Software-Controlled Mobile Fading Simulator

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Overview

- Motivation
- The mobile fading channel
- Software modeling of fading
- Possible hardware designs
- The chosen design
- Performance results
- Recommendations and conclusions

Motivation

- Want to build a simulator to test mobile devices under real-life conditions (fading channel)
- Current hardware simulators are expensive (tens of 1000's of $$$)
- Difficult to incorporate new fading models into current simulators
- *We want more flexibility than current commercial simulators can provide*

The mobile fading channel

- Multiple paths from transmitter to receiver (reflections, diffraction)
- Items of size at least comparable to λ are of interest — at 1 GHz, this is only 30 cm!
- The *instantaneous* signal-to-noise ratio (SNR) varies (phase cancellation)
- Varying SNR causes a varying bit error rate (BER)

Software Modeling of Fading

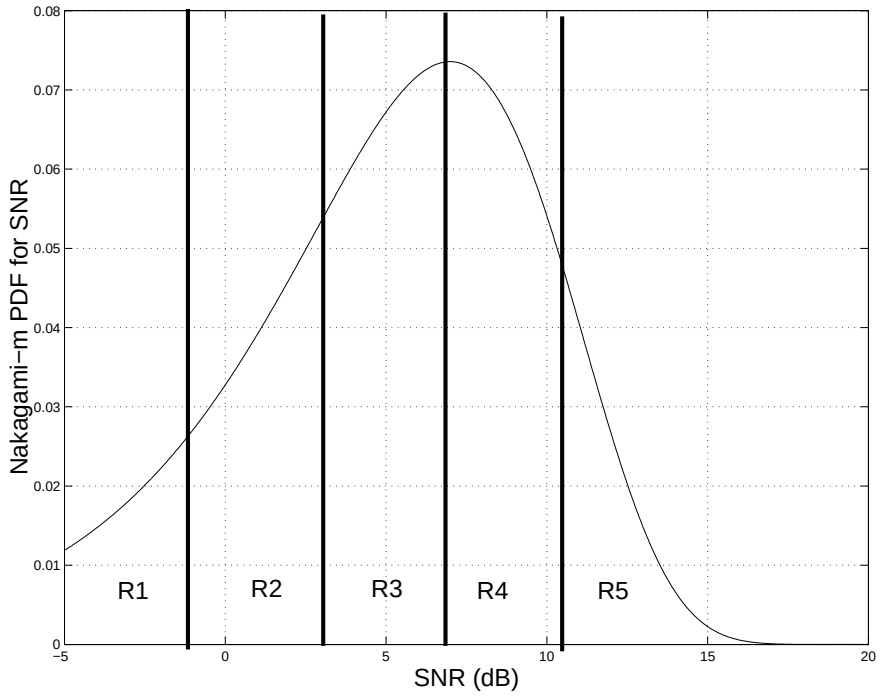
- Characterize the received amplitude by the *Nakagami-m* distribution

$$p_R(r) = \frac{2}{\Gamma(m)}\left(\frac{m}{\Omega}\right)^m r^{2m-1} e^{-mr^2/\Omega}$$

