA, USA, April 2007.
- [6] B. Raman and K. Chebrolu. Design and Evaluation of a new MAC Protocol for Long-Distance 802.11 Mesh Networks. In *11th Annual International Conference on Mobile Computing and Networking (MOBICOM)*, Cologne, Germany, August/September 2005.

3.2 TDMA MAC Protocols

- [1] P. Bahl, R. Chandra, and J. Dunagan. SSCH: slotted seeded channel hopping for capacity improvement in IEEE 802.11 ad-hoc wireless networks. In *MobiCom '04: Proceedings of the 10th annual international conference on Mobile computing and networking*, Philadelphia, PA, USA, September 2004.
- [2] J. Gronkvist, J. Nilsson, and D. Yuan. Throughput of Optimal Spatial Reuse TDMA for Wireless Ad-Hoc Networks. In *IEEE Vehicular Technology Conference, 2004*, Los Angeles, CA, USA, May 2004.

- [3] A. Kanzaki, T. Hara, and S. Nishio. An Adaptive TDMA Slot Assignment Protocol in Ad Hoc Sensor Networks. In *SAC '05: Proceedings of the 2005 ACM symposium on Applied computing*, Santa Fe, NM, USA, March 2005.
- [4] A. Kanzaki, T. Uemukai, T. Hara, and S. Nishio. Dynamic TDMA Slot Assignment in Ad Hoc Networks. In *AINA '03: Proceedings of the 17th International Conference on Advanced Information Networking and Applications*, March 2003.
- [5] H. Lim, C. Lim, and J. C. Hou. A Coordinate-Based Approach for Exploiting Temporal-Spatial Diversity in Wireless Mesh Networks. In *MobiCom '06: Proceedings of the 12th annual international conference on Mobile computing and networking*, Los Angeles, CA, USA, September 2006.
- [6] S. Ramanathan. A Unified Framework and Algorithm for (T/F/C)DMA Channel Assignment in Wireless Networks. In *INFOCOM apos;97. Sixteenth Annual Joint Conference of the IEEE Computer and Communications*, Kobe, Japan, April 1997.
- [7] A. Rao and I. Stoica. An Overlay MAC Layer for 802.11 Networks. In *MobiSys '05: Proceedings of the 3rd international conference on Mobile systems, applications, and services*, pages 135–148, Seattle, WA, USA, June 2005. ACM.
- [8] I. Rhee, A. Warriier, M. Aia, and J. Min. Z-MAC: A Hybrid MAC for Wireless Sensor Networks. In *SenSys '05: Proceedings of the 3rd international conference on Embedded networked sensor systems*, San Diego, CA, USA, November 2005.
- [9] I. Rhee, A. Warriier, J. Min, and L. Xu. DRAND: Distributed Randomized TDMA Scheduling For Wireless Ad-hoc Networks. In *MobiHoc '06: Proceedings of the 7th ACM international symposium on Mobile ad hoc networking and computing*, Florence, Italy, May 2006.
- [10] S. Singh, P. Aravinda, K. Acharya, U. Madhow, and E. M. Belding-Royer. Sticky CSMA/CA: Implicit synchronization and real-time QoS in mesh networks. *Ad Hoc Networks*, 5(6):744–768, August 2007.
- [11] J. Snow, W. chi Feng, and W. chang Feng. Implementing a Low Power TDMA Protocol Over 802.11. In *Wireless Communications and Networking Conference*, New Orleans, LA, USA, March 2005.
- [12] J. So and N. H. Vaidya. Multi-Channel MAC for Ad Hoc Networks: Handling Multi-Channel Hidden Terminals Using a Single Transceiver. In *MobiHoc '04: Proceedings of the 5th ACM international symposium on Mobile ad hoc networking and computing*, Roppongi Hills, Tokyo, Japan, September 2004.
- [13] X. Wang and Y. Chen. A Wireless TDMA/FDD MAC Protocol Based On a Novel Resource Updating Scheme. In *Global Telecommunications Conference, 2001. GLOBECOM '01. IEEE*, San Antonio, TX, USA, November 2001.
- [14] C. Zhu and M. S. Corson. A Five-Phase Reservation Protocol (FPRP) for Mobile Ad Hoc Networks. *Wireless Networks*, 7(4):371–384, August 2001.

