COVER PAGE

Wireless At Iowa State University 2000 (Network Security, Telecordia)

August 17, 2000

Wireless at Iowa State University, An invited Corporate Distinguished Lecture, Telecordia Technologies, Inc. (Bell Labs), Morris Corporate Center, Morristown, New Jersey. An overview of national needs for Wireless Network Security, cooperative learning and research at Iowa State University, Information Systems Security at ISU, overview of electronic warfare, electronic security model for civil systems, technologies and strategies in wireless network security.

Wireless at Iowa State

Presented to:

by

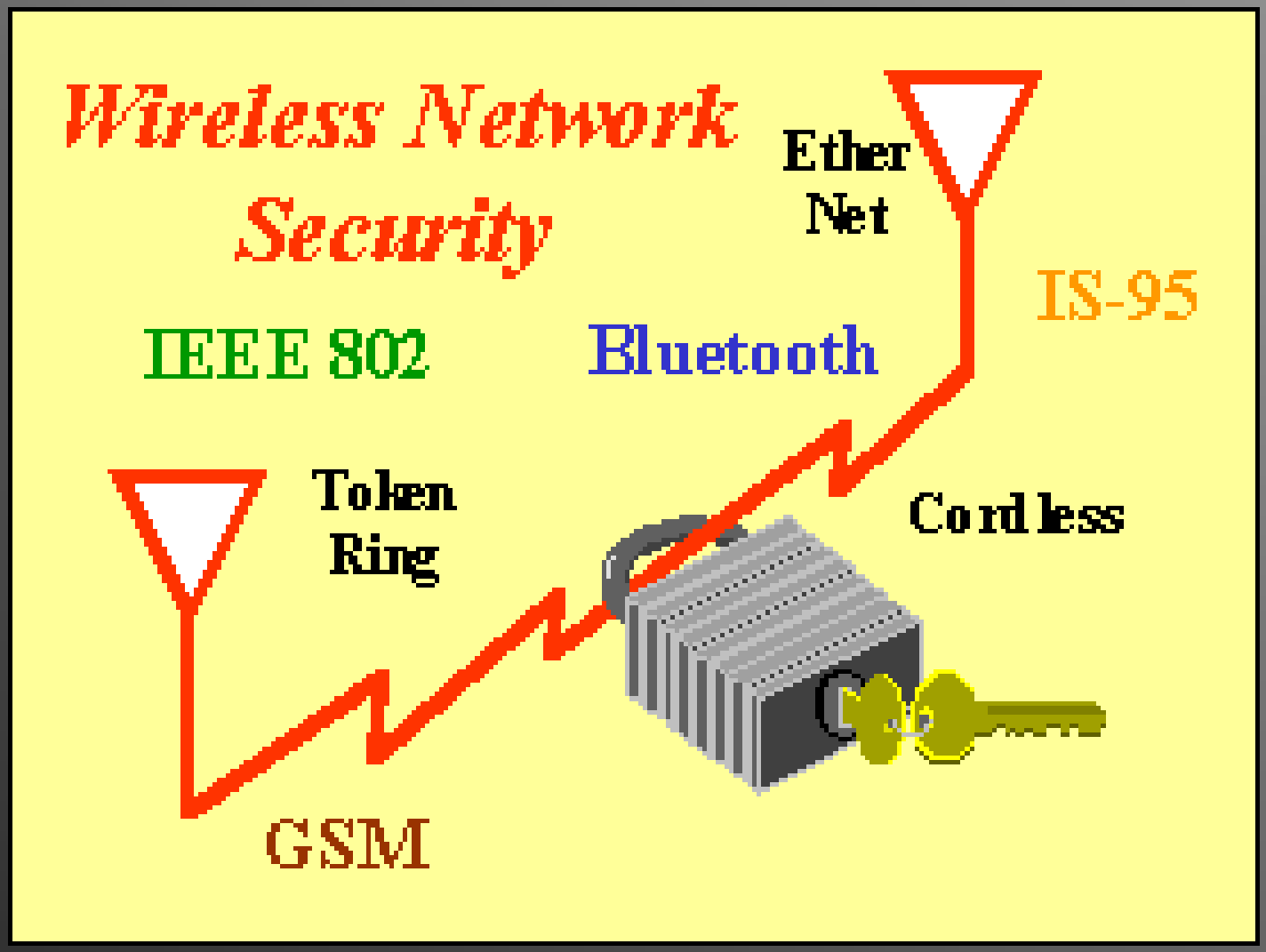
Steve F. Russell

Iowa State University

Department of Electrical and Computer Engineering

August 17, 2000

ISU
WIRELESS COMMUNICATION SYSTEMS



ISU
WIRELESS
COMMUNICATION
SYSTEMS

Summer 2000

Motivation

Speech by Secretary of Defense William S. Cohen, February 18, 1999

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- *There is a sense ... that some in the "digital world" dismiss the importance of the national security world.*
- *We are ...preparing for the future by addressing dangers you know well -- threats to the integrity of our information infrastructure.*
- *Today, as you well know, small groups, even single individuals, can wage electronic war against the most powerful nation in the world using off the shelf, existing tools and technologies.*
- *All together, the Department of Defense will spend $3.6 billion on computer security in the next four years.*

http://www.defenselink.mil/speeches/1999/s19990218-secdef.html

Changing Needs

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- The public need for wireless reliability and privacy increased dramatically when PCS started to become a reality
- In the past, reliability and privacy issues were addressed from the viewpoint of the service provider -- not necessarily the user
- Future systems must satisfy the needs of users as well

Need for Wireless Security

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- Wireless communication systems are very vulnerable to denial-of-service attacks
- Wireless network links are natural “wire taps” into a network
- Users are generally unaware of the security issues associated with a wireless link
- “End-to-end’ seamless security needs to be provided by the equipment manufacturers

Principal Investigator Background

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- Rockwell-Collins, GPS Programs, High Anti-jam General Development Model (GDM), 4 years
- Anti-jam receiver design at Rockwell
- Author of anti-jam systems design monograph at Rockwell
- Consultant to RCA/Camden on high-antijam frequency-hopping communication system
- PI on wireless security grant from Rockwell Foundation, 2 years
- Developed wireless security program and web site at ISU

