Firewall-on-Demand

GRNET's approach to advanced network security services' management via bgp flow-spec and NETCONF

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Contents

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Διασυνδέοντας την Έρευνα και την Εκπαίδευση

DDoS illustrated

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Διασυνδέοντας την Έρευνα και την Εκπαίδευση

DDoS illustrated

Attackers use zombies

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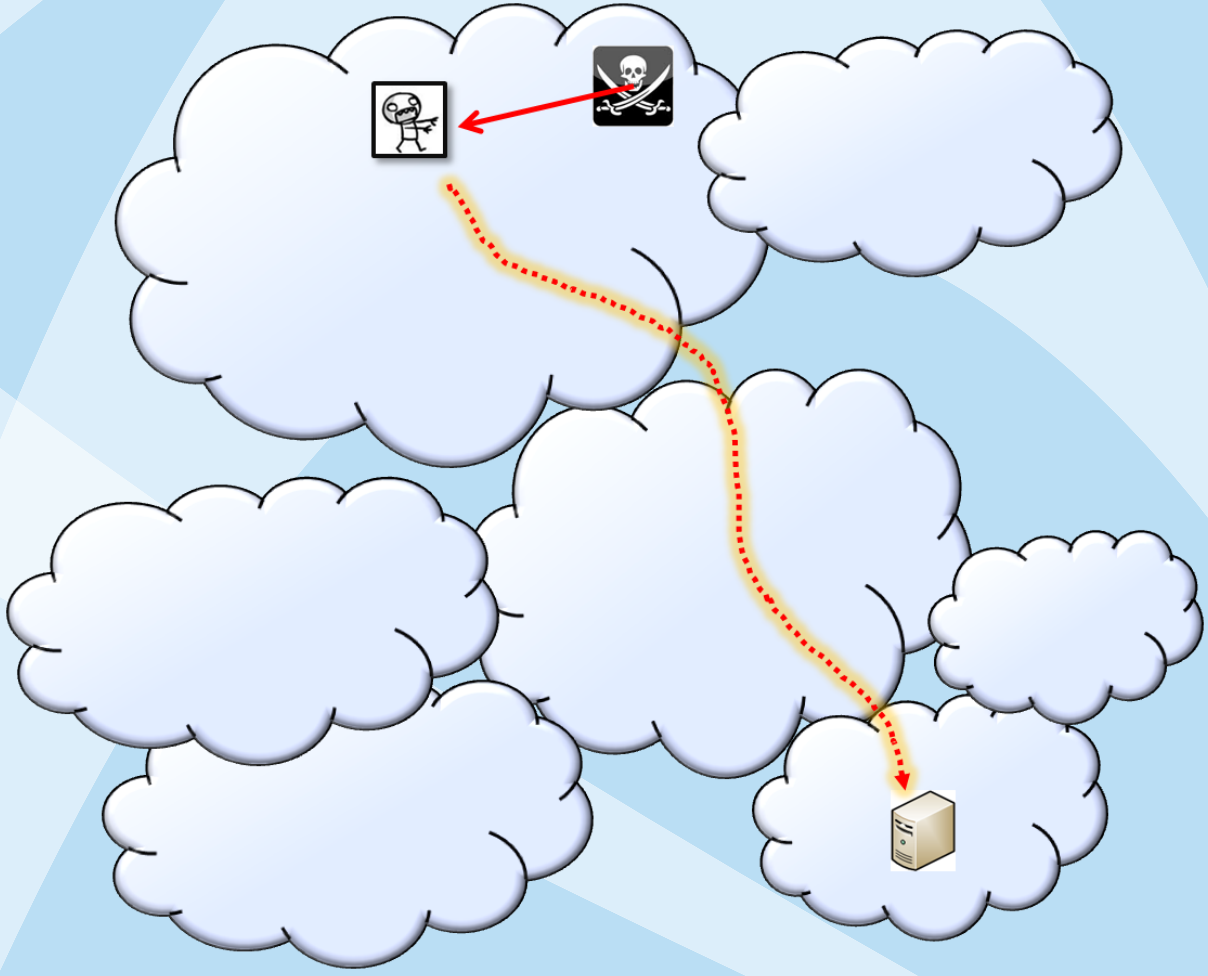
1 zombie:

