

# Using Self-interest to Prevent Malice

## Fixing the Denial of Service Flaw of the Internet

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# context & problem

defend against what attackers *could* do  
not what they do  
need to win the last battle  
not just the next one

- infrastructure must serve v large population
  - even during genuine flash crowds of demand
- most cost-effective attack: flood requests during flash crowd
  - when most people need/value a service most
  - when least effort needed to tip it over the edge
- assume virus-prone end systems won't go away
  - cell phones, TVs, MP3 players, game boxes, domestic control systems
- attackers can amass 100,000s into zombie botnets
  - can and do saturate even the biggest links in the Internet at will

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- other approaches all try to detect attack traffic
  - then block future attempts from same source address
  - they need to stop attackers faking different source addresses for each packet
  - still problem with floods of single packets
  - with this mindset, researchers have defined success as
    - forcing an attacker to imitate a flash crowd



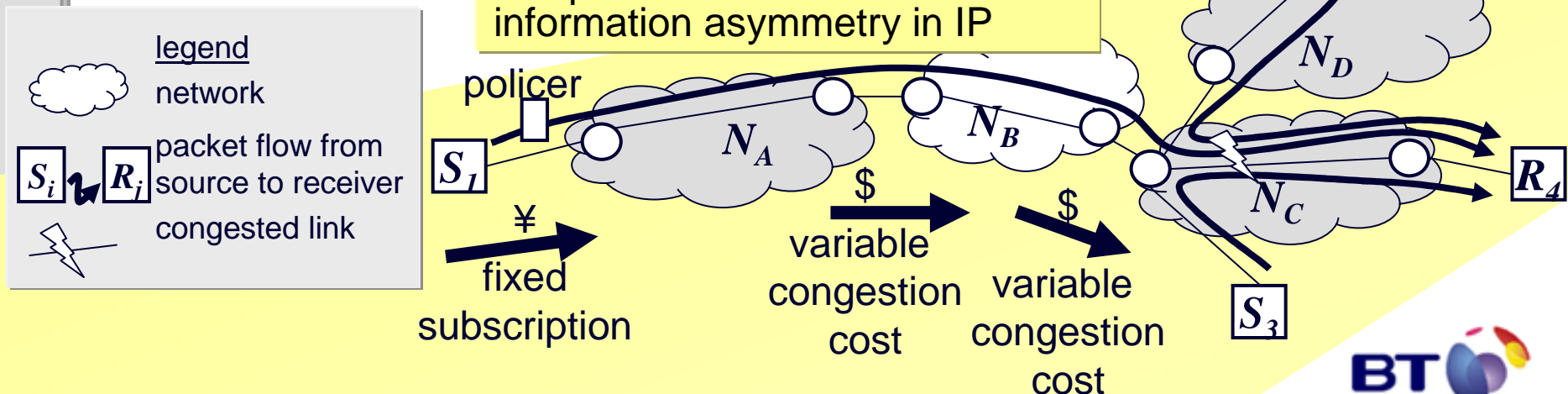
# status

- one result of 3yrs research to fix Internet architecture
  - prime directive: don't unduly restrict Internet's ability to foster surprises
  - fixed Internet resource sharing – DDoS fix a pleasant consequence
- plan to do whatever it takes to standardise into IP
  - 2005 full standards specs drafted
    - been progressing them through IETF
  - propose to use last undefined bit in IP packet header
    - we don't underestimate the task ahead
- huge effort trying to pervert protocol
  - two major flaws successfully fixed without additional complexity
- seeking wider collaboration
  - co-operative or adversarial

