Software Testing, Quality Assurance and Maintenance	Winter 2015
Lecture 7 — January 19, 2015	
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Further properties of paths

We've seen so far length-0 (NC), length-1 (EC) and length-2 (EPC) paths. We could keep on going, but that gets us to Complete Path Coverage (CPC), which requires an infinite number of test requirements.

Criterion 1 Complete Path Coverage. *(CPC)* TR *contains all paths in* G.

Note that CPC is impossible to achieve for graphs with loops.

Instead of going to CPC, we would like to capture "the essence" of all loops. To do so, we first set up a few definitions:

Definition 1 *A path is* simple *if no node appears more than once in the path, except that the first and last nodes may be the same.*

In the graphs above, some simple paths are:

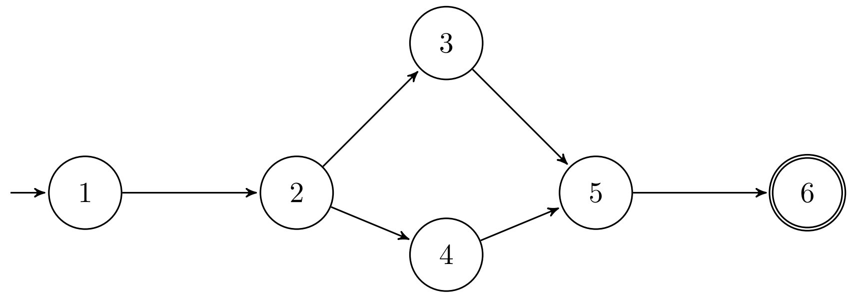
but not:

Some properties of simple paths:

- no internal loops;
- can bound their length;
- can create any path by composing simple paths; and
- many simple paths exist (too many!)

Because there are so many simple paths, let's instead consider *prime* paths, which are simple paths of maximal length.

For instance, in the following graph:



- Simple paths:
- Prime paths:

Definition 2 *A path is* prime *if it is simple and does not appear as a proper subpath of any other simple path.*

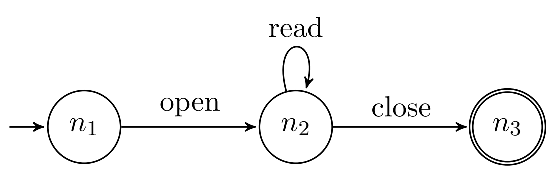
Criterion 2 Prime Path Coverage. *(PPC)* TR *contains each prime path in G.*

There is a problem with using PPC as a coverage criterion: a prime path may be infeasible but contain feasible simple paths.

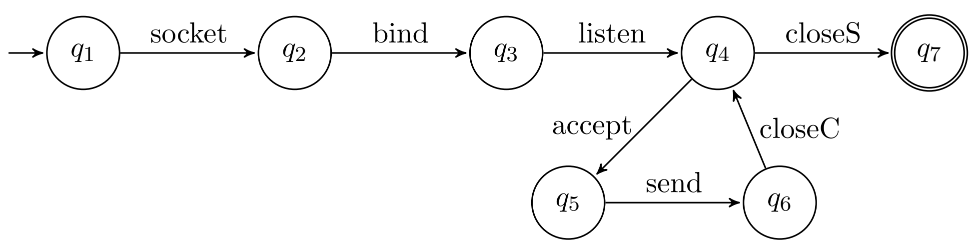
Example:

One could replace infeasible prime paths in TR with feasible subpaths, but we won't bother.

Beyond CFGs. Let's now move beyond control-flow graphs and think about a different type of graph. The next few graphs represent finite state machines rather than control-flow graphs. Our motivation will be to set up criteria that visit round trips in cyclic graphs.



or perhaps



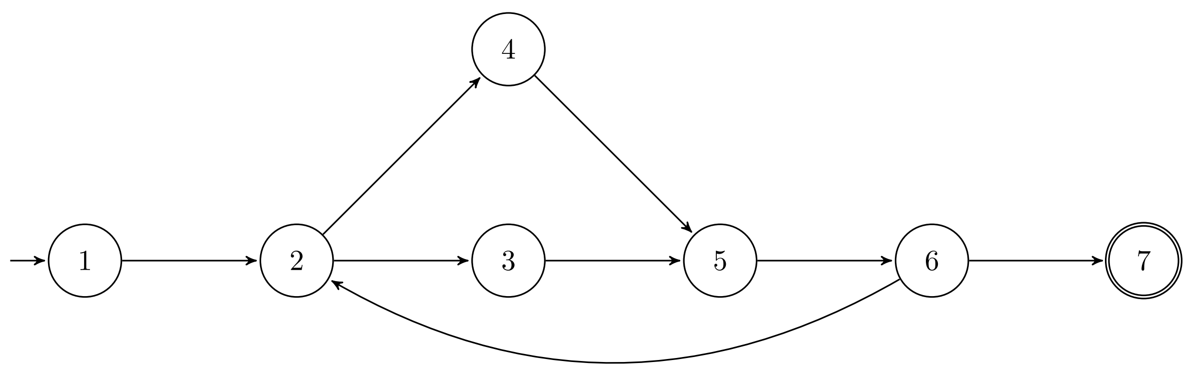
Prime paths apply to both CFGs and other graphs. The next criteria are mostly not for CFGs.

Definition 3 *A* round trip *path is a prime path of nonzero length that starts and ends at the same node.*

Criterion 3 Simple Round Trip Coverage. *(SRTC)* TR *contains at least one round-trip path for each reachable node in G that begins and ends a round-trip path.*

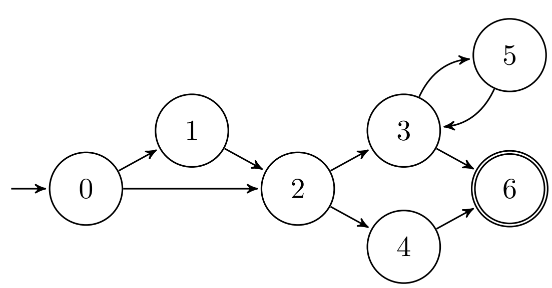
Criterion 4 Complete Round Trip Coverage. *(CRTC)* TR *contains all round-trip paths for each reachable node in G.*

Exercise: Computing Prime Paths. Last time, we saw this graph:



I recommend computing all of the simple paths for this example. (There are 53 simple paths, with length up to 5, and 12 prime paths.) Hint: write out simple paths of length up to N. To get the simple paths of length $N+1$, start with the paths of length N and extend the ones that are extendable; the non-extendable paths are prime, so mark them as you go along.

Here's another graph:



This graph has 38 simple paths and 9 prime paths:

$$[0,1,2,3,6], [0,1,2,4,6], [0,2,3,6], [0,2,4,6], [0,1,2,3,5], [0,2,3,5], [5,3,6], [3,5,3], [5,3,5].$$

To compute the prime paths, we could also enumerate all of the simple paths and note non-extendable paths and cycles (which are both prime). In doing so, one would also get all of the information necessary to write out the test requirements for NC, EC and EPC. Since there is a loop, it is impossible to explicitly write out all test requirements for CPC, but one could write out some of them.