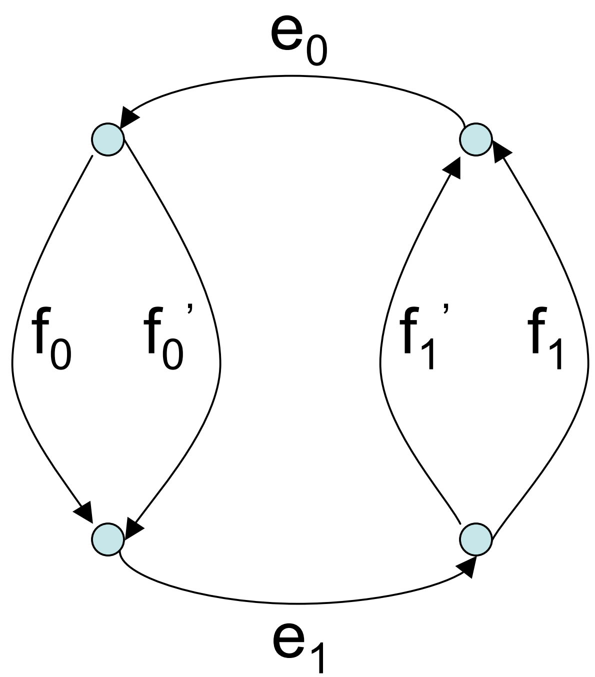
Demonstrating the Instability of FIFO

(from the paper by Andrews et al).



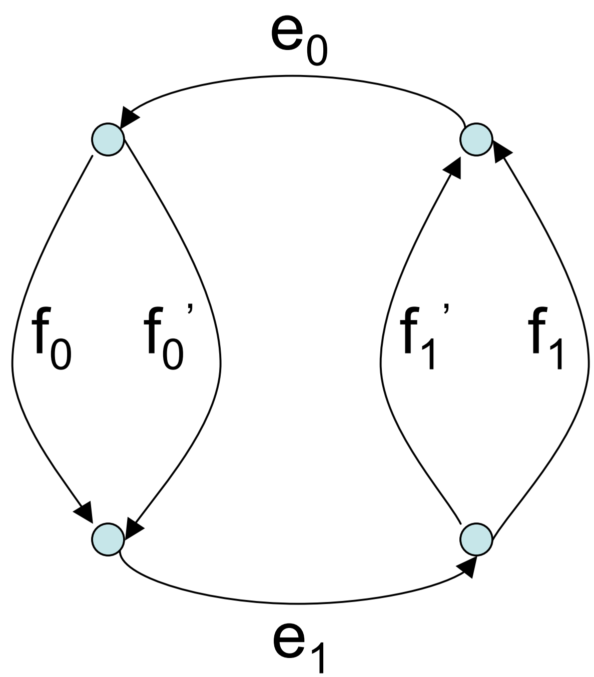
Assume:

1) adversary of rate r

2) s packets are waiting at e_0

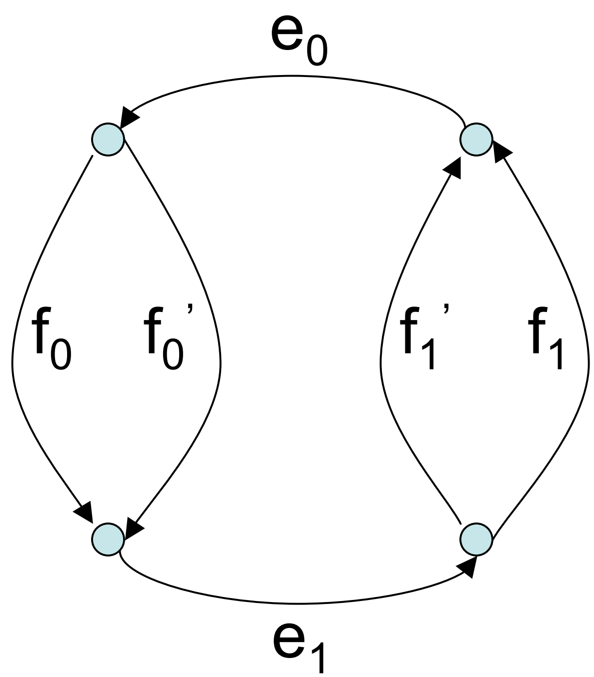
PHASE	1
PACKETS WAITING	s, of type e_0
PHASE DURATION	s
PACKETS INJECTED	rs, of type $e_0f_0e_1$
PACKETS WHICH MOVE	e_0
PACKETS WHICH REMAIN	rs, of type $e_0f_0e_1$

Red edge denotes current location of packets



Fact: If a stream of rate r_1 merges with a stream of rate r_2 in a FIFO queue then the streams get forwarded at rates $r_1/(r_1+r_2)$ and $r_2/(r_1+r_2)$ respectively

PHASE	2
PACKETS WAITING	rs, of type $e_0f_0e_1$
PHASE DURATION	rs
PACKETS INJECTED	r^2s, of type $e_0f_0'e_1$ r^2s, of type f_0
PACKETS WHICH MOVE	$rs(r/(1+r))$, of type f_0 $rs/(1+r)$, of type $e_0f_0e_1$
PACKETS WHICH REMAIN	$r^3s/(1+r)$, of type f_0 [IGNORE] $r^2s/(1+r)$, of type $e_0f_0e_1$ r^2s, of type $e_0f_0'e_1$



If r > 0.85, then $r^3 + r^2/(1+r) > 1$

More than s packets waiting at e_1

Can repeat to get unbounded queue sizes

PHASE	3
PACKETS WAITING	$r^2s/(1+r)$, of type $e_0f_0e_1$ r^2s, of type $e_0f_0'e_1$
PHASE DURATION	r^2s
PACKETS INJECTED	r^3s, of type e_1
PACKETS WHICH MOVE	Doesn't matter
PACKETS WHICH REMAIN	Effectively $r^3s + r^2s/(1+r)$, of type e_1