Cooperative Learning/Research

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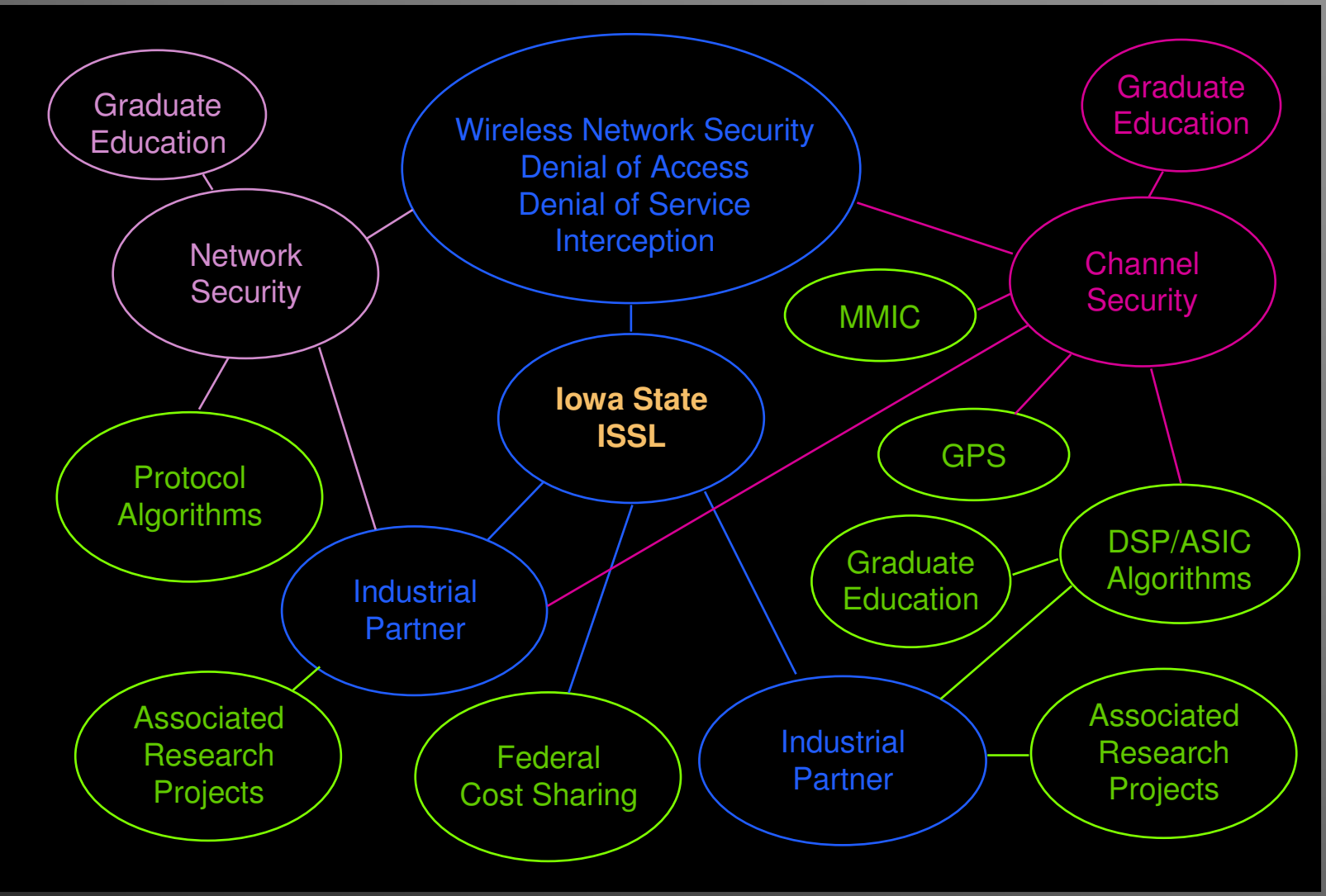

Wireless Network Security Research and Education at ISU

- Unique program started by ISU
- Startup supported by a grant from the Rockwell
- Collaboration with Information Systems Security Group, ISSL Lab
- Research focus is physical (and network) layer design, intrusion detection, and counterfeit base
- New graduate course, CPrE 537 in Wireless Communications Security
  - First in the country

Information Systems Security

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- Information (Data) Security
- Computer Security
- Network Security
- Wireless Channel Security

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Security Services Provided by a Telecommunication System

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- Identification and Authentication
- Privacy
- Reliability

Electronic Warfare

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SERVICE	ECM	ECCM
Authentication	Spoofing	Anti-Spoofing
Privacy	Intercept	Anti-Intercept
Reliability	Jam	Anti-Jam

Security and Reliability Issues and Perceptions

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- The Service Provider
- The Equipment Manufacturer
- The Customer

The Service Provider

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- Loss of Revenue
- Quality of Service
- Customer Perceptions

The Equipment Manufacturer

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- Cost
- Reliability
- Customer and Service Provider Perceptions

The Customer

- Cost
- Reliability
  - Robust Airlink
  - Antijam and Anti-interference
- Privacy (Security and anonymity)
  - Encryption
  - Position Location and Identification (E 9-1-1)
  - User identification outside the service providers system

Examples of Lost Privacy

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- Wireless Enhanced 9-1-1*
  - Implemented by October 2001
  - Location of Mobile Station Must be Provided to Public Safety Answering Point
  - Latitude & Longitude
    - Accuracy of 125 Meters 67% of the Time
  - Users need to be able to deny this capability or only enable for actual 9-1-1 calls
- Transmitter waveform signature identification ("Transmitter Fingerprinting")

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*Based on a presentation by Betsy Kidwell
Wireless Standards Development, Lucent Technologies
National Communications Forum 1997

Some Wireless Systems

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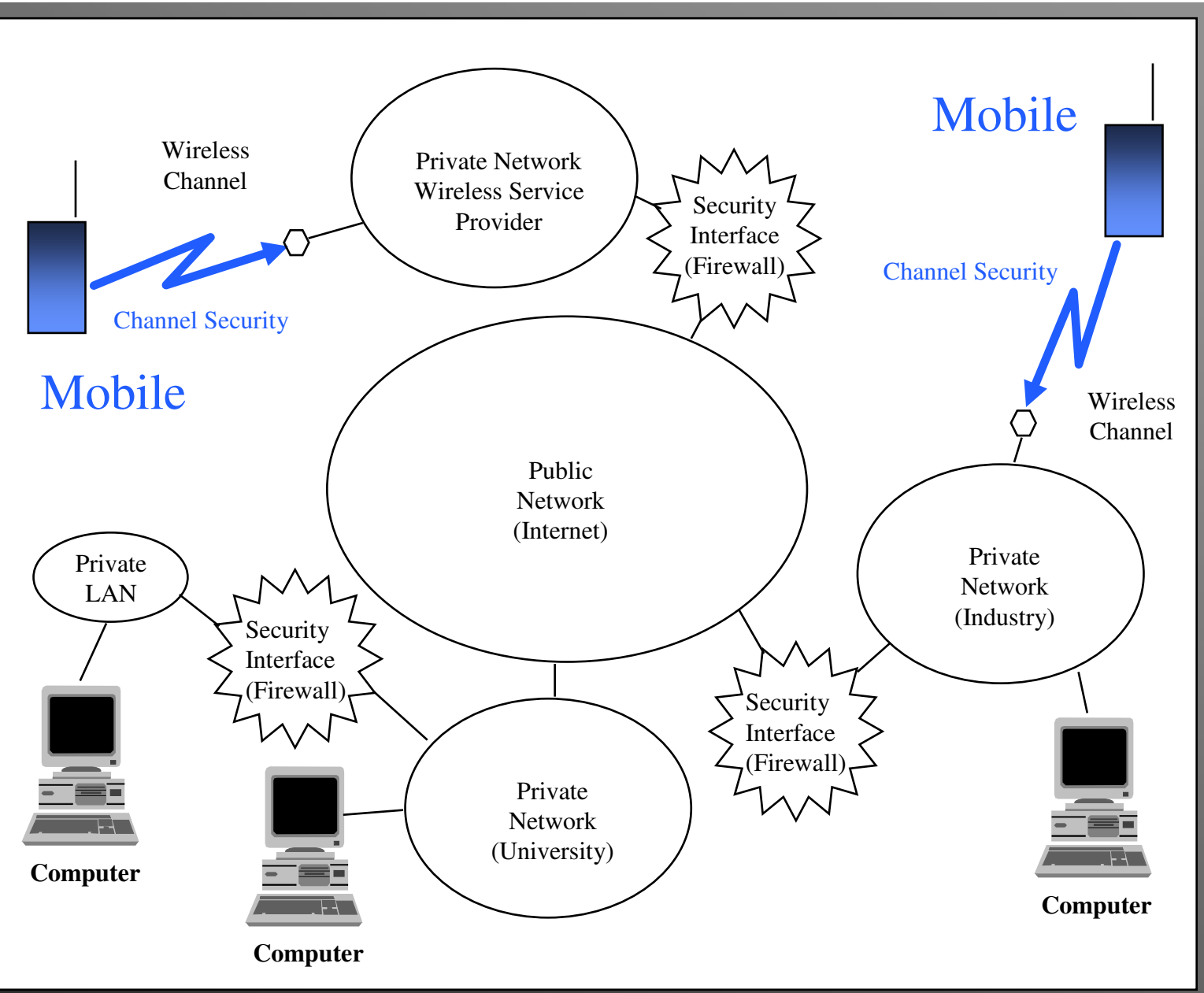
- Cellular Radio Telephone
  - FDMA (AMPS, Analog FM)
  - TDMA (D-AMPS, GSM)
  - CDMA (IS-95)
- Wireless LAN
  - 802-11
  - Bluetooth
  - etc. etc.
- Land Mobil and Special Mobile Radio (SMR)
- Cordless Telephone