Relative easy to handle



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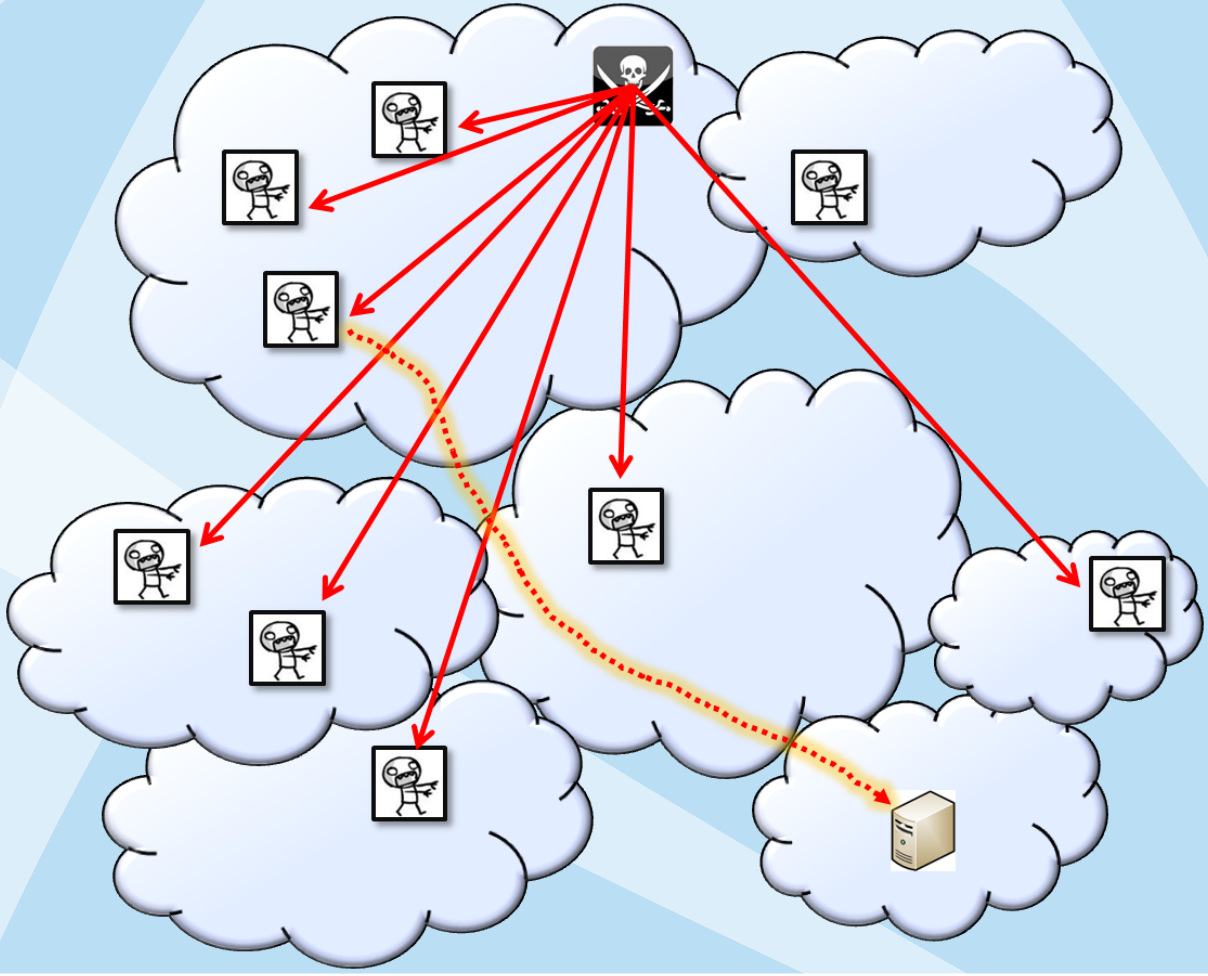
big problem