4 Delay Tolerant Routing

- [1] A. Balasubramanian, B. Levine, and A. Venkataramani. DTN Routing as a Resource Allocation Problem. In *In Proceedings of ACM Sigcomm 2007*, Kyoto, Japan, August 2007.
- [2] M. Demmer and K. Fall. DTLSR: Delay Tolerant Routing For Developing Regions. In *NSDR '07: Proceedings of the 2007 workshop on Networked systems for developing regions*, Kyoto, Japan, August 2007.

- [3] B. DeRenzi, Y. Anokwa, T. Parikh, and G. Borriello. Reliable Data Collection in Highly Disconnected Environments Using Mobile Phones. In *NSDR '07: Proceedings of the 2007 workshop on Networked systems for developing regions*, Kyoto, Japan, August 2007.
- [4] K. Fall. A Delay Tolerant Network Architecture for Challenged Internets. In *ACM SIGCOMM 2003*, Karlsruhe, Germany, August 2003.
- [5] D. Kutscher, J. Greifengberg, and K. Loos. Scalable DTN Distribution over Uni-Directional Links. In *NSDR '07: Proceedings of the 2007 workshop on Networked systems for developing regions*, Kyoto, Japan, August 2007.
- [6] U. Lee, J.-S. Park, J. Yeh, G. Pau, and M. Gerla. CodeTorrent: Content Distribution using Network Coding in VANETs. In *The First International Workshop on Decentralized Resource Sharing in Mobile Computing and Networking (MobiShare'06)*, Los Angeles, CA, USA, September 2006.
- [7] J. Ott, D. Kutscher, and C. Dwertmann. Integrating DTN and MANET routing. In *CHANTS '06: Proceedings of the 2006 SIGCOMM workshop on Challenged networks*, Pisa, Italy, September 2006.
- [8] L. Song and D. F. Kotz. Evaluating Opportunistic Routing Protocols with Large Realistic Contact Traces. In *CHANTS '07: Proceedings of the second workshop on Challenged networks*, Montreal, Quebec, Canada, September 2007.
- [9] M. Thomas, A. Gupta, and S. Keshav. *High Performance Computing - HiPC 2006*, chapter Group Based Routing in Disconnected Ad Hoc Networks, pages 399–410. Springer Berlin / Heidelberg, 2006.
- [10] L. Wood, W. M. Eddy, W. Ivancic, jim McKim, and C. Jackson. Saratoga: a Delay-Tolerant Networking convergence layer with efficient link utilization. In *IWSSC '07. International Workshop on Satellite and Space Communications*, Salzburg, Austria, September 2007.

5 Energy Efficient Protocols

- [1] A. Ephremides. Energy Concerns in Wireless Networks. *Wireless Communications, IEEE*, 9(4):48–59, August 2002.
- [2] L. M. Feeney and M. Nilsson. Investigating the Energy Consumption of a Wireless Network Interface in an Ad Hoc Networking Environment. In *INFOCOM 2001. Twentieth Annual Joint Conference of the IEEE Computer and Communications Societies*, Anchorage, AK, USA, April 2001.
- [3] C. E. Jones, K. M. Sivalingam, P. Agrawal, and J. C. Chen. A Survey of Energy Efficient Network Protocols for Wireless Networks. *Wireless Networks*, 7(4):343–358, July 2001.

5.1 Rate Adaption

- [1] M. Lin and Y. Ganjali. Power-Efficient Rate Scheduling in Wireless Links Using Computational Geometric Algorithms. In *IWCMC '06: Proceedings of the 2006 international conference on Wireless communications and mobile computing*, pages 1253–1258, Vancouver, Canada, July 2006. ACM.
- [2] S. Nedeveschi, L. Popa, G. Iannaccone, S. Ratnasamy, and D. Wetherall. Reducing Network Energy Consumption via Rate-Adaptation and Sleeping. Technical Report UCB/EECS-2007-128, EECS Department, University of California, Berkeley, November 2007.