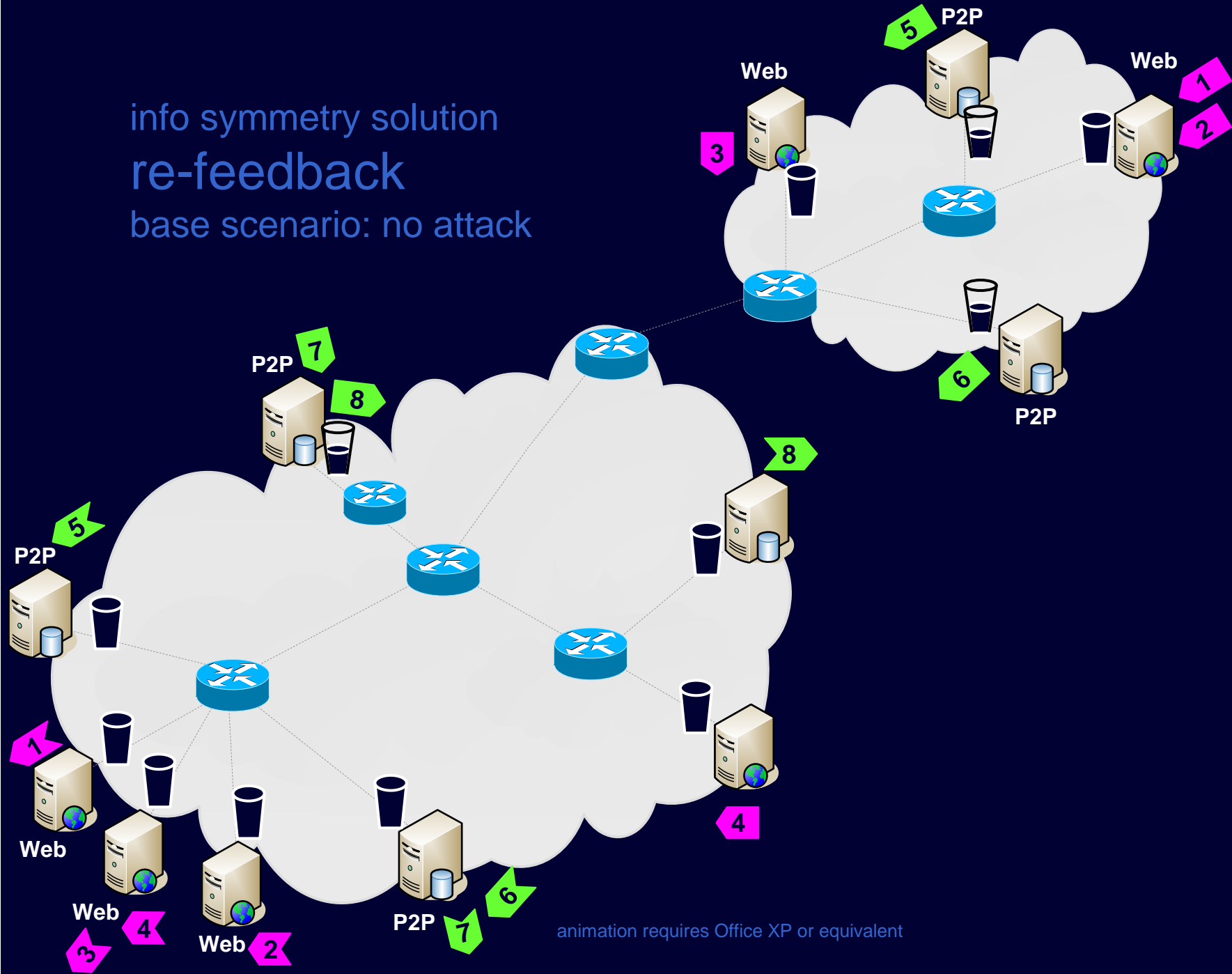
# approach

- fix generic IP layer first
  - will raise the bar (increasing attacks on higher layer vulnerabilities)
- treat DoS for what it is: extreme congestion – an externality
- genuine sources should slow down in response to congestion
  - voluntary response inherent to current Internet design
  - persistently sending fast into high congestion is never genuine behaviour
  - ★ don't need to judge good/bad, ISP can just force response to congestion
  - ★ stability of Internet depends on congestion response anyway
- ★ designers don't mandate congestion response, each ISP does
  - ★ market decides
  - ★ but relevant ISP liable for externality if it doesn't act
- ★ focus on liabilities between networks
- ★ enforce liability for congestion externality, but recursively
  - ★  $N_B$  liable for congestion it lets into  $N_C$  and onward
  - ★  $N_A$  liable for congestion it lets into  $N_B$  and onward