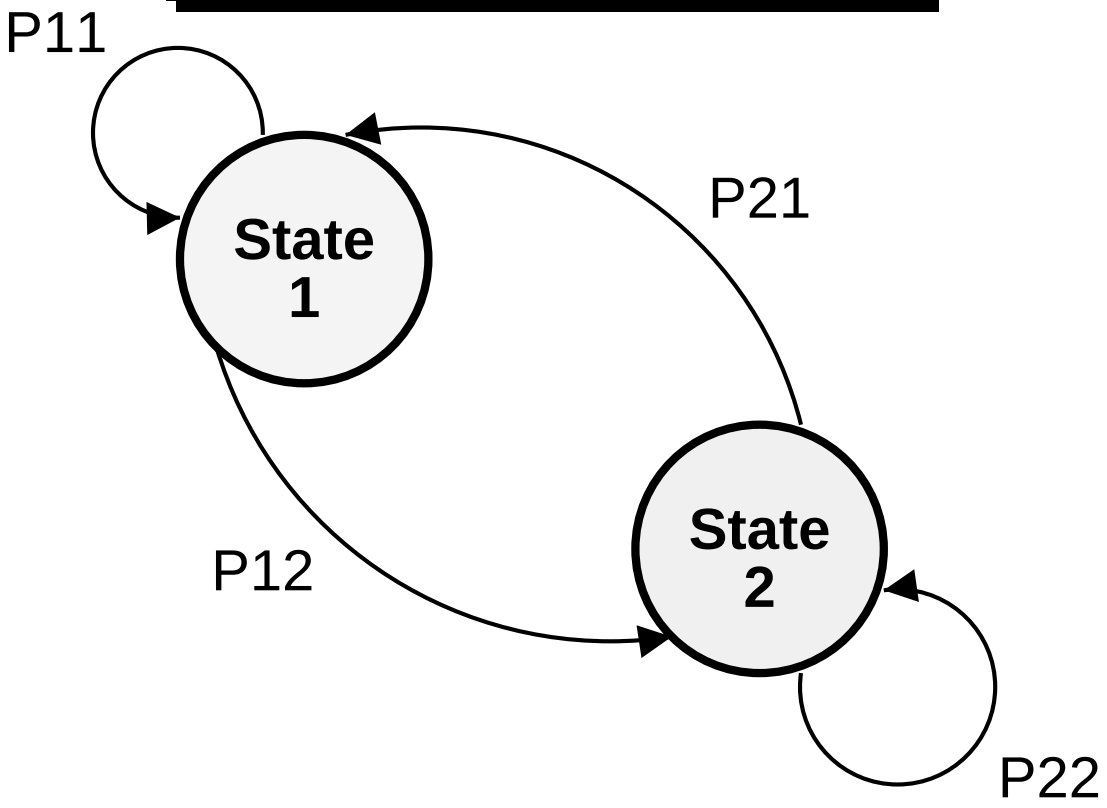
- The parameter m is related the the fading severity
- Includes *Rayleigh* distribution (many incoming signals, uniformly distributed phase) as a specific case ($m = 1$)
- Need to find a computationally simple model, for simulation purposes

Markov model of the Fading Channel

- Divide the envelope pdf into n distinct regions
- Calculate the *average* BER over each region
- Find *transition probabilities* $Prob(R_i \Rightarrow R_j) \quad \forall i, j$
- Build a Markov chain describing the states

