# Powering the Wireless World

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Wireless Network Security

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# Overview

- Demand for Wireless Power
- Battery technology
- Equipment efficiency
- Power conserving protocols
- Conclusions

# Demand for Wireless Power

- More capable wireless devices
  - Higher bit rates
  - More supporting functions
  - Perform more like fixed devices
- Want to increase time between recharging and decrease battery weights
  - Longer talk/standby times in cellular phones
- Three areas of focus
  - Battery Technology
  - Equipment Subsystem's Efficiency
  - Energy Efficient Wireless Protocols

# Battery Technology

- Four Main Types of Batteries
  - Lead Acid
  - Nickel Cadmium (Ni-Cd)
  - Nickel Metal Hydride (Ni-MH)
  - Lithium Ion (Li-Ion)
- Considerations for Comparison
  - Capacity
  - Cycle Life
  - Charging
  - Cost
  - Other (Temperature, Hazardous Materials, etc.)

# Lead Acid Battery Technology

- Capacity- 30 Wh/kg
- Cycle Life- ~ 650 cycles
- Charging- Tolerates tough charging conditions as overcharging and deep discharging well
- Cost- Very cheap
- Other
  - Contains lead and strong acid (health hazard)
  - Temperate affects performance (70% of capacity in 32°F weather)

# Nickel Cadmium Battery Technology

- Capacity- 40-60 Wh/kg
- Cycle Life- ~ 1000 cycles
- Charging-
  - Susceptible to “memory-effect”
  - Tolerant to deep discharging and overcharging
- Cost- Reasonable
- Other- Cadmium is toxic

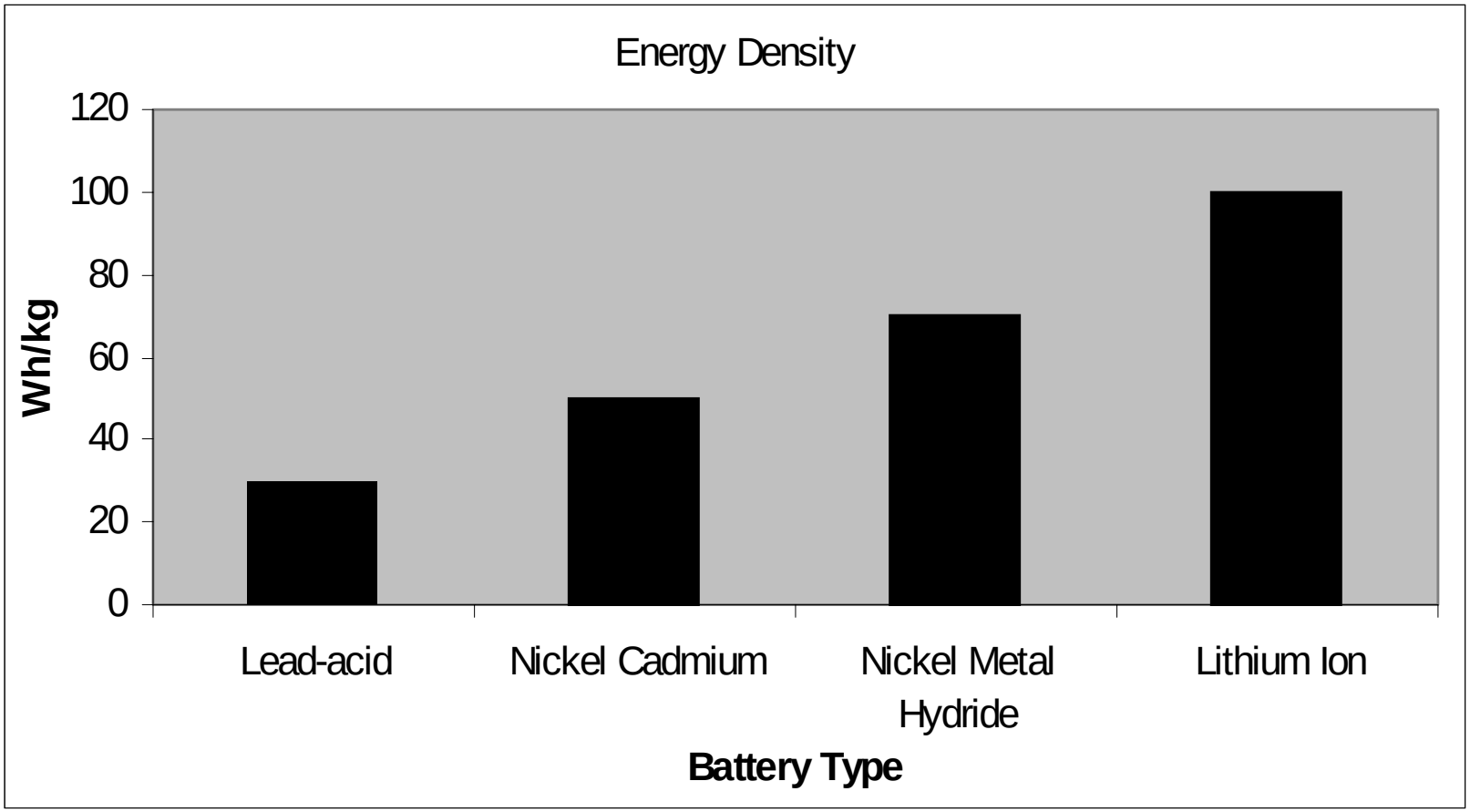
# Nickel Metal Hydride Battery Technology