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Secure Wireless Communications

Some Security Issues

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- Encryption
- Interception
- Jamming or Service Degradation (Intentional)
- Interference (unintentional)
- Position Location

Electronic Security Model for Civil Systems

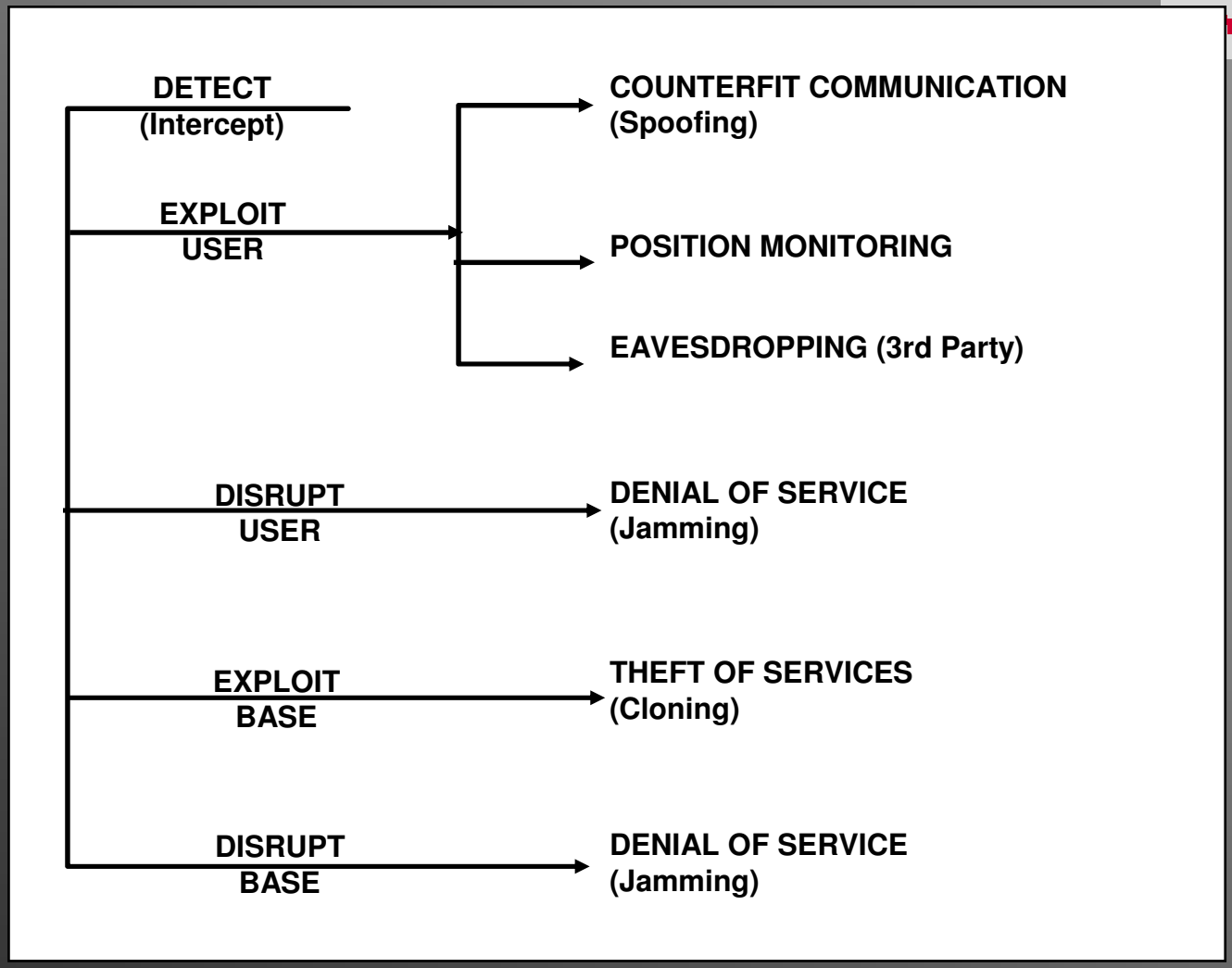

Fig. 0085

Past, Immediate and Future Threats

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- Number Cloning
  - Skills and technology costs needed to clone numbers are relatively low
  - This was a significant problem for service providers in the past but effective solutions are now available
- Decryption
  - Computational time and costs are prohibitive for advanced methods
  - Encryption techniques continue to advance to the point where this is not a problem in well-designed systems

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Past, Immediate and Future Threats (cont.)

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- Intrusion
  - This is a significant threat but is still too costly and/or sophisticated except for government agencies
  - Intrusion detection methods are still in the research stage and much work remains to be done
  - IS-95 counterfeit base (an example is given later)
- Position Location
  - The technologies being developed for E911 can be used for locating and tracking individuals
  - Public resistance to “big brother” tracking will increase

Immediate and Future Threats (cont.)