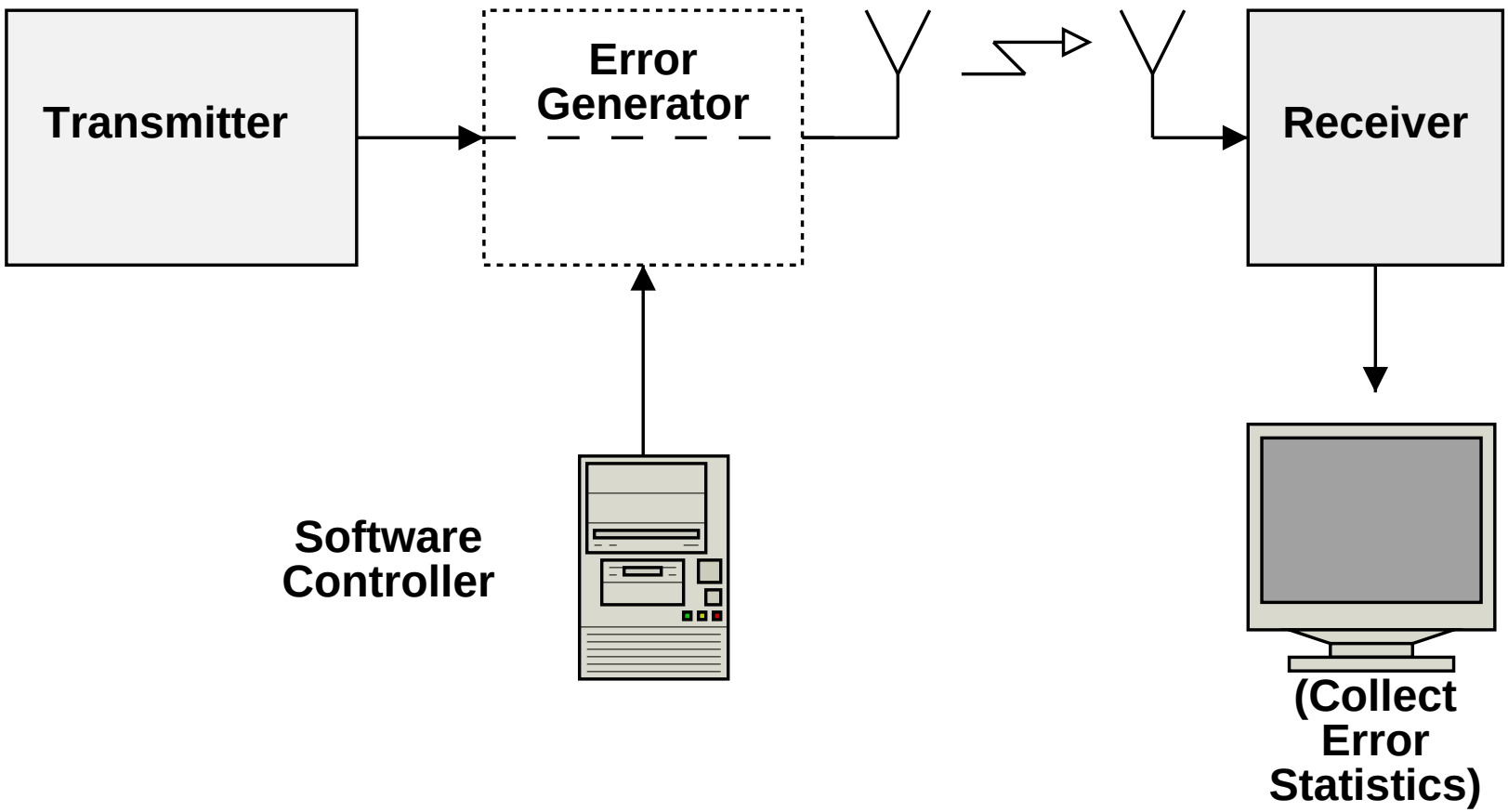


Markov model (cont'd)



Markov Chain, $n = 2$ states

Hardware Fading Testing



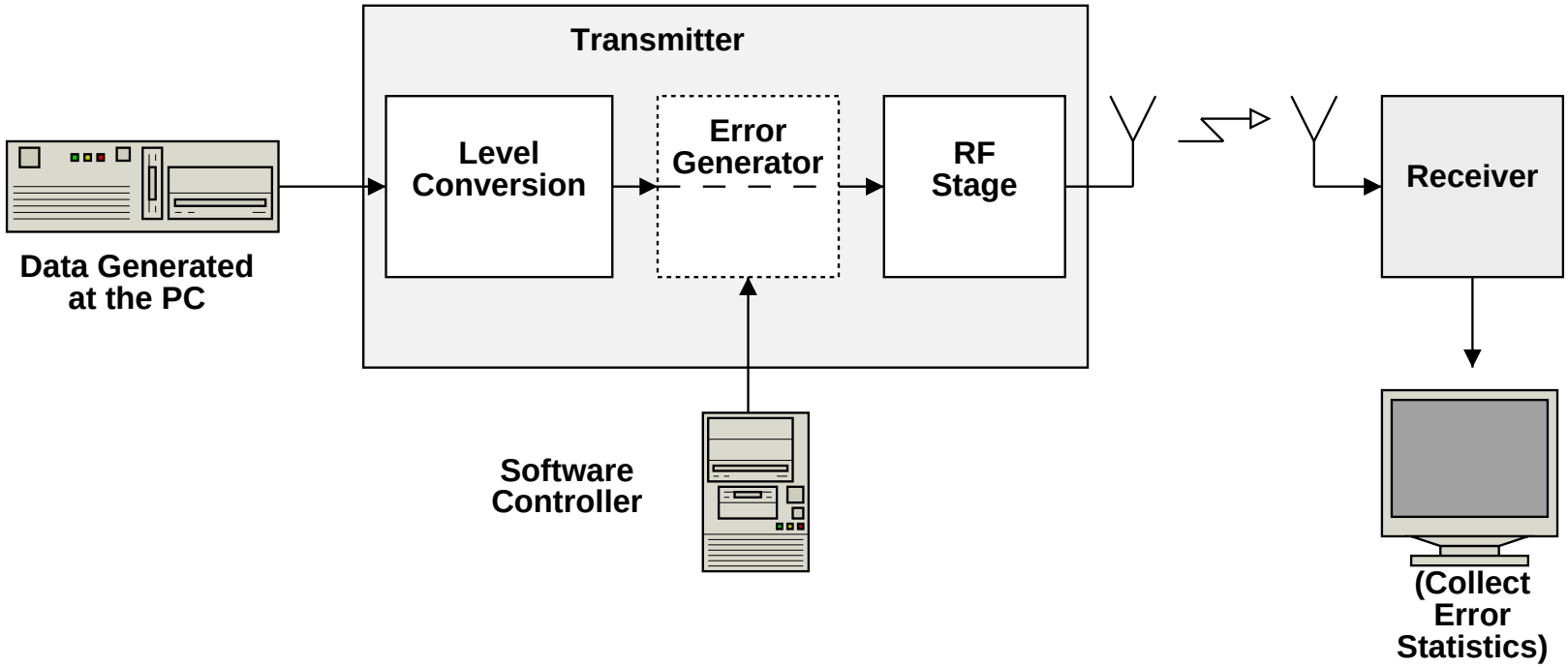
Fading Simulator Hardware Design — Constraints