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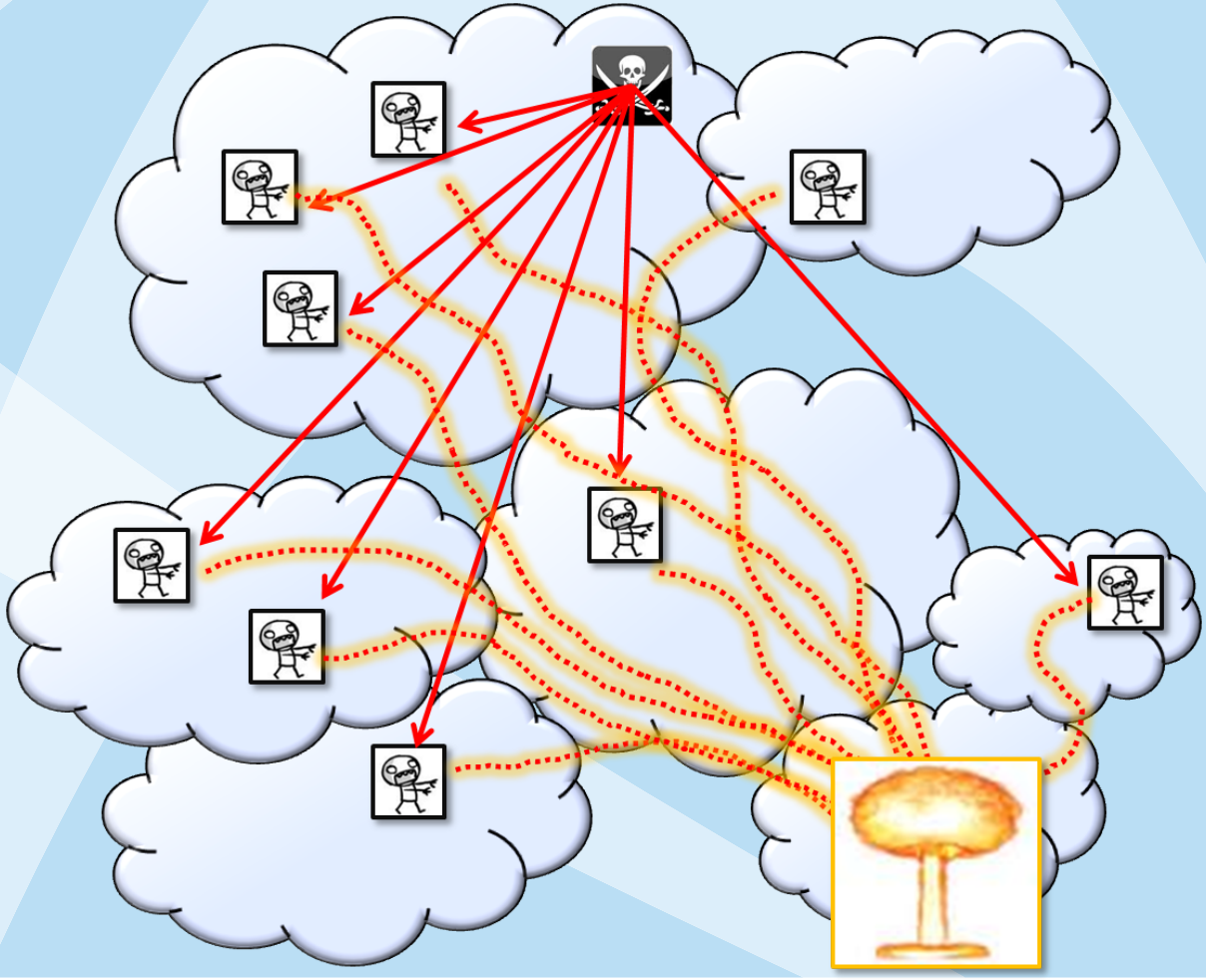