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- Denial-of-Service
  - Antijam system designs are needed
  - Data Interleaving and proper media access control (MAC) design can improve reliability
- Spoofing
  - System designs must improve the ways that both the mobile and base are identified and authenticated

The simple, low-cost strategies

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- Denial-of-Service (DOS)
  - Brute force jamming (barrage jamming)
    - "Wavewall" product (Demo?)
  - Base station call setup spoofing
  - False control signals over the setup (usually paging) channel
- Eavesdropping
  - Forced analog operation (jam the TDMA or CDMA cellphone channel
  - Base station impersonation (very costly in some systems but easy in some cordless phones)

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A well-designed denial-of-service attack will act like network congestion or an intermittent data connection

Wireless Channel Security
"The Big Tradeoff"

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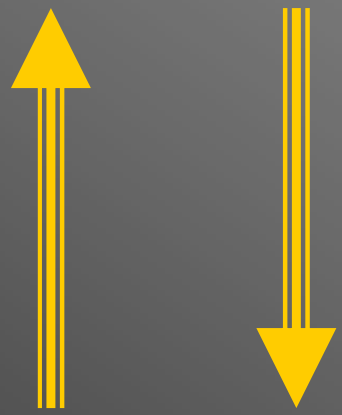
Reliability & Privacy



Data Throughput

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Modeling

Wireless Network Model

Simplified Diagram of a
Wireless Access Point in a
Wireless Local Area Network

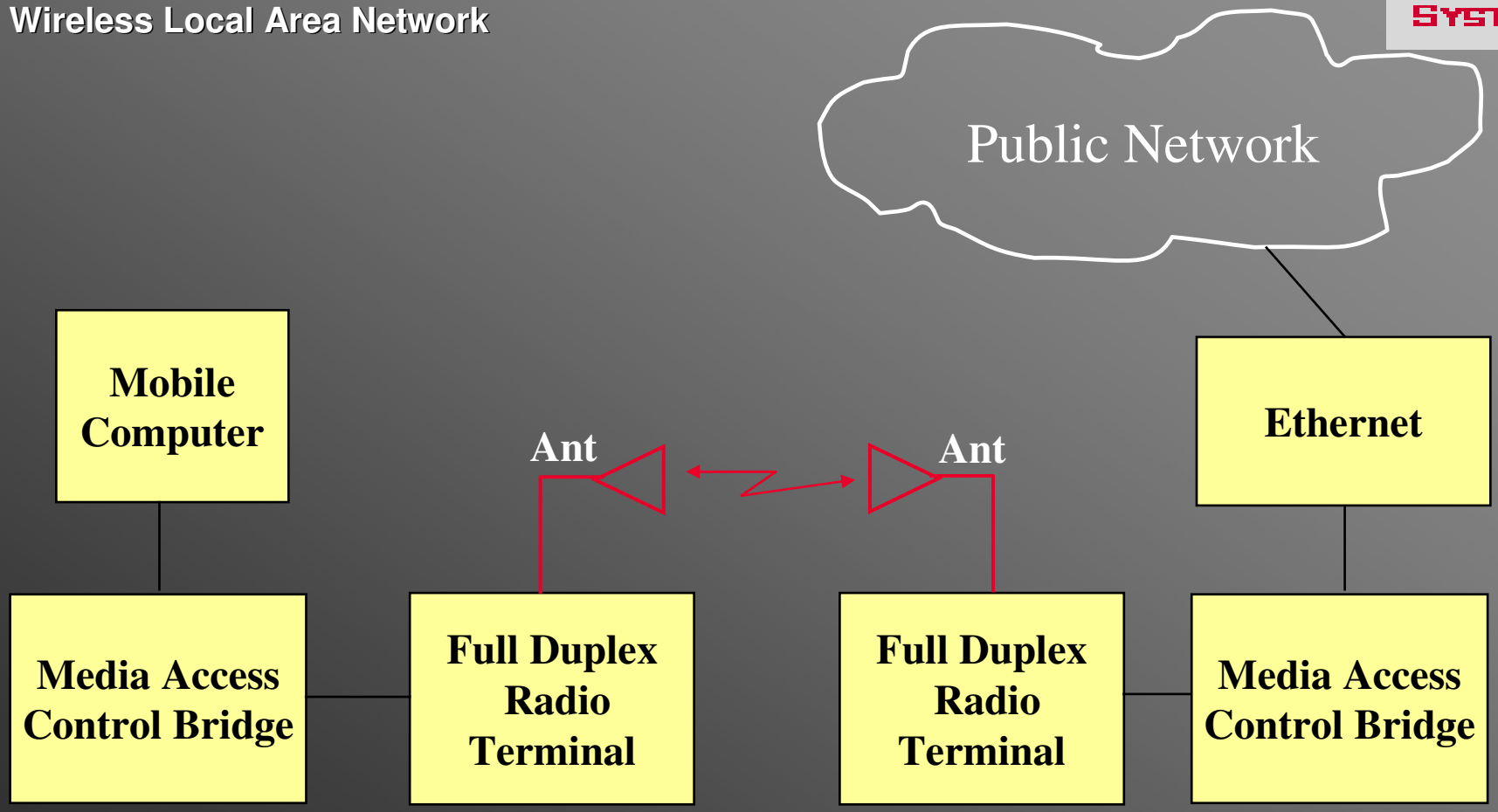
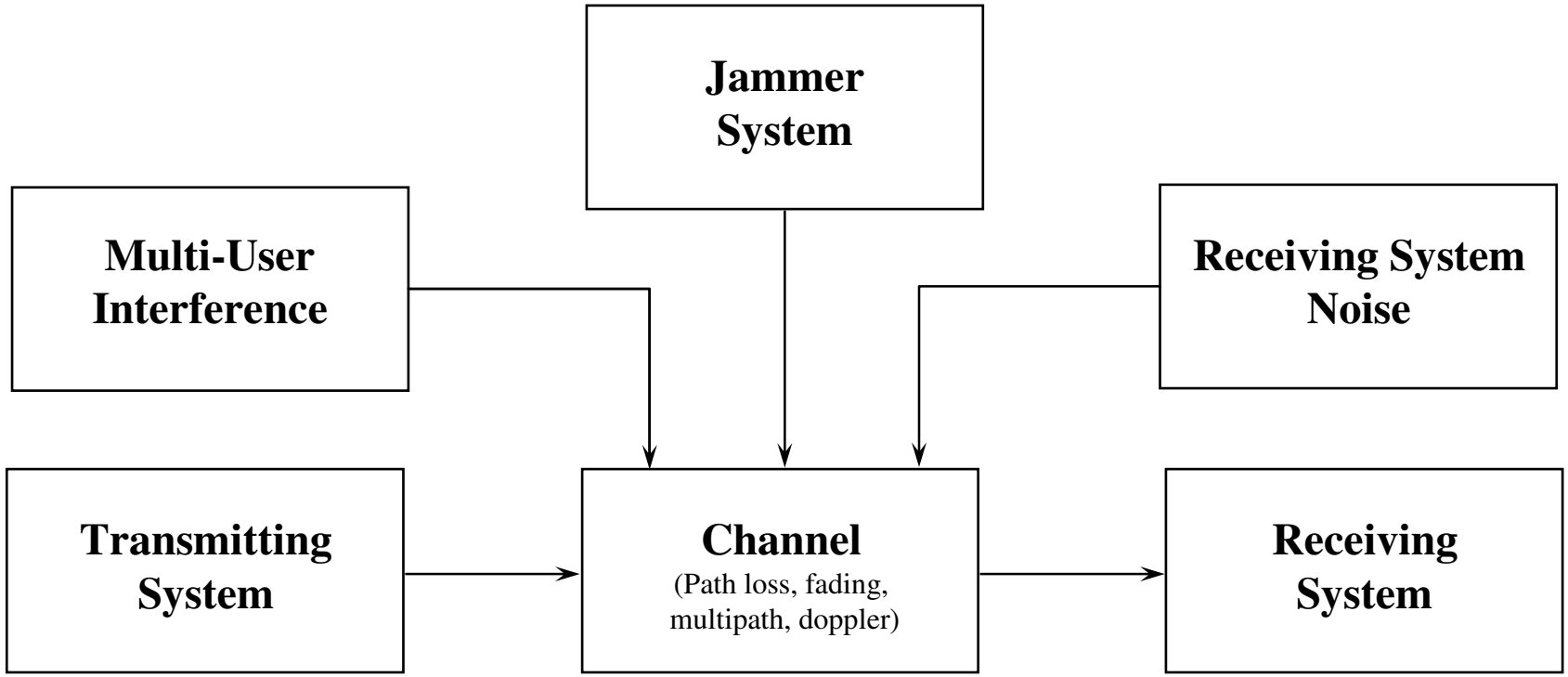