★ requires solution to an inherent information asymmetry in IP



info symmetry solution  
re-feedback  
base scenario: no attack

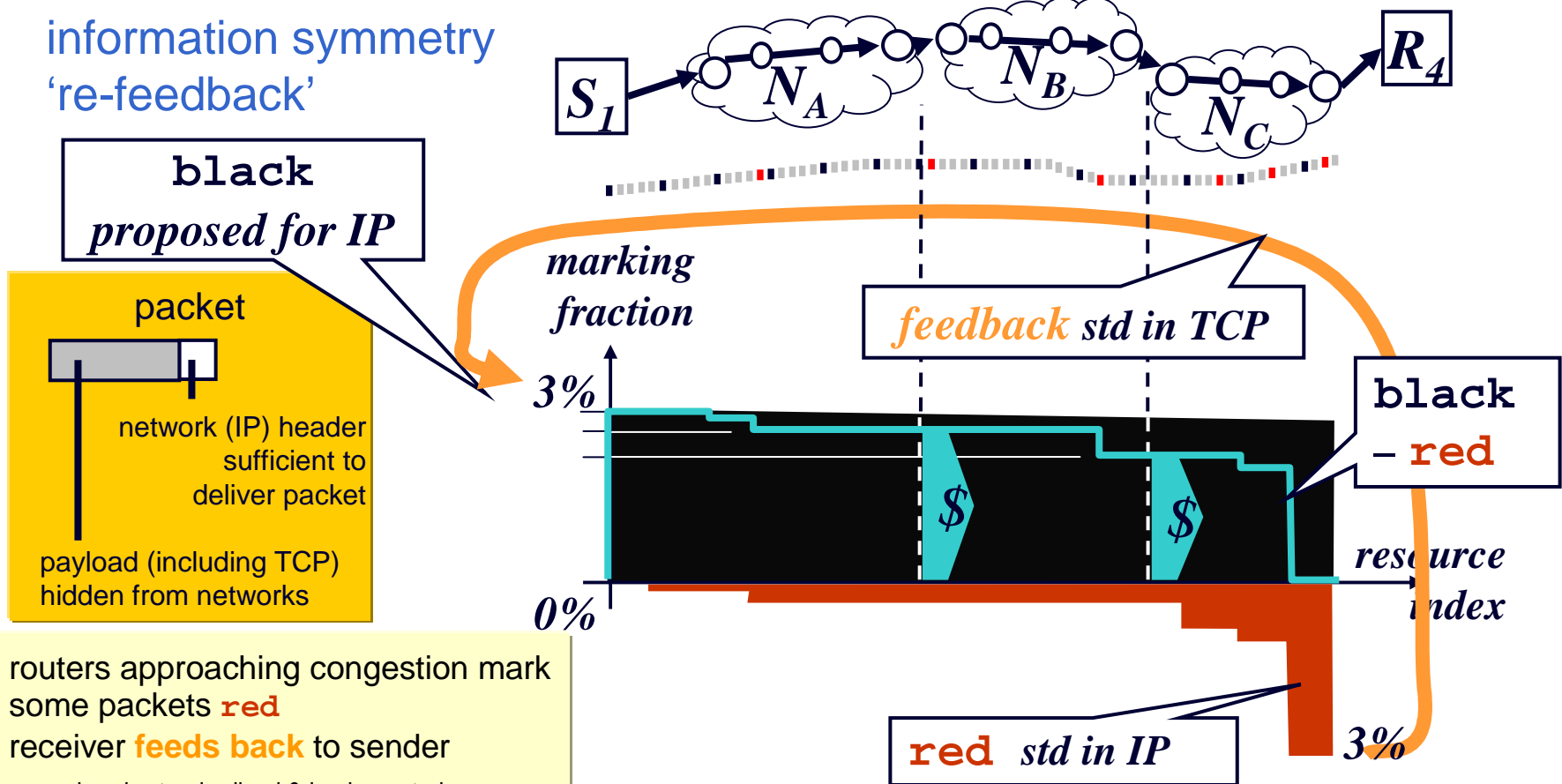


animation requires Office XP or equivalent

# solution

information symmetry  
're-feedback'