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Motivation

- Better tools to mitigate *transient* attacks and anomalies (eg DDoS, spambots, viruses, scans, ...),
- "Better" in terms of
  - **Granularity:** Per-flow level (Source/Dest IP/Ports, protocol type, DSCP, TCP flag, fragment encoding, ...),
  - **Action:** Drop, rate-limit, redirect,
  - **Speed:** quicker (seconds/minutes rather than hours/days)
  - **Efficiency:** closer to the source, multidomain
  - **Automation:** integration (eg IDS/IPS, log analyzers,...)
  - **Manageability:** UI, web, AAI

BGP FlowSpec

RFC 5575, August 2009: "Dissemination of flow specification rules with BGP"

Allows BGP to propagate an n-tuple filter with flow matching criteria and actions

- matching criteria: a combination of source/dest prefix, source/dest port, ICMP type/code, packet size, DSCP, TCP flag, fragment encoding, etc ... , E.g.:
  - all packets to 10.0.0.1/24 and TCP port 25
  - all packets to 10.0.0.1/24 from 192.0.0.0/8 and destination port (range [137, 139] or 8080),
- Filtering actions: accept, discard, rate-limit, sample, redirect, etc ...
- Information independent of unicast routing (different NLRI), but it is automatically validated against unicast routing.

Advantages of signaling via BGP

- Incremental addition to deployed mechanisms,
- Complexity/scalability issues already solved, flexibility of BGP in adding new services (Multicast, IPv6, L3 VPN, L2 VPN, VPLS),
- Reuse of:
  - internal route distribution infrastructure (e.g.: route reflector or confederation design)
  - existing external relationships (e.g.: inter-domain BGP sessions to a customer network)
- Trust model in place
  - normally follows (the well-established trust of) unicast routing
  - Accept filter when advertised by next-hop for the destination prefix (compare destination address of traffic filtering rule with best match unicast route for this prefix)
    - Originator of filter and unicast route must be same
    - No more specifics from a different AS.
  - Can be overridden

Comparing BGP flowspec with

Traditional Firewalls, ACLs
(Complementary technologies, rather than competitive)

- No expensive, dedicated hardware
- Distributed applied as soon as traffic enters the network
- Actions closer to source
- Fine-grained
- Multidomain —easy propagation towards the upstream
- Easy automation & integration

BGP blackhole routing

- Flowspec $\rightarrow$ enhancement of BGP blackhole routing:
- Less coarse
- More actions
- Separate NLRI

BGP FlowSpec Status

Vendor support:

- Juniper: Supported in JUNOS since 7.3 !!!!
- Cisco: Not supported, no official plan ... But participates in the RFC
- Other big vendors: No
- But: Supported by Quagga, ExaBGP and some other routing daemons,
- IPv6 support: No

Design Principles (1)

Goal: *A service that will allow GRNET customers to mitigate transient attacks & anomalies at their upstream (GRNET) level. NOT a permanent firewalling service. Rules should be removed at the end of the attack (otherwise auto-expire).*

- Target audience: GRNET customers (NOCs)
- Target network: GRNET
- Web-based tool, shibboleth authentication of the users
- Customers control internal access via appropriate "Entitlement"

Design Principles (2)