Fig. 0150



Basic System Components in a Multi-User, Spread-Spectrum Communication System

Fig. 0002

Wireless Channel Security Scenario

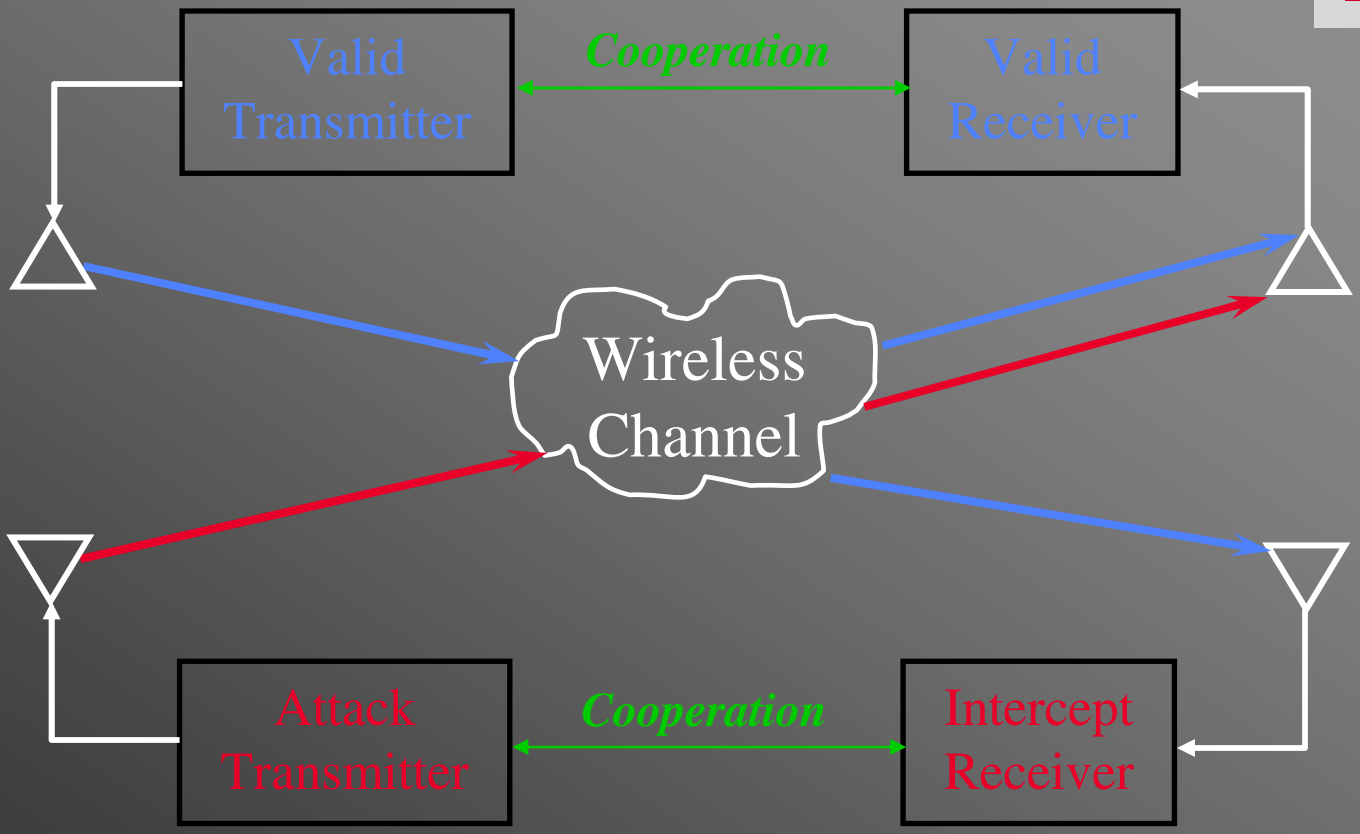
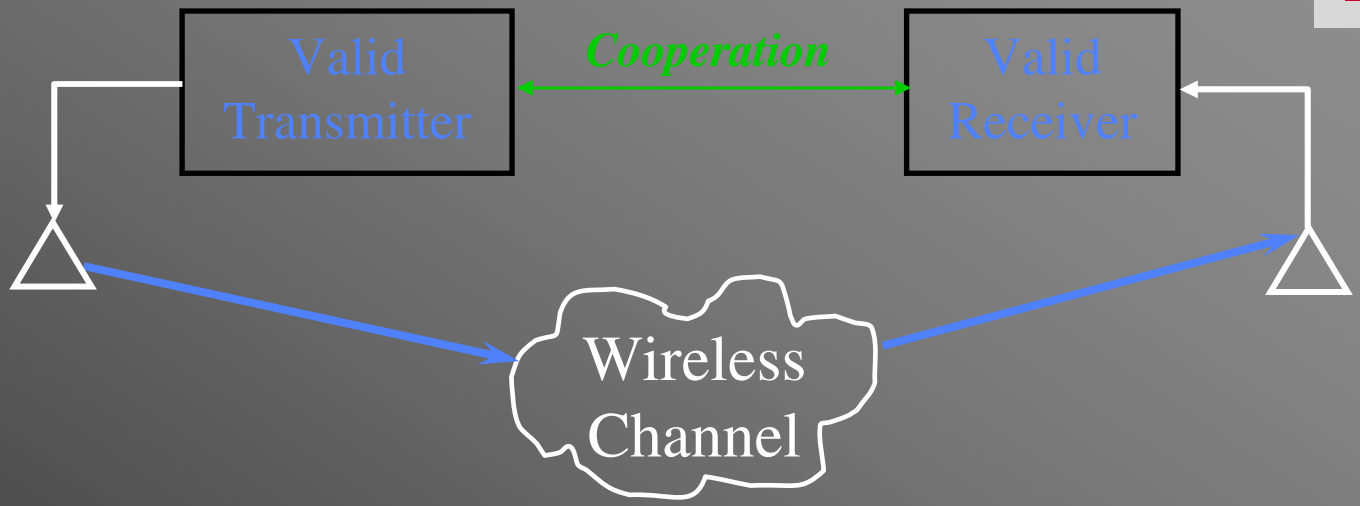