- Capacity- 60-80 Wh/kg
- Cycle Life- ~ 500-600 cycles
- Charging-
  - No “memory effect”
  - Not as tolerant to overcharging as Ni-Cd
- Cost- 50-100% more expensive than Ni-Cd
- Other-
  - Not good for high current applications
  - Operate well at low temperatures

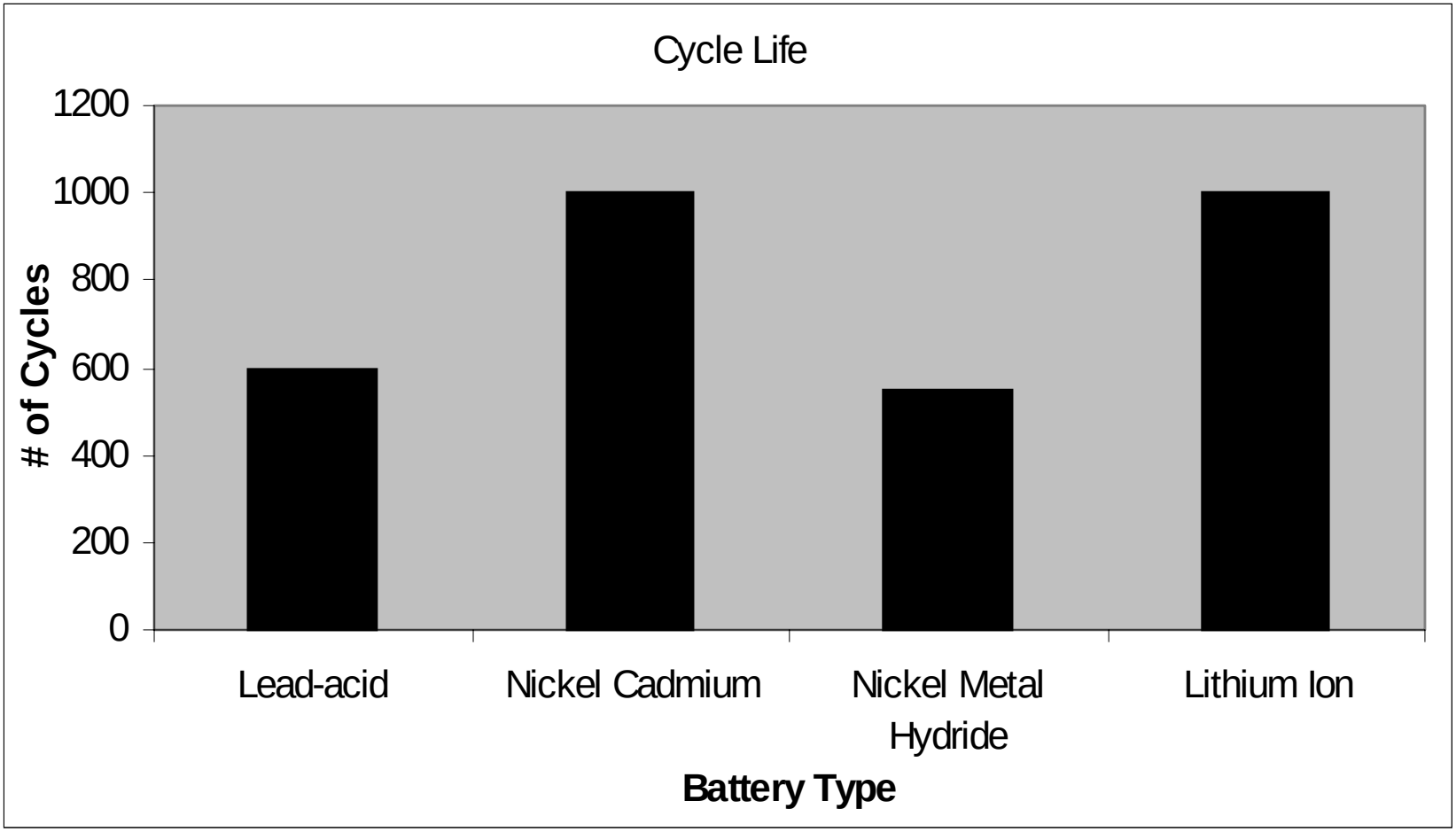
# Lithium Ion Battery Technology

- Capacity- 100 Wh/kg
- Cycle Life- ~ 1000 cycles
- Charging-
  - Special Charging Required: Can accept rapid charge, but must be slow charged during last 15% of its charge cycle
  - No “memory effect”
- Cost- Twice as much as Ni-MH
- Other- Overheating must be avoided

