Experiences with the ns-2 Network Simulator
Explicitly Setting Seeds Considered Harmful

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Overview
- The ns-2 RNG
- Examples:
  - Correlation Experiment
  - Wired Topology Example
  - Wireless Example
- Impact on Real-world Simulations
- How to Avoid

The ns-2 RNG
- ns-2 versions <= 2.1b8: old RNG
  Minimal Standard multiplicative Linear Congruential Generator [Park and Miller, 1988]
  Period \( p=2^{31}-2 \)
  API: \$rng seed \$s;
  Sensitive to seeds [Entacher, Hechenleithner, 2002]
- ns-2 versions >= 2.1b9 until today: new RNG
  MRG32k3a [L’Ecuyer, 1999]
  Period \( p = 3.1 \times 10^{37} \)
  API: \$rng next-substream;
  Promises to fix seed-sensitivity

Correlation Experiment
- Set up 3 RNGs – old method:
  ```
  for {set i 0} {$i < 3} {incr i} {
  set rng($i) [new RNG]
  $rng($i) seed $n($i)
  set u($i) [new RandomVariable/Uniform]
  $u($i) use-rng $rng($i)
  }
  ```
- Draw triplets of values \$u($i) from \$rng($i)
- Interpret as vector \(<u(1), u(2), u(3)>\)
- Sets of Seeds:

<table>
<thead>
<tr>
<th>Set 1</th>
<th>Set 2</th>
<th>Set 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973272912</td>
<td>1764399534</td>
<td>1376804624</td>
</tr>
<tr>
<td>1822174485</td>
<td>1564297937</td>
<td>1764399534</td>
</tr>
<tr>
<td>1998078925</td>
<td>2743561517</td>
<td>3456789012</td>
</tr>
</tbody>
</table>

Expected Result for Uniform Values

1,000,000 triplets drawn

Expected Result for Uniform Values

100,000 triplets drawn
Expected Result for Uniform Values

10,000 triplets drawn

Expected Result for Uniform Values

1,000 triplets drawn

Result for bad Seed Set 2

Old RNG /w bad seed set
New RNG /w old method & bad seed set

10,000 triplets drawn

Result for bad Seed Set 3

Old RNG /w bad seed set
New RNG /w old method & bad seed set

10,000 triplets drawn

Wired Topology Example / 1

Exponential On/Off-Traffic:
On: 0.08µs / 1 pkt / 1000bytes
Off: 41ms

BW=1 Mbps
QS=1000 Packets

Expected mean queue length:

\[
\bar{q} = \frac{\rho^2}{1 - \rho} - \frac{2\rho^2}{2(1 - \rho)} = 26.48\text{ pkt/s}
\]

Simulation time 7200s
Sampling time 10ms

Wired Topology Example / 2

Seed Set 1
Seed Set 2

Seed Set 1
Seed Set 2

Good
Bad

Expected: 20.48

New RNG
New method
20.2996

New RNG
Set 2 - bad
20.4527

Old RNG
Set 1 - good
19.4398

Old RNG
Set 2 - bad
24.2785

Expected: 20.488
Wireless Example / 1

Simulation time 600s

Run lengths vs. burst lengths:

Wireless Example / 2

- New RNG / old method / bad seed
  - $rng1$ seed 1;
  - $rng2$ seed 2;
  - $rng3$ seed 3;

  VS.

- New RNG / new method
  
  ```
  for {set i 1} {$i < $rep} {incr i} {
    $rng1 next-substream;
    $rng2 next-substream;
    $rng3 next-substream;
  }
  ```

Wireless Example / 3

Old method, bad seed set 2

REPs 1-10 of new method

Impact on Real-world Simulations

Postings on ns-users mailing list (2005, 2006)

- Advice or example incorrectly using old method: 22
- Correct advice in response to seeding question: 2
- Example containing correct method in other context: 7
- Ambiguous example or advice: 4
- Advice to use consecutively numbered seeds: 2

28 incorrect vs. 9 correct!

Results affected if

- Seeds are chosen badly (eg. 1, 2, 3,...)
- Several RNG objects used

How to Avoid

- Do NOT use:
  ```
  $rng$ seed <value> where <value> <= REP
  ```

- Only USE:
  ```
  for {set i 1} {$i < $rep} {incr i} {
    $rng1 next-substream;
    $rng2 next-substream;
    $rng3 next-substream;
  }
  ```

- Optionally:
  ```
  global defaultRNG;
  $defaultRNG seed <value>
  ```

Thank You!