Fig. 0146

Normal Operation



Eavesdropping Scenario

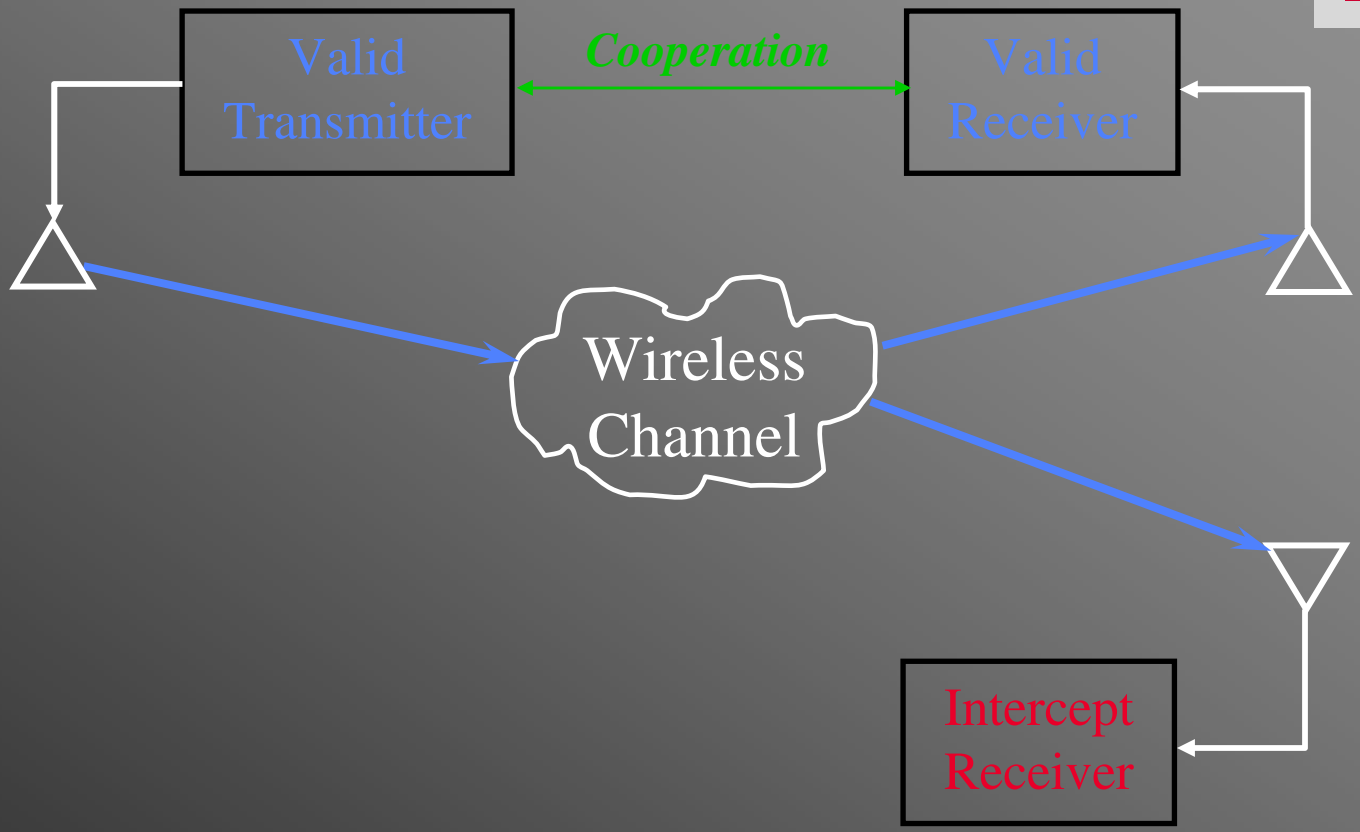


Fig. 0146

Jamming Scenario
(Denial-of-Service Attack)

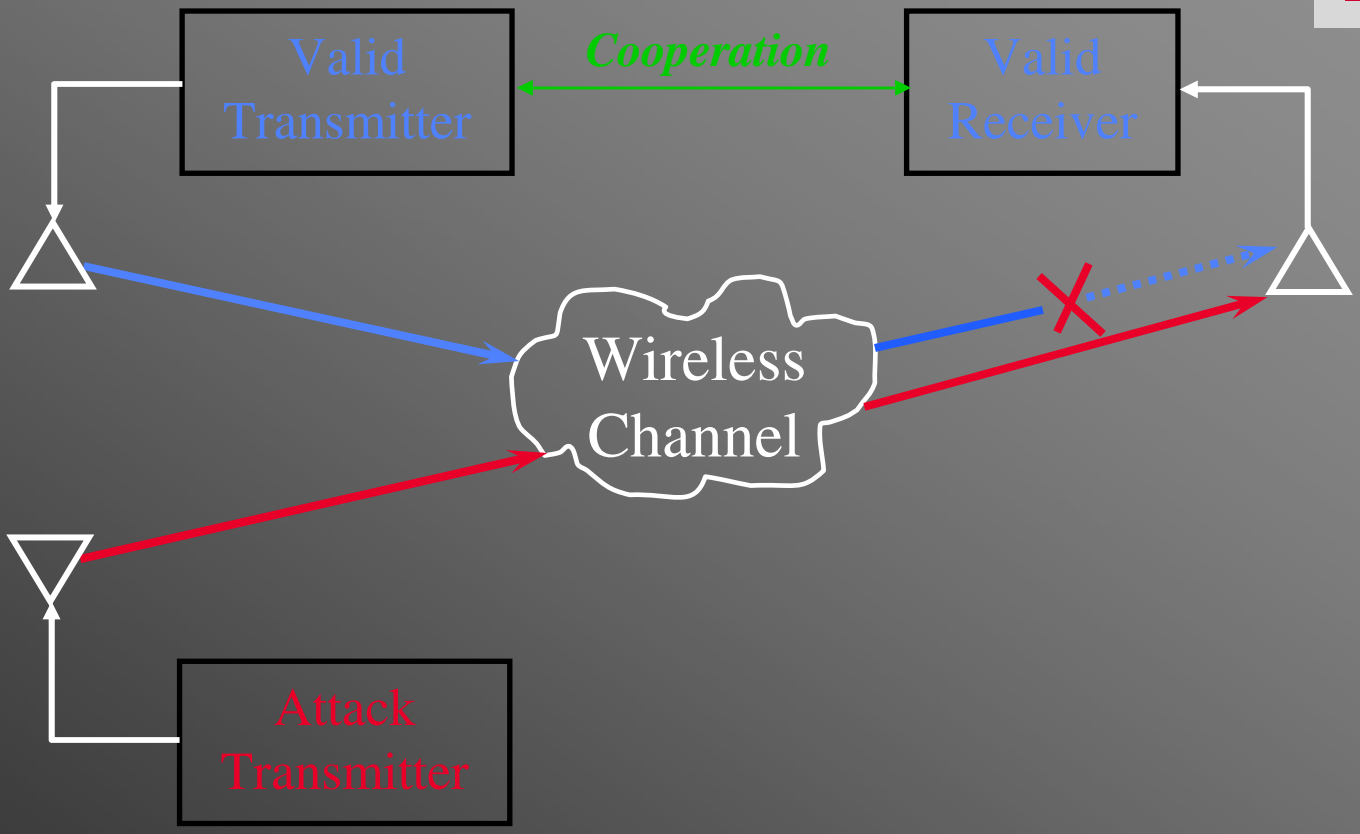


Fig. 0146

Counterfeit Base Scenario
(Spoofing Attack)