- currently  $N_A$  contracts with  $N_B$  to deliver packets but without information about  $N_B$ 's quality (congestion)
- $S_1$  has this information, so make it reveal it



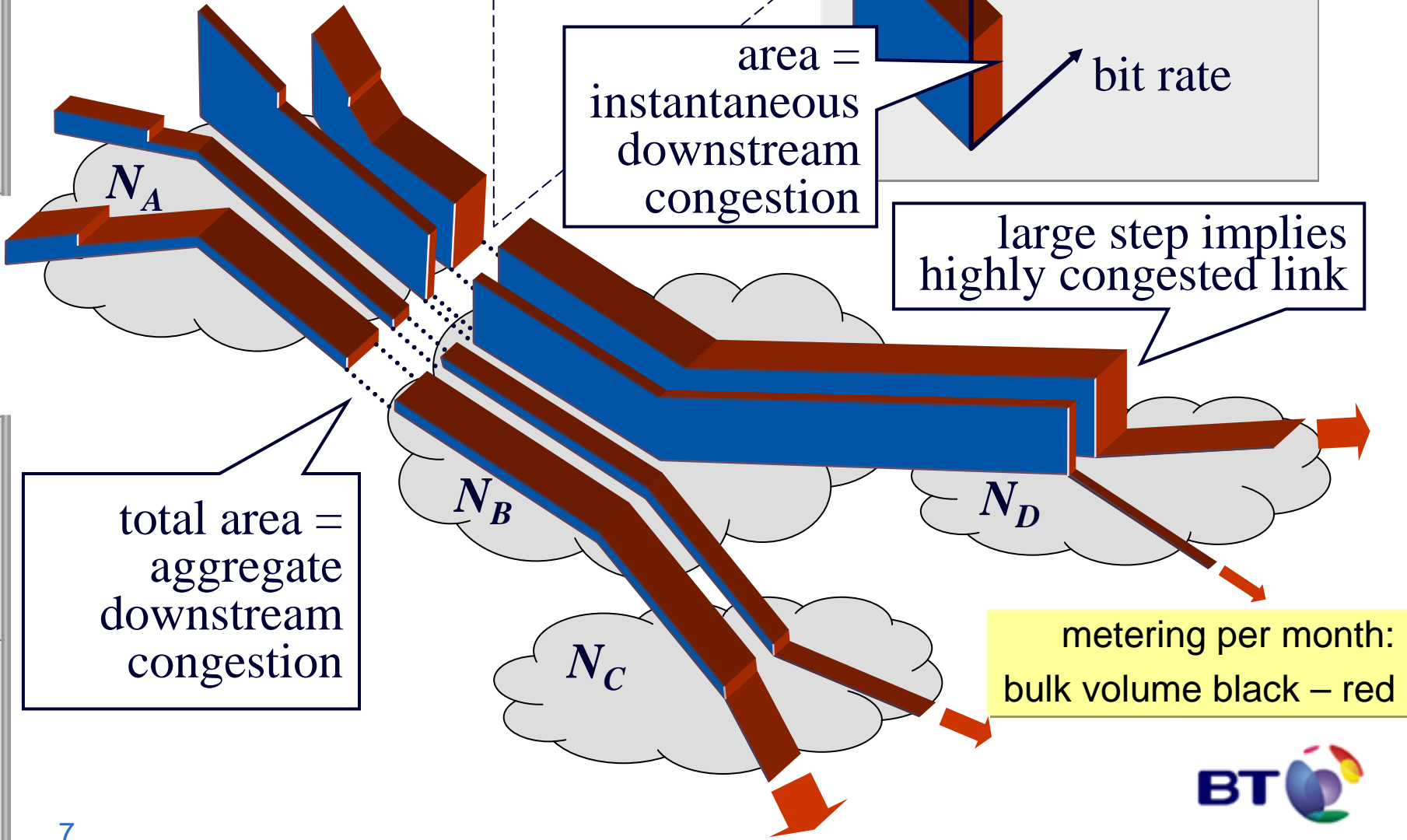
- routers approaching congestion mark some packets **red**
- receiver **feeds back** to sender
  - already standardised & implemented
  - not generally turned on by operators
- sender re-inserts **feedback** by marking packets **black**
  - **re-feedback** requires standardisation