# Battery Technology Comparison



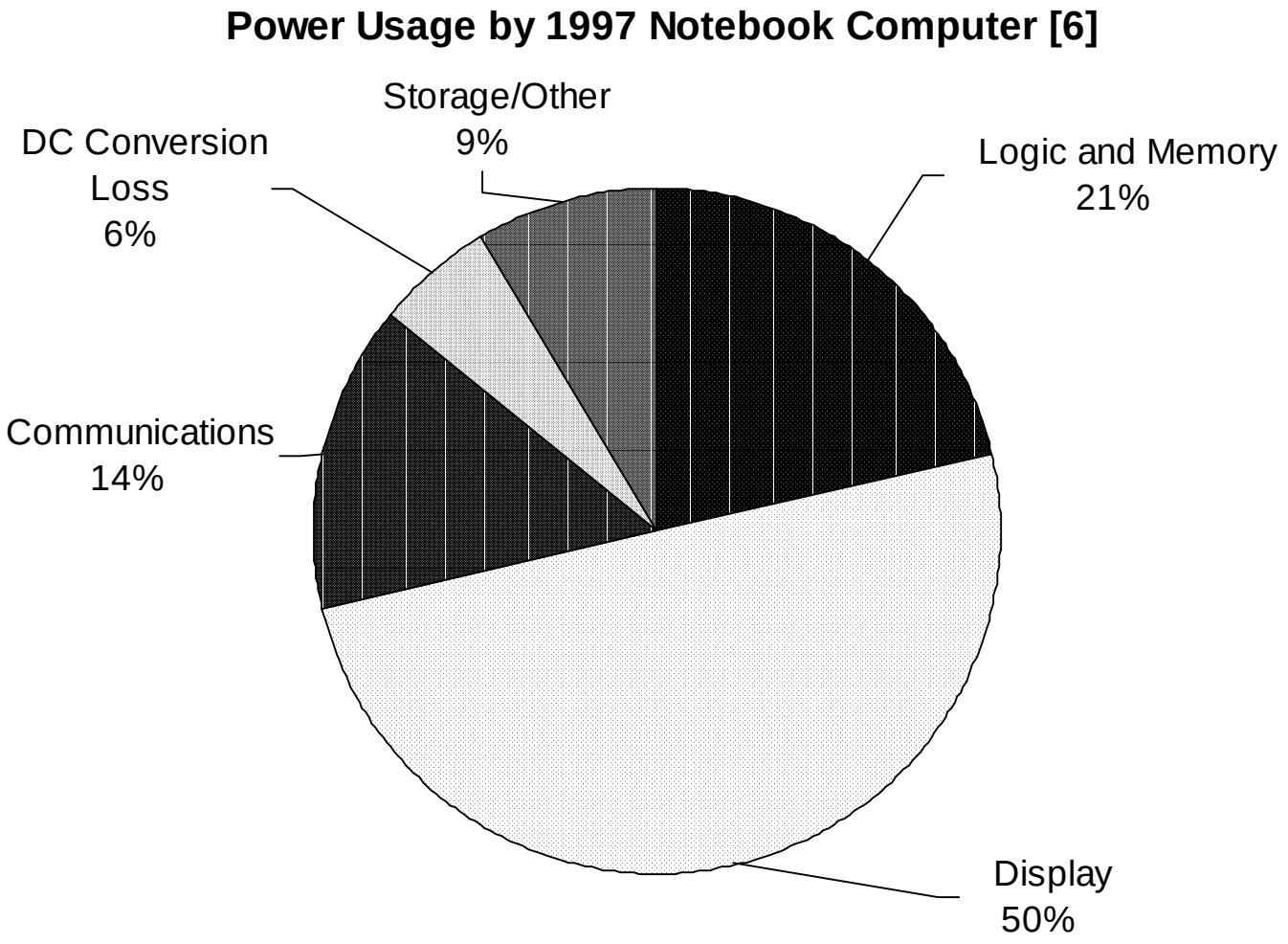
# Battery Technology Comparison



# Equipment Efficiency

- Devices
  - Cellular phones, Portable notebook computers, PDAs, etc.
- Cellular Phones Substantial Power Use
  - Transmit power
    - Cellular/PCS Technology Used (AMPS, CDMA, TDMA)
    - Well designed Power Amplifiers for high-power transmission signal
  - Internal hardware
  - Features Activated (Backlight, Minute counters, Calculators, etc.)

# Portable Notebook Computer Power Use



# Power Conservation Techniques in Laptops

- Display
  - Backlit liquid-crystal (LC) display requires much power
- Low-Power CMOS electronics
- Power conversion
  - Efficient dc/dc converters
- System power management
  - Switch into power saving modes

# Wireless Protocol Power Conservation

- Necessary to consider power conservation in design at all layers of protocol
- Examples of power conservation
  - IS-95 CDMA Power Control
  - IEEE 802.11
  - Bluetooth
  - Wireless ad-hoc routing

# IS-95 Power Control

- All DS-CDMA signals interfere with one another
  - Near-orthogonal codes make other users appear as interference noise at the receiver
  - High transmitted power levels of mobiles near the base raise noise level at base (Near-far problem)
- Multipath fading channel
- Prolong battery life
  - Smallest level possible to maintain quality
- Tight power control needed
  - Power level updated at 800 bps (1.25ms)
  - Attempts to maintain $E_b/I_t$ at base

# IEEE 802.11 Power Management

- Ready to receive takes power
- Permanent readiness is not necessary
- Power Management
  - Switch between two states, Sleep and Awake
  - Buffer data at access point when when station is in the Sleep mode
  - Wake up mobile to send buffered data
- Tradeoff between throughput of wireless system and battery life
- Power Management highly dependent on good synchronization

# Power Conservation in Wireless Ad-Hoc Network Routing

- Transmission level determines range of reception
- Higher transmit levels increases the range of interference
- Leads to higher probability of collisions
- More collisions result in greater number of retransmissions
- More retransmissions leads to more power
- Power Managed routing techniques should be used in the ad hoc network protocol to balance the power transmit levels while reducing the number of hops

# Conclusions

- Lithium Ion battery is best technology available, but is more expensive and requires special charging and ventilation to keep cool
- Equipments use power conservation through efficient displays, low-power electronics, and powering down unneeded subsystems
- Power conservation should be a consideration at all levels of wireless protocols because of the high demand for longer battery lives and lower device weights

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