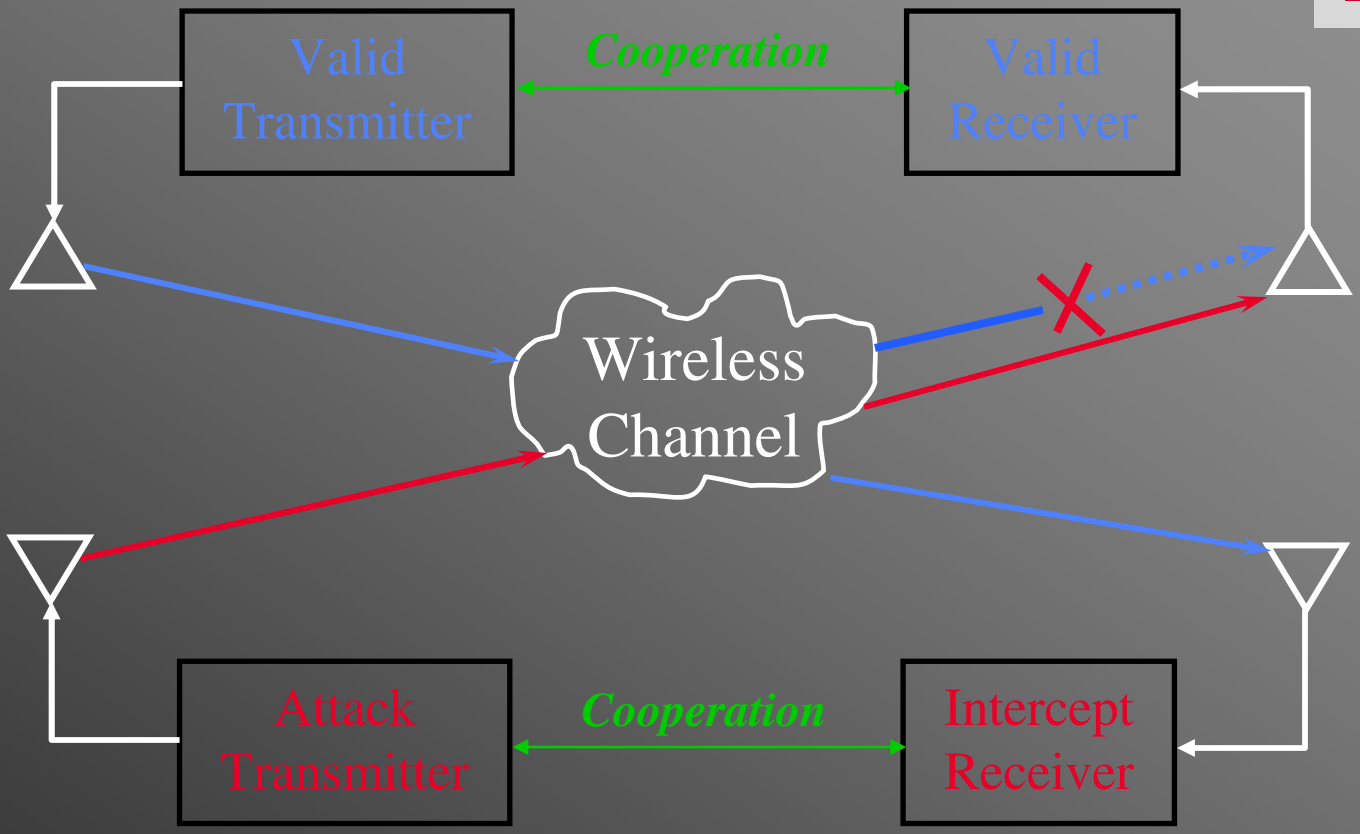


Fig. 0146

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Design Recommendations

Designing for Wireless Security and Reliability

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- Adaptive (Smart) Antennas (very costly)
  - Transmitting antennas maximize EIRP in the direction of friendly receivers
  - Receiving antennas maximize directive gain in the direction of friendly transmitters
  - Receiving antennas steer a null in the direction of an interfering transmitter

Designing for Wireless Security and Reliability (cont.)

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- Antijam Receiver Design (moderate cost increase)
  - Use frequency hopping designs
    - Direct sequence systems are too easy to jam unless the antijam (AJ) margin is large (this means a large spreading bandwidth)
  - Hop as fact as practical
    - 400-1000 hops per second should make it difficult for most follower jammers

Designing for Wireless Security and Reliability (cont.)

ISU Wireless Communication Systems

- Antijam Receiver Design (cont.)
  - Use high-performance narrowband filters
    - These minimize interference due to out-of-band, front end overload and spurious response
  - Implement adaptive, interference-rejection spectral filters
  - Employ high-dynamic-range circuits and software algorithms
    - This minimizes overload due to high interfering signals

Designing for Wireless Security and Reliability (cont.)

WIRELESS COMMUNICATION SYSTEMS

CONTINUE HERE NEXT TIME

- Antijam Receiver Design (cont.)
  - Implement a hopping RF preselector filter
    - This gives best performance but is costly

Designing for Wireless Security and Reliability (cont.)

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- Data Link (MAC) and physical layer designs
  - Design for a high error rate
  - Smaller data packets
  - Error detection and correction
  - Robust ACK/NAK for uncorrectable errors
  - Use data interleaving to mitigate unsophisticated jammers
    - This will probably make voice over data impractical

Designing for Wireless Security and Reliability (cont.)

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- Intrusion Detection and Wireless Channel Management
  - Much research is still needed
  - Monitor spectrum for interfering signals
  - Log historical error rates and signal levels
    - Alert system manager to unusual conditions

Designing for Wireless Security and Reliability (cont.)

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- Identification and Authentication
  - Both mobile and base should identify and authenticate each other
- Data Encryption at the Physical Layer
  - !DO IT!

Variable Levels of Service

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- High data rates when the RF environment is benign
- Adaptive data rates when the RF environment is hostile
- Level of service can be user selected via software or selected by automated intrusion detection

Proprietary vs. Standards

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- Proprietary Systems
  - Waveform information must be gathered by signal monitoring and analysis -- sometimes a difficult and expensive task
- Standard System 802.11
  - Waveform information is readily available in the standards documents