- Fading simulated at the transmitter — don't want to modify receiver equipment
- Minimum modification to transmitter hardware
- Software controllable
- Real-time, "online" simulation
- Should be transparent to equipment under test

Possible Hardware Designs

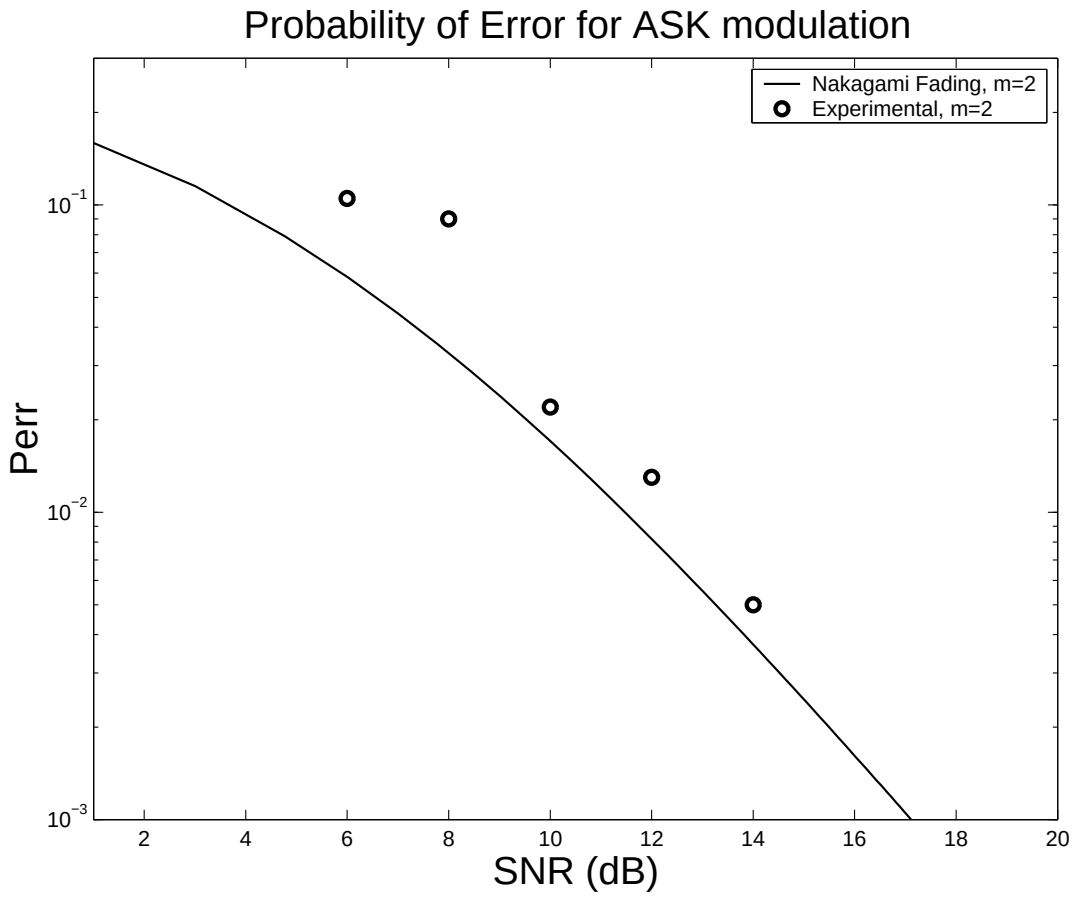
- Use actual fading channel measurements
- Sum-of-sinusoids circuit (phase shifters and amplifiers)
- Mismatch circuits at the transmit antenna — divert some power from the antenna. Use transmission lines
- Voltage-controllable attenuator/amplifier (at RF frequencies)
- Interface at the bitstream of the transmitter

Chosen Hardware Design



TLP/RLP ASK Radio. 434 MHz. 2400 bps. Interfaced to PC Serial port.

Performance Results



Recommendations

- Bit-level interface is suboptimal
- Preferred method would be at RF frequencies — requires microwave circuit techniques
- Commercial application would use a voltage-controlled, variable attenuator connected to a real-time PC or embedded microcontroller

Conclusions

- A software-controlled hardware fading simulator has been constructed
- Test results show that the simulator is working properly
- Software control allows flexibility in the error model used
- Easily reconfigurable for different test conditions