MSc Module: ELEC0086
Communications Systems Modelling (CSM)

By

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Introduction

Why CSM?

- The complexity of communication and signal processing systems has grown considerably during the past decades

- At the same time the emergence of a variety of new technologies such as fast and inexpensive hardware for DSP, fibre optics, integrated optical devices and microwave ICs, etc. has had significant impact on the implementation of communication systems

- We need to design and analyse communication systems in a timely, cost-effective and effort-free manner

$\Rightarrow$ These demands can be met only through the use of computer-aided analysis and design tools

Computer-aided Techniques

- Computer-aided techniques fall into two categories:
  - Formula-based approaches, where the computer is used to *evaluate* complex formulas, and
  - Simulation-based approaches, where the computer is used to *simulate* the waveforms or signals that flow through the system
- Our focus will be on the ***use of simulation for evaluating the performance*** of digital communications systems

Methods of Performance Evaluation

- **Formula-based techniques**

- Based on simplified models, provide considerable insight
- However, except for some idealised and oversimplified cases it is extremely difficult to evaluate the performance analytically

- **Measurements**

- If you can do it, that's perfect!
- But this approach is costly, time-consuming and not very flexible

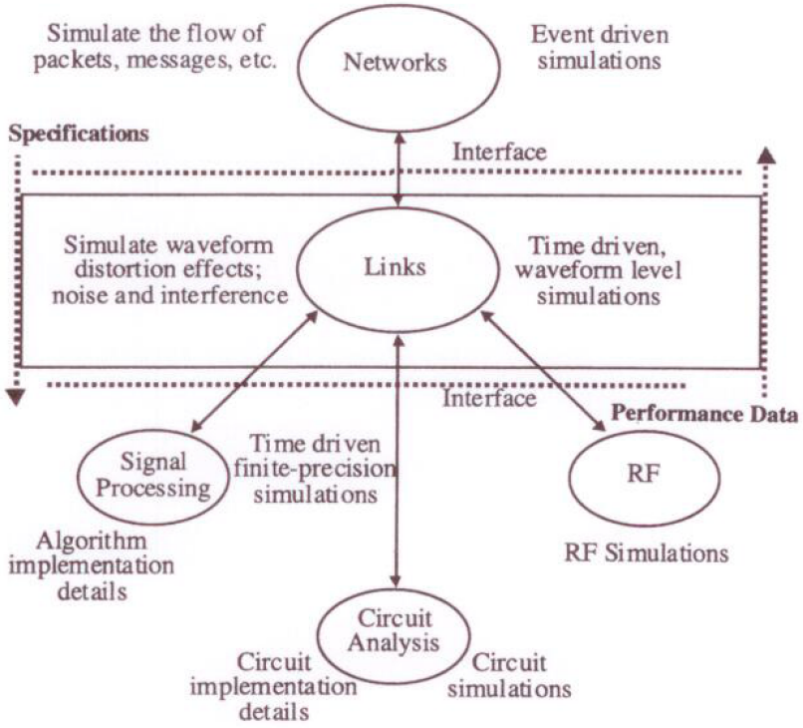
Methods of Performance Evaluation

- **Simulation-based approaches**

- Systems can be modelled with almost any level of detail desired
- Can combine mathematical and empirical models and incorporate measured characteristics of devices into analysis and design
- Can be used to create a rapid prototyping environment for analysis and design of communication and signal processing systems
- Software models can be combined with hardware data and real signals to produce designs that are timely, cost-effective and error-free
- The primary disadvantage is the computational burden

Hierarchical View

- "Communication system" might refer to a global communication network, a geosynchronous communication satellite, a terrestrial microwave transmission system or a modem in a PC
- A hierarchical view that is often used is:



← A demo by RC

← Labs

Hierarchical View

- At the network level the flow of packets and messages over the network is simulated using an event-driven simulator with performance measures such as throughput, delay and resource utilisation etc

- Communication links deal with the transmission of information-bearing waveforms over different types of channels (space, optical fibres etc)

- For digital transmission systems, the performance of communication links is measured in terms of bit error rate which is estimated by simulating the flow of waveforms using models for functional blocks such as modulators, encoders, channels, filters, amplifiers and etc

Hierarchical View

- The bottom layer deals with implementation of components such as filters and equalisers using either analogue or digital technologies
- Circuit simulators like Spice or digital simulators like HDL (Hardware Description Language) are used to simulate, verify functionality, and characterise the behaviour of the components
- **The focus of this course** is on waveform-level simulation of communication links and some on network-level simulation

The Application of Simulation to the Design

- Simulation can play an important role during all phases, from the early stages of conceptual design to implementation and testing
- The design typically has top-level specifications such as rate
- The performance is governed by two important factors: (1) the SNR and (2) the accumulated signal distortions
- The designer starts with a candidate system and a list of parameters
- During the early phase of the design, estimates of SNRs and signal degradations are obtained using simpler models & educated guesses

The Application of Simulation to the Design

- If the initial design produces candidate systems that meet performance objectives, then proceeds to the next phase; otherwise repeats
- The next design phase is the development of detailed specification for subsystems and components and verification of signal distortions
- Simulation is flexible and efficient and is often the only method available for performing trade-off studies and establishing detailed specifications for hardware development
- If simulations produce satisfactory values for performance objectives then the remaining hardware components are built and a prototype hardware for the entire system is “wired together” and tested

Computer Software Technologies

- The current generation of simulation software packages (SPW, COSSAP, **MATLAB**/SIMULINK, NS2 and many others) offer interactive, graphical and user-friendly frameworks for developing simulation models in a hierarchical fashion (you can do almost everything you can think of)

- These tools also provide database management, online help, online documentation and other services and features

- While the simulation frameworks are powerful, attention is now focused on important issues such as modelling and simulation techniques, estimation of performance measures and computational efficiency