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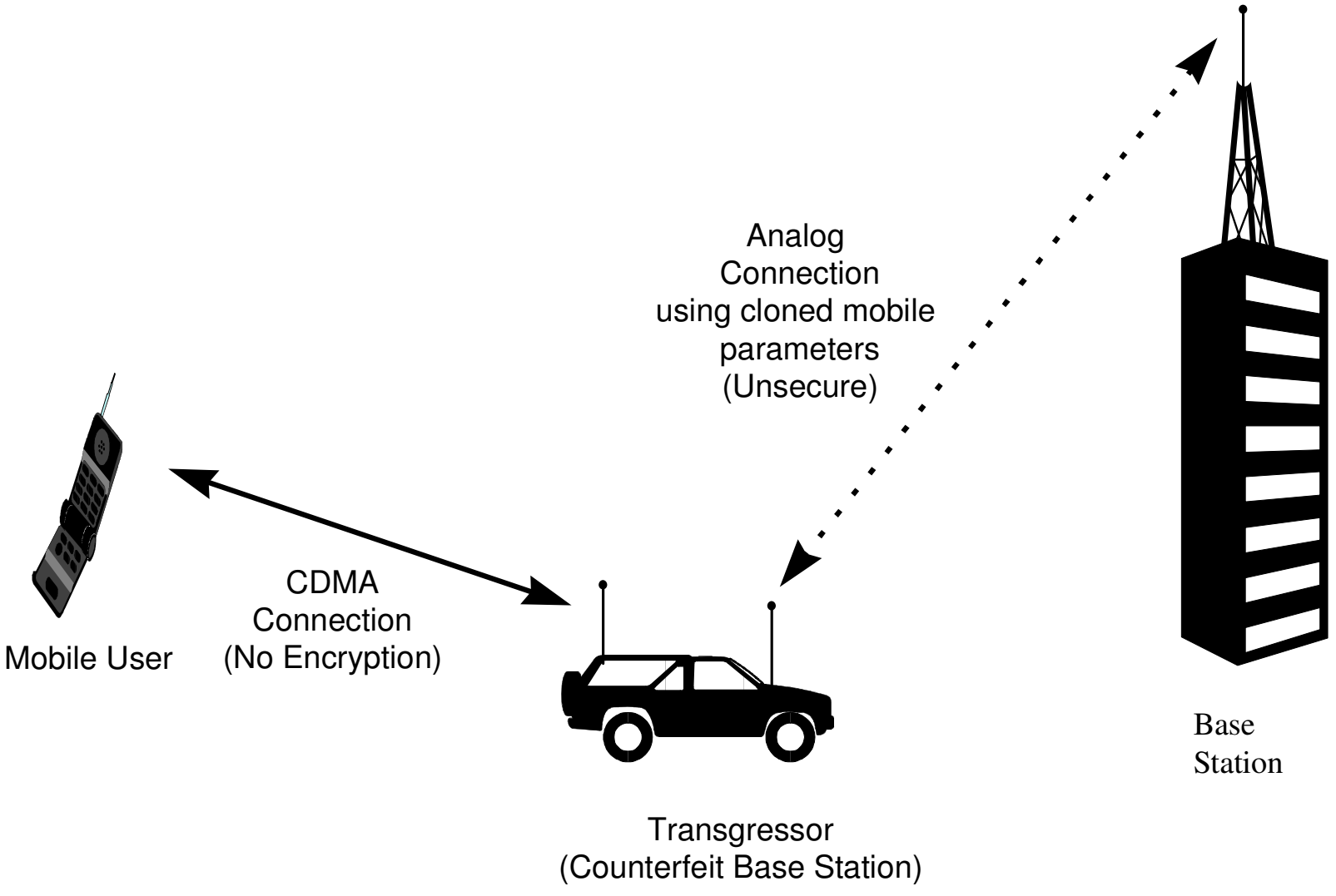
- **Example:**
  - **IS-95 counterfeit base**


Analog
Connection
using cloned mobile
parameters
(Unsecure)
CDMA
Connection
(No Encryption)
Mobile User
Transgressor
(Counterfeit Base Station)
Base
Station

Example:
"Spectrum24(R)" System (IEEE 802.11)

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- Operates under FCC Rules, Section 15.247
- Frequency Span of 2.4 GHz band (USA)
  - ~2400 - 2483.5 MHz
- Frequency Spreading Method
  - Frequency Hopping
- Hopping Channel Frequency Separation
  - ~1 MHz (based on 2-4 GFSK)

Example (cont.): "Spectrum24(R)" System (IEEE 802.11)

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- Number of Hopping Frequencies
  - 78 in the USA
- Hopping Dwell Time
  - 0.1 Seconds (10 hops/second)
- Modulation Format
  - Gaussian 2-4 Frequency Shift Keying (GFSK)

Example (cont.): "Spectrum24(R)" System (IEEE 802.11)

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- Data Rate
  - 1.0-2.0 Megabits per second (specifications quote both)
- Multiple Access
  - Carrier-sense, multiple access, collision avoidance (CSMA/CA)
- Power outputs
  - 500 milliwatts out of the transmitter

Example (cont.): "Spectrum24(R)" System (IEEE 802.11)

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- Media Access Control (MAC) layer Security
  - Not available

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Some Current Resources

Conferences and Web Sites

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- Journal of Electronic Defense
  - http://www.jedefense.com
- Iowa State University - Information Systems Security Laboratory (ISSL)
  - http://www.issl.org
- Purdue University - Center for Education and Research in Information Assurance and Security
  - Http://cerias@purdue.edu
- Telecommunications and Information Security Workshop 2000 (TISW2000)
  - Tulsa, OK, Sept. 27-28, with a post-session on Sept. 29
  - http://ww.cis.utulsa.edu/tisw2000

Cellular Intercept

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- FP - ELECTRONIC - Security Systems - *Swift Cellular Intercept System*
  - http://www.fp-electronic.de/swift.htm
- BARTEC, Bartlett Technologies - Communications Assistance for Law Enforcement Act (CALEA)
  - http://www.bartec.com/
  - http://www.bartec.com/content/whatshotCOPS.html
- GSM INTERCEPT WORKSHOPS
  - http://spyzone.com/spyzone/news/gsmwork.html

Wireless Security and Reliability

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- QUESTIONS?

Steve F. Russell
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August 19, 2000

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331 Newman Springs Road, Red Bank, NJ 07701-5699, USA
Phone: +1 732 758-3081 Fax: +1 732 758-4372
Email: mbarton@research.telcordia.com

Dear Dr. Barton:

Thank you for hosting me as a distinguished speaker at Telecordia this past week. Meeting you and the other members of your organization was a pleasure.

Thanks also for giving me the opportunity to tell your organization about a small part of our Information Systems and Security Laboratory work at Iowa State.

Please feel free to have any of you staff contact me if they would like further information about our work.

My conversation with Joe Wilkes was interesting and I hope to possibly work with him in the future.

I wish you the best in your future activities in the information security area.

Sincerely,

Steve F. Russell
Associate Professor
Sfr@iastate.edu

August 19, 2000

Marilyn Welsh
Telcordia Technologies, Inc.
331 Newman Springs Road, Red Bank, NJ 07701-5699, USA

Dear Marilyn,

Thanks for the fine travel arrangements you made for me. I had a great trip.

Enclosed is a statement of my out-of-pocket expenses for the trip. I have enclosed the receipts for the car rental and the parking. If you require anything else, please email me and let me know.

It was nice visiting New Jersey again. I had lived there a summer doing consulting work and really enjoyed it.

Sorry we did not meet.

Sincerely,

Steve F. Russell

Enclosure: Travel Expenses

August 19, 2000

ENCLOSURE
Travel Expenses for Steve F. Russell

Wednesday, August 16, 2000

Breakfast	--
Lunch	$3.08
Dinner	$32.01 (Rod's Steak House at Hotel)
Personal Auto	42 Miles @ 0.21/mile = $8.82

Thursday, August 17, 2000

Breakfast	$6.98
Lunch	--
Dinner	$23.82 (Poor Herbie's in Madison)

Friday, August 18, 2000

Breakfast	$3.90
Lunch	$3.04
Personal Auto	42 Miles @ 0.21/mile = $8.82
Airport Parking	$15.50 (Des Moines International Airport)
Rental Car	$149.90

TOTAL REIMBURSEMENT = $255.87

_____ _____
Signed Date