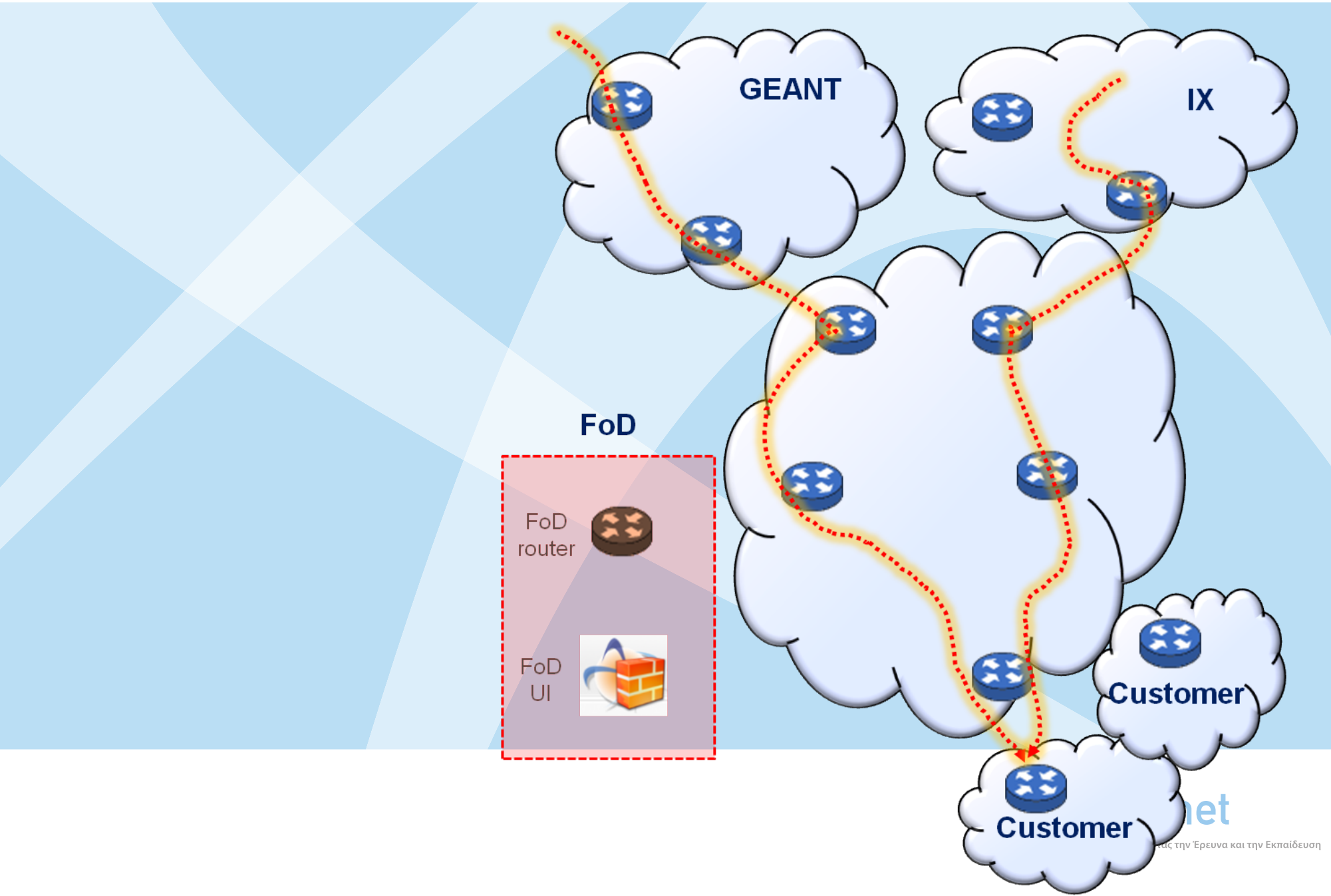
Functionality:

- Transient firewall filters across all GRNET routers,
- Empowered by BGP flowspec
- Flow granularity:
  - Source/Destination IPs
  - Source/Destination ports
  - More to be added in later versions (eg TCP flags)
- Flow Manipulation:
  - Drop
  - Rate limit to: 10Mbps. 1Mbps, 100Kbps (we can add as many as we want),
  - More actions in later versions, eg redirect
- Authorization & Security
  - Customers $\rightarrow$ affect traffic destined to themselves
  - Core network $\rightarrow$ immune to the tool (in case of bug, misbehavior, compromise)

Design Principles (3)

- Programmatic API
  - REST API to be added in future versions, in order to allow integration with other tools
- Coding:
  - Secure
  - Based on modern technologies,
  - Open: Open-source license, well-documented, no GRNET-specifics or hardwired stuff
- Synergies:
  - Customers
  - GEANT & NRENs
  - GRNET or 3rd party security tools. CERT/CIRTs, IPS/IDS, ...