- flows get no further than their 'fare' pays for
- routers discard persistent negative balance



# aggregation

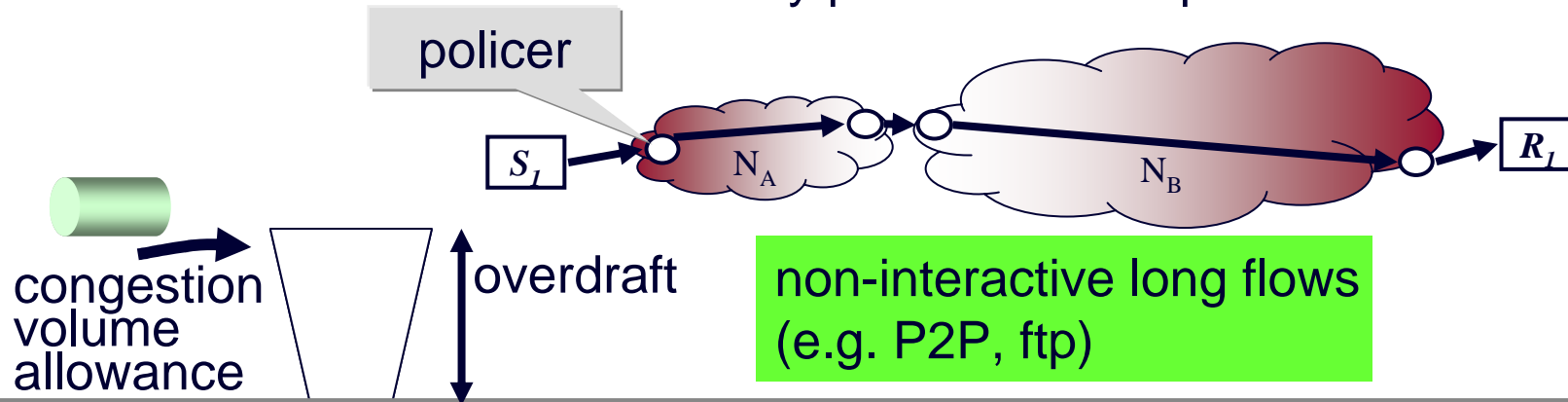
internalisation of externalities



# congestion policer

base scenario: no attack

one example: per-user policer  
