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Unit II

Random Number Generation

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Unit II

- GPSS:
  - Model Structure
  - Entities and Transactions
  - Blocks in GPSS
  - Process Oriented Programming
  - User Defined Functions
  - SNA
  - Logic Switches
  - Save Locations
  - User Chains
  - Tabulation of Results
  - Programming examples

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Unit II

- Random Number Generation:
  - Congruence Generators
  - Long Period Generators
    - Combined Linear Congruential Generators
  - Uniformity and
  - Independent Testing

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What is True Random Numbers?

Random Numbers

generated using unpredictable

physical processes

are called

Truly Random Numbers.

Unpredictable Physical Processes:

thermal or atmospheric noise,
photoelectric effect, radio-active decays etc.

True Random Vs. Pseudo Random Numbers

Truly Random :- is defined as exhibiting ``true'' randomness.

Pseudo Random :- is defined as having the *appearance* of randomness, but nevertheless exhibiting a specific, repeatable pattern.

True Random Vs. Pseudo Random Numbers

As digital computers are deterministic machines, they are incapable of generating random numbers.

Instead they generate large cycles of pseudo-random numbers (i.e.) numbers which will pass most of the statistical tests for randomness.

Computer-generated "random" numbers are more properly referred to as *pseudorandom numbers*, and *pseudorandom sequences* of such numbers.

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Can a computer generate Truly Random Numbers?

Numbers calculated by a computer through a deterministic process, cannot, by definition, be random.

On a completely deterministic machine we can't generate anything we could really call a random sequence of numbers, because the machine is following the same algorithm to generate them.

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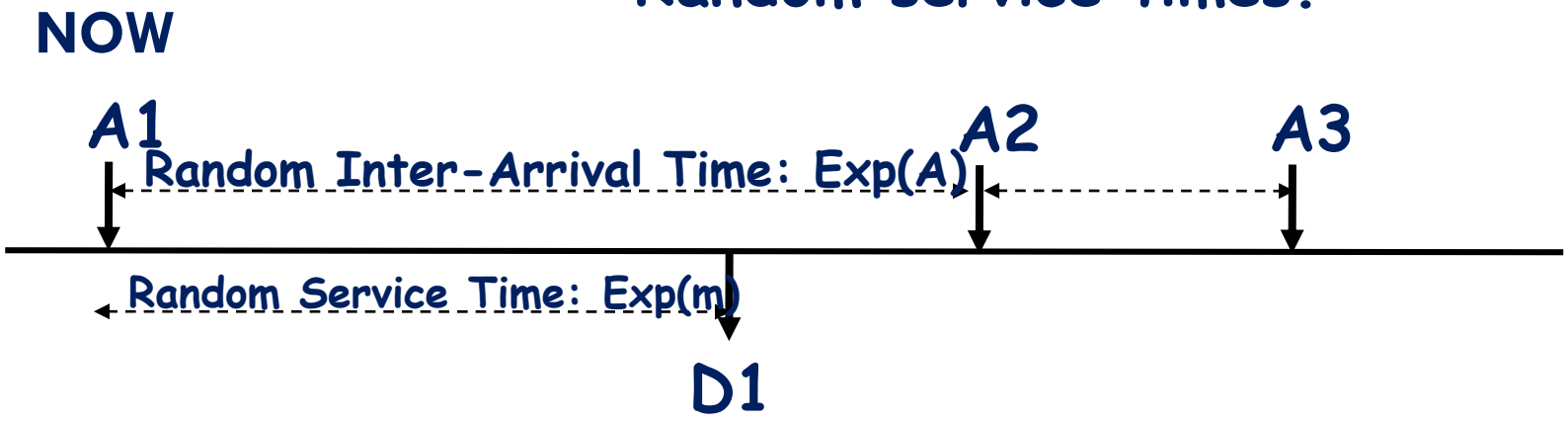
Why Random Number Generators?

Random Numbers: are needed for doing simulations

Random Inter-arrival times.

Random service times.



Random numbers must be Independent (unpredictable).

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Why Random Number Generators?

Usage of Pseudorandom Numbers

Network Security:

Almost all network security protocols rely on the randomness of certain parameters.

Monte Carlo Simulations:

Randomly generates scenarios for collecting statistics.

Characteristics of Good Random Number Generator

1. Uniformity
2. Independence (Uncorrelated Sequence)
3. Replication
4. Cycle length
5. Speed (Efficiency)
6. Memory usage

Characteristics of Good Random Number Generator

1. Uniformity

The number should appear to be distributed uniformly on [0,1] and should not exhibit any correlation.

The sequence of random numbers should be uniform, and unbiased.

That is, equal fractions of random numbers should fall into equal ``areas'' in space.

For Example:

if random numbers on [0,1) are to be generated, it would be poor practice were more than half to fall into [0, 0.1), presuming the sample size is sufficiently large.

Characteristics of Good Random Number Generator

2. Independence (Uncorrelated Sequence)

The numbers generated show no correlation with each other.

The sequences of random numbers should be serially *uncorrelated*

Characteristics of Good Random Number Generator

3. Replication

The numbers should be replicable.

Given the starting point, it should be possible to generate the same set of random numbers, completely independent of the system that is being simulated.

Example: for debugging or comparison of different systems).

Characteristics of Good Random Number Generator

4. Cycle length

Have sufficiently *long cycle*.

It should take long before numbers start to repeat.

The *cycle length*, or *period* represents the length of random number sequence before previous numbers begin to repeat in an earlier order.

Characteristics of Good Random Number Generator

4. Cycle length or Period should be long (Long Period)

   Ideally, the generator should not repeat; practically, the repetition should occur only after the generation of a very large set of random numbers

Characteristics of Good Random Number Generator

5. Speed (Efficiency)

The generator should be fast. (Why?)

Individual computations are inexpensive, but a simulation may require many millions of random numbers

Characteristics of Good Random Number Generator

6. Memory usage

   The generator should not require a lot of storage.

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Terminology

Period: number of elements before the first repeat

1,6,15,12,13,2,11,8,9,14,7,4,5,10,3,0,
1,6,15,12,13,2,11,8,9,14, ..

Here period=16

Long Period: Longest possible period.

Full Period: The sequence containing all possible numbers is called a full-period sequence .

Terminology

Full Cycle

A pseudo-random number generator is said to be full cycle if it leaves no gaps in the range of numbers it generates.

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Terminology

(0,1): Open interval does not include its end-points

Means greater than zero and less that 1

[0,1]: Close interval includes its end-points

Means greater than or equal to 0 and less that or equal to 1

[0,1): Half- closed interval –closed at beg and open at end.

Means greater than or equal to zero and less than 1

(0,1]: Half-closed interval-Open at beg and closed at end.

Means greater than zero and less than or equal to 1

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Questions

- Describe the characteristics of good random generator.
- Explain the term maximum density with respect to random number generation.
- Use Linear congruential Generator Method to generate a sequence of random number, X_0=27, a=13, c=37 and m=100 for i=0 to 7
- What is the method for testing random number generation of non-uniformity distributed random numbers?

Questions

- Consider 20 two digits value. Use chi-square test with $\alpha=0.005$ to test whether the data are uniformly distributed where $X_{0.05,\ 9}=16.9$.
- Explain any two long period Generators in detail.
- What do you understand by Poker Test for independence testing?