5.2 Energy Efficient MAC Protocols

- [1] M. Buettner, G. V. Yee, E. Anderson, and R. Han. X-Mac: A Short Preamble MAC Protocol For Duty-Cycled Wireless Sensor Networks. In *SenSys '06: Proceedings of the 4th international conference on Embedded networked sensor systems*, Boulder, Colorado, USA, October/November 2006.
- [2] B. Hohlt, L. Doherty, and E. Brewer. Flexible Power Scheduling For Sensor Networks. In *IPSN '04: Proceedings of the third international symposium on Information processing in sensor networks*, Berkeley, California, USA, April 2004.
- [3] S. Singh and C. Raghavendra. PAMAS: Power Aware Multi-Access protocol with Signalling for Ad Hoc Networks. *ACM Computer Communications Review*, 28(3):5 – 26, July 1998.
- [4] K. M. Sivalingam, J.-C. Chen, P. Agrawal, and M. B. Srivastava. Design and Analysis of Low-Power Access Protocols for Wireless and Mobile ATM Networks. *Wireless Networks*, 6(1):73–87, February 2000.

5.3 Energy Efficient Routing

- [1] M. X. Cheng, J. Sun, M. Min, and D.-Z. Du. Energy-Efficient Broadcast And Multicast Routing In Ad Hoc Wireless Networks. In *Performance, Computing, and Communications Conference, 2003*, April 2003.
- [2] S. Doshi, S. Bhandare, and T. X. Brown. An On-Demand Minimum Energy Routing Protocol for a Wireless Ad Hoc Network. *ACM SIGMOBILE Mobile Computing and Communications Review*, 6(3):50 – 66, July 2002.
- [3] L. M. Feeney. An Energy Consumption Model for Performance Analysis of Routing Protocols for Mobile Ad Hoc Networks. *Mobile Networks and Applications*, 6(3):239–249, June 2001.

5.4 Powering-off Strategies

- [1] Y. Agarwal, R. Chandra, A. Wolman, P. Bahl, K. Chin, and R. Gupta. Wireless Wakeups Revisited: Energy Management for VoIP Over Wi-Fi Smartphones. In *MobiSys '07: Proceedings of the 5th international conference on Mobile systems, applications and services*, San Juan, Puerto Rico, June 2007.
- [2] B. Chen, K. Jamieson, H. Balakrishnan, and R. Morris. SPAN: An Energy-Efficient Coordination Algorithm For Topology Maintenance in Ad Hoc Wireless Networks. *Wireless Networks*, 8(5):481 – 494, September 2002.
- [3] A. P. Jardosh, G. Iannaccone, K. Papagiannaki, and B. Vinnakota. Towards an Energy-Star WLAN Infrastructure. In *HotMobile 2007: 8th IEEE Workshop on Mobile Computing Systems and Applications*, Tucson, AZ, USA, February 2007.
- [4] N. Mishra, K. Chebrolu, B. Raman, and A. Pathak. Wake-on-WLAN. In *World Wide Web Conference WWW 2006*, Edinburgh, Scotland, May 2006.
- [5] E. Shih, P. Bahl, and M. J. Sinclair. Wake on Wireless: An Event Driven Energy Saving Strategy for Battery Operated Devices. In *MobiCom '02: Proceedings of the 8th annual international conference on Mobile computing and networking*, Atlanta, GA, USA, September 2002.