many possibilities – up to ISPs



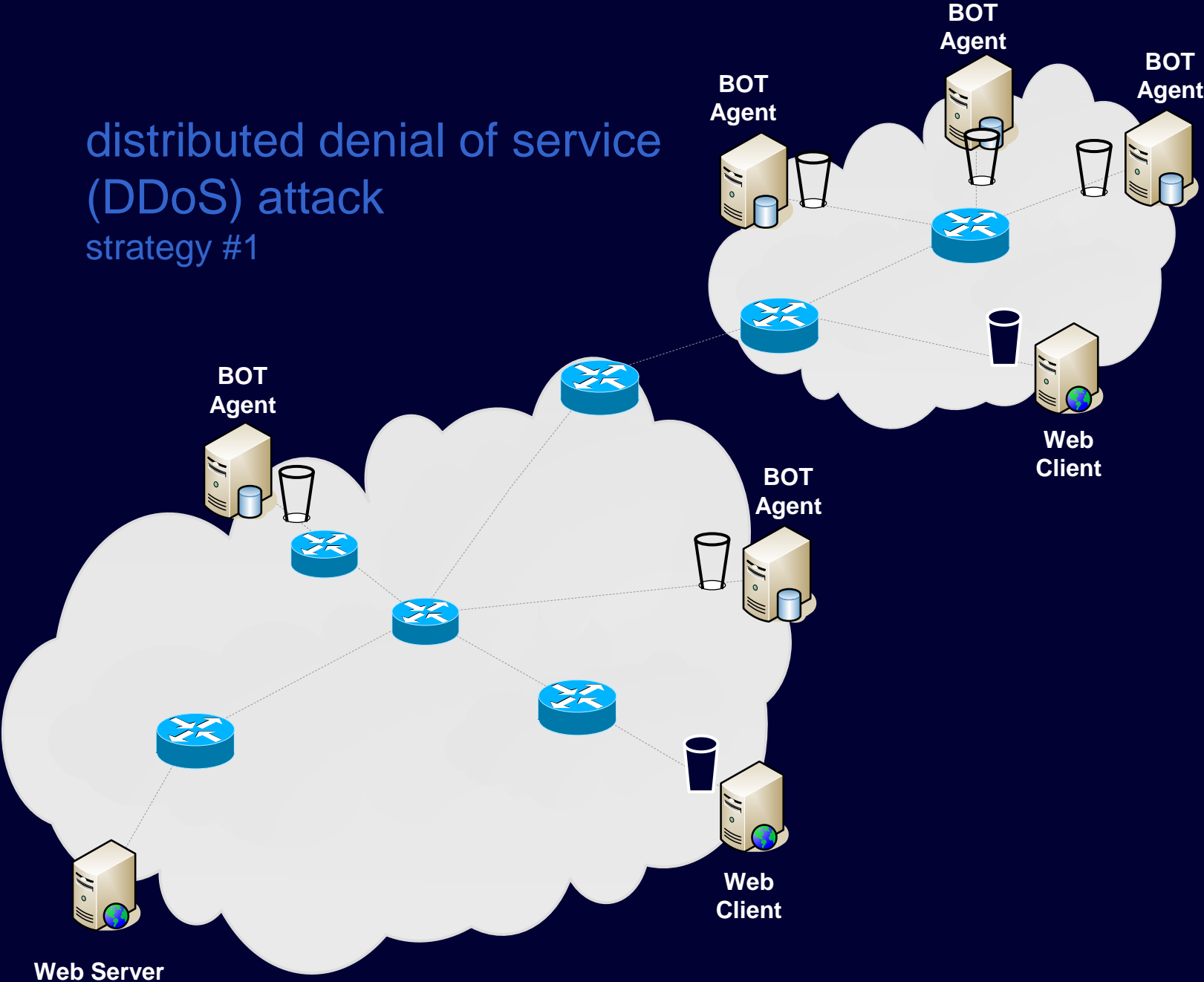
two different customers, same deal

animation requires Office XP or equivalent





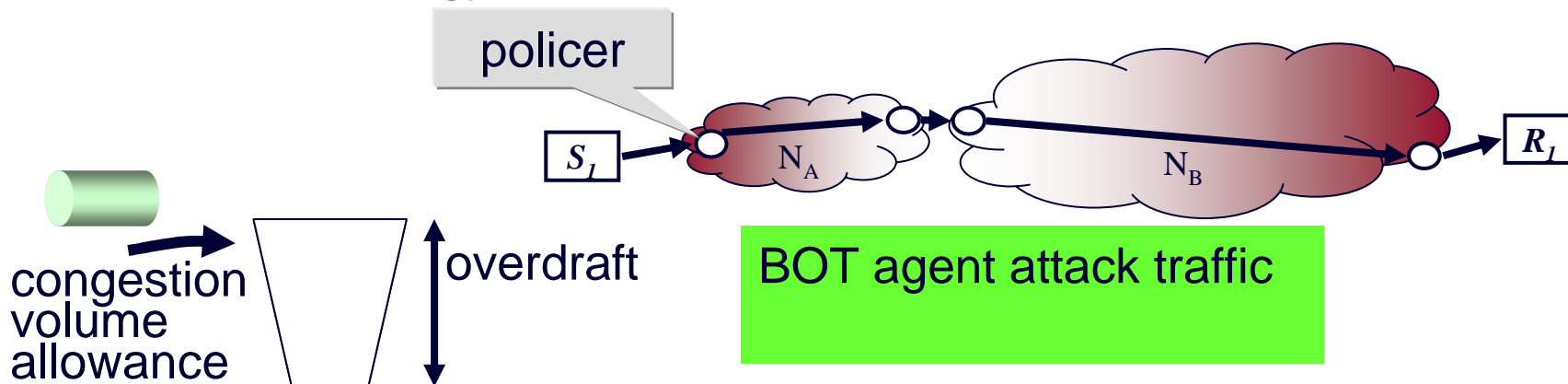
distributed denial of service  
(DDoS) attack  
strategy #1



animation requires Office XP or equivalent

# per-user congestion policer

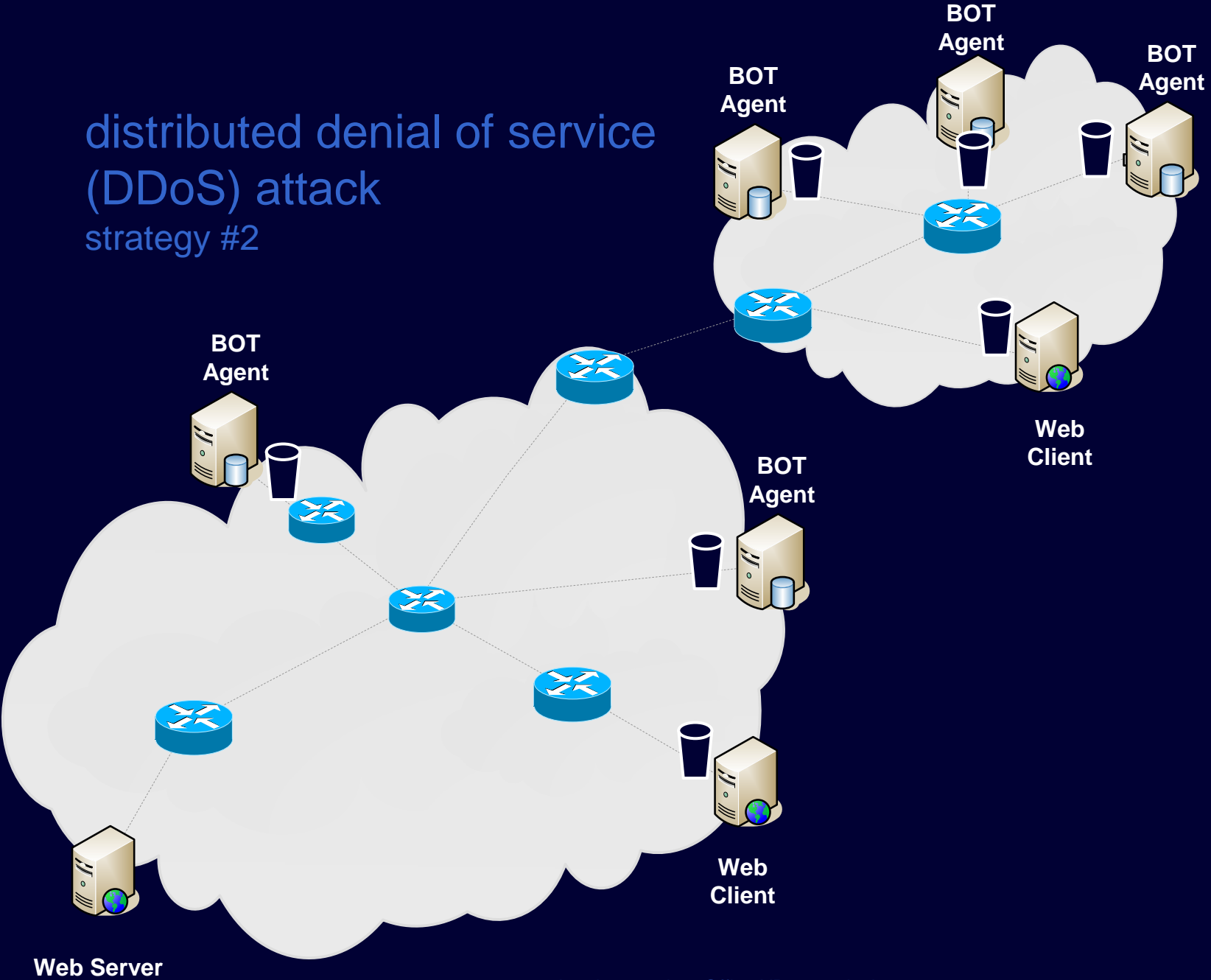
DDoS attack strategy #1



animation requires Office XP or equivalent



distributed denial of service  
(DDoS) attack  
strategy #2



animation requires Office XP or equivalent

# will re-feedback prevent DDoS? ≡ will it be deployed widely enough?

- deployment bootstrap incentives
- deployment closure incentives
  - doesn't have to finish the job itself
  - can create right incentives to deploy complementary solutions
- once fully deployed, winning the war
  - distinguishing genuine flash crowd from simultaneous attack



# deployment bootstrap incentives

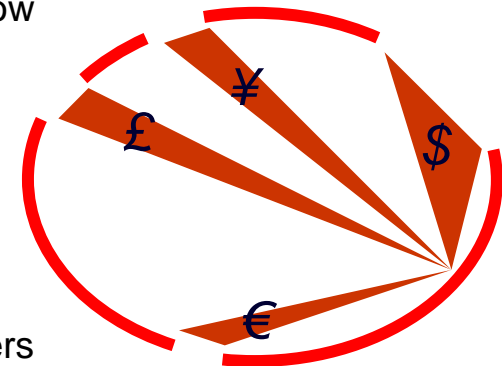
- deployment effectively involves architectural change
  1. (minor) change to sender's Internet stack
  2. network deploys edge/border incentive functions
- preventing gridlock between these actors requires strong incentives

# deployment bootstrap incentives

- ★ bundling with itself
    - re-feedback solves central cost control problem of ISPs
      - third party services competing with ISP pay below network cost
      - ISP has to compete *while* paying balance of competitor's costs
    - hits very big fear and button and greed button
    - but keeps moral high ground
      - net neutral and doesn't help lock-in or lock-out
    - re-f/b as a solution to DDoS bundled with re-f/b as cost-control
  - alliance deployment strategy
    - 3GPP alliance has most to lose from not deploying, followed by NGNs
    - controls vertically integrated network and mobile terminal market
  - ★ deployment by cross-infection
    - nomadic, roaming devices
  - ★ inverse bundling
    - can degrade a substitute product (legacy network service without re-feedback)