6 Performance Measurement and Network Monitoring

- [1] D. Aguayo, J. Bicket, S. Biswas, G. Judd, and R. Morris. Link-level Measurements from an 802.11b Mesh Network. In *ACM SIGCOMM 2004*, Portland, OR, USA, August/September 2004.
- [2] K. Chebrolu, B. Raman, and S. Sen. Long-Distance 802.11b Links: Performance Measurements and Experience. In *12th Annual International Conference on Mobile Computing and Networking (MOBICOM)*, Los Angeles, CA, USA, September 2006.
- [3] V. Gambiroza, B. Sadeghi, and E. W. Knightly. End-to-End Performance and Fairness in Multihop Wireless Backhaul Networks. In *MobiCom '04: Proceedings of the 10th annual international conference on Mobile computing and networking*, Philadelphia, PA, USA, September/October 2004.
- [4] D. Gokhale, S. Sen, K. Chebrolu, and B. Raman. On the Feasibility of the Link Abstraction in (Rural) Mesh Networks. In *INFOCOM 2008*, Phoenix, AZ, USA, April 2008.
- [5] T. Henderson, D. Kotz, and I. A Byzov. The Changing Usage of a Mature Campus-Wide Wireless Network. In *MobiCom '04: Proceedings of the 10th annual international conference on Mobile computing and networking*, Philadelphia, PA, USA, September/October 2004.
- [6] A. P. Jardosh, K. N. Ramachandran, K. C. Almeroth, and E. M. Belding-Royer. Understanding Congestion in IEEE 802.11b Wireless Networks. In *IMC'05: Proceedings of the Internet Measurement Conference 2005*, Berkeley, CA, USA, October 2005.
- [7] J. Robinson, K. Papagiannaki, C. Diot, X. Guo, and L. Krishnamurthy. Experimenting with a Multi-Radio Mesh Networking Testbed. In *1st workshop on Wireless Network Measurements (Winmee)*, Riva del Garda, Italy, April 2005.
- [8] A. Sheth, S. Nedeveschi, R. Patra, S. Surana, L. Subramanian, and E. Brewer. Packet Loss Characterization in WiFi-based Long Distance Networks. In *26th Annual IEEE Conference on Computer Communications IEEE INFOCOM 2007*, Anchorage, AK, USA, May 2007.
- [9] S. Surana, R. Patra, and E. Brewer. Simplifying Fault Diagnosis in Locally Managed Rural WiFi Networks. In *NSDR '07: Proceedings of the 2007 workshop on Networked systems for developing regions*, Kyoto, Japan, August 2007.
- [10] S. Xu and T. Saadawi. Does the IEEE 802.11 MAC Protocol Work Well in Multihop Wireless. *Communications Magazine, IEEE*, 39(6):130–137, June 2001.

7 Multimedia Oriented Solutions

- [1] C. An and T. Q. Nguyen. Cross-Layer Optimization for Video Communication Over AWGN Channel. In *IEEE Global Telecommunications Conference, GLOBECOM '07*, Washington, DC, USA, November 2007.
- [2] I. Haratcherev, J. Taal, K. Langendoen, R. Lagendijk, and H. Sips. Optimized Video Streaming Over 802.11 by Cross-layer Signaling. *IEEE Communications Magazine*, 44(1):115–121, January 2006.
- [3] T. Suzuki and S. Tasaka. Performance evaluation of integrated video and data transmission with the IEEE 802.11 standard MAC protocol. In *Global Telecommunications Conference, 1999. GLOBECOM '99*, Rio de Janeiro, Brazil, December 1999.

8 Social Implications of Rural Networking

- [1] R. Albanese and D. D. van Fleet. Rational Behavior in Groups: The Free-Riding Tendency. *The Academy of Management Review*, 10:244–255, April 1985.
- [2] M. L. Best and C. M. Maclay. *The Global Information Technology Report 2001-2002: Readiness for the Networked World*, chapter Community Internet Access in Rural Areas: Solving the Economic Sustainability Puzzle, pages 76–88. Oxford University Press., 2002.
- [3] S. Corbett. Can the Cellphone Help End Global Poverty? *New York Times*, -:online, April 2008.
- [4] R. Kumar and M. L. Best. Social Impact and Diffusion of Telecenter Use: A Study from the Sustainable Access in Rural India Project. *The Journal of Community Informatics*, 2:1–22, 2006.
- [5] H. V. Milner. The Digital Divide: The Role of Political Institutions in Technology Diffusion. *Comparative Political Studies*, 39:176 – 199, March 2006.
- [6] B. A. Petrazzini and A. Guerrero. Promoting Internet Development: The Case of Argentina. *Telecommunications Policy*, 24:89–112, September 2000.
- [7] O. E. Project. Digital Entrepreneurship and Innovation: A Framework for Policy, Legal and Regulatory Action. Technical report, United Nations ICT Task Force and World Economic Forum Global Digital Divide Initiative, February 2002.
- [8] www.internetworldstats.com. Internet Users and Population Statistics. Technical report, Miniwatts Marketing Group, April 2008.