    - generally useful model for security products – tend to restrict rather than enhance
- 
- ★ novel deployment models wrt Ozment & Schechter

# deployment closure incentives

- assume 1<sup>st</sup> mover (cellular industry?) has deployed
- 2<sup>nd</sup> movers (NGNs?) didn't because benefit lower than cost (if rational)
  - but first mover removed costs (risks of unknown, R&D recovered)
  - early adopters also change operational finances for non-adopters...
- money valve effect
  - between adopters and non-adopters
  - re-feedback controls congestion costs for adopters
  - peaks in incoming traffic demand drive money inward
  - outgoing traffic peaks only generate averaged money flow
    - costs of non-adopters depend on peak not average
  - stronger effect, the more variance in demand
  - DDoS is extreme variance in demand
  - like alternating current through a diode/valve
- chain reaction
  - adopters' incoming border charges focus on non-adopters
  - bots concentrate into smaller non-adopter space
  - money valve effect surrounds more of non-adopters' borders



# winning the last battle (not just the next)

## distinguishing flash crowds from attacks

- incentives not to be too greedy
  - a rate policer is effectively a revenue limiter
  - if policer allows DDoS attacks, customer has to buy bigger quota
  - why would operators try to distinguish the two?
- customers will switch to responsible operators
  - distinguishing true demand from zombies is in operator's interest
- fortunately society still civilised enough
  - huge white market revenue not worth risking
    - just to capture marginal gains from black market
  - strategic greed overcomes myopic greed





Self-interest can Prevent Malice

Q&A



# incentive framework

downstream  
path  
congest-  
ion