FoD Operation Overview



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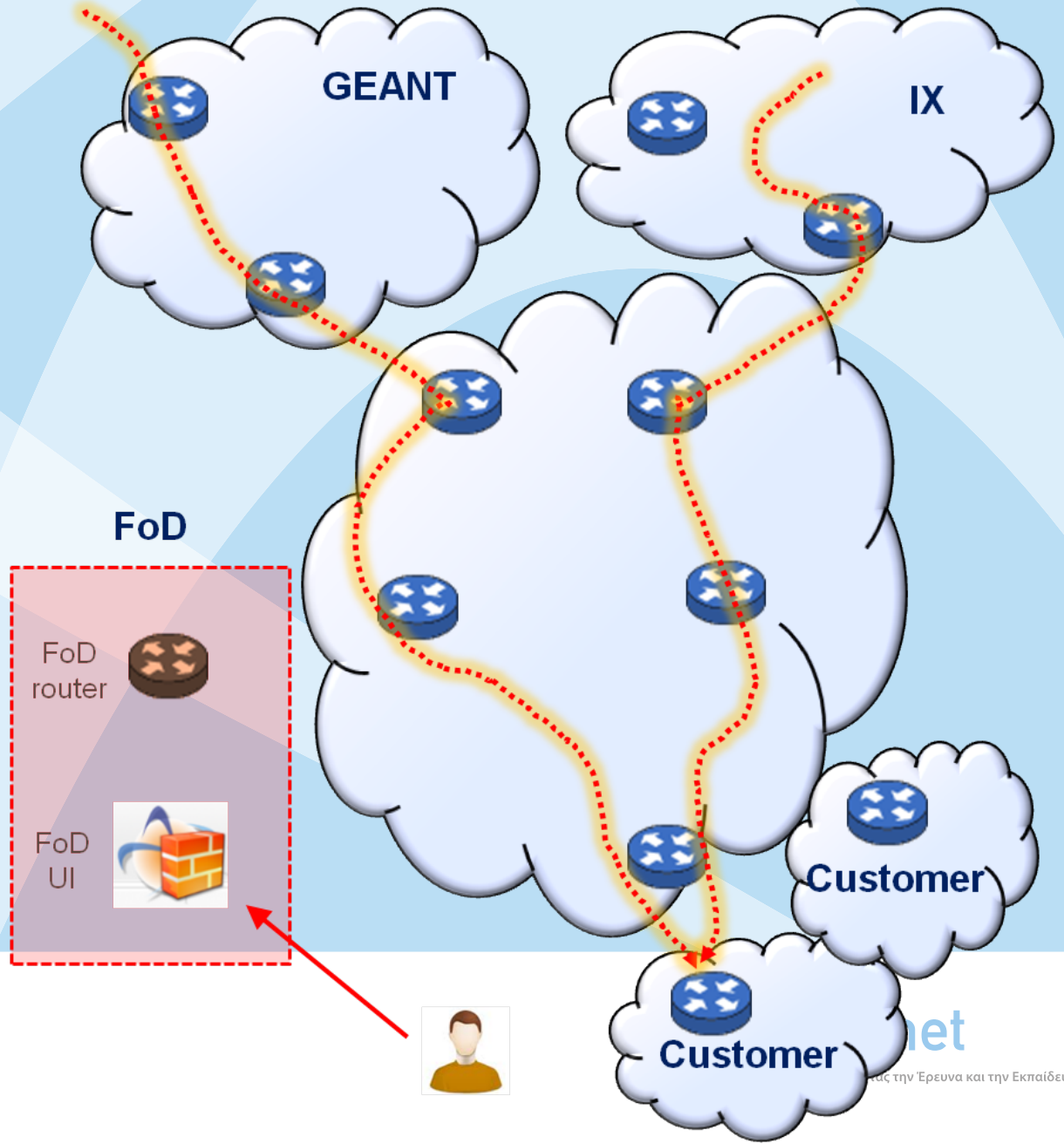
User logs in a web tool and describes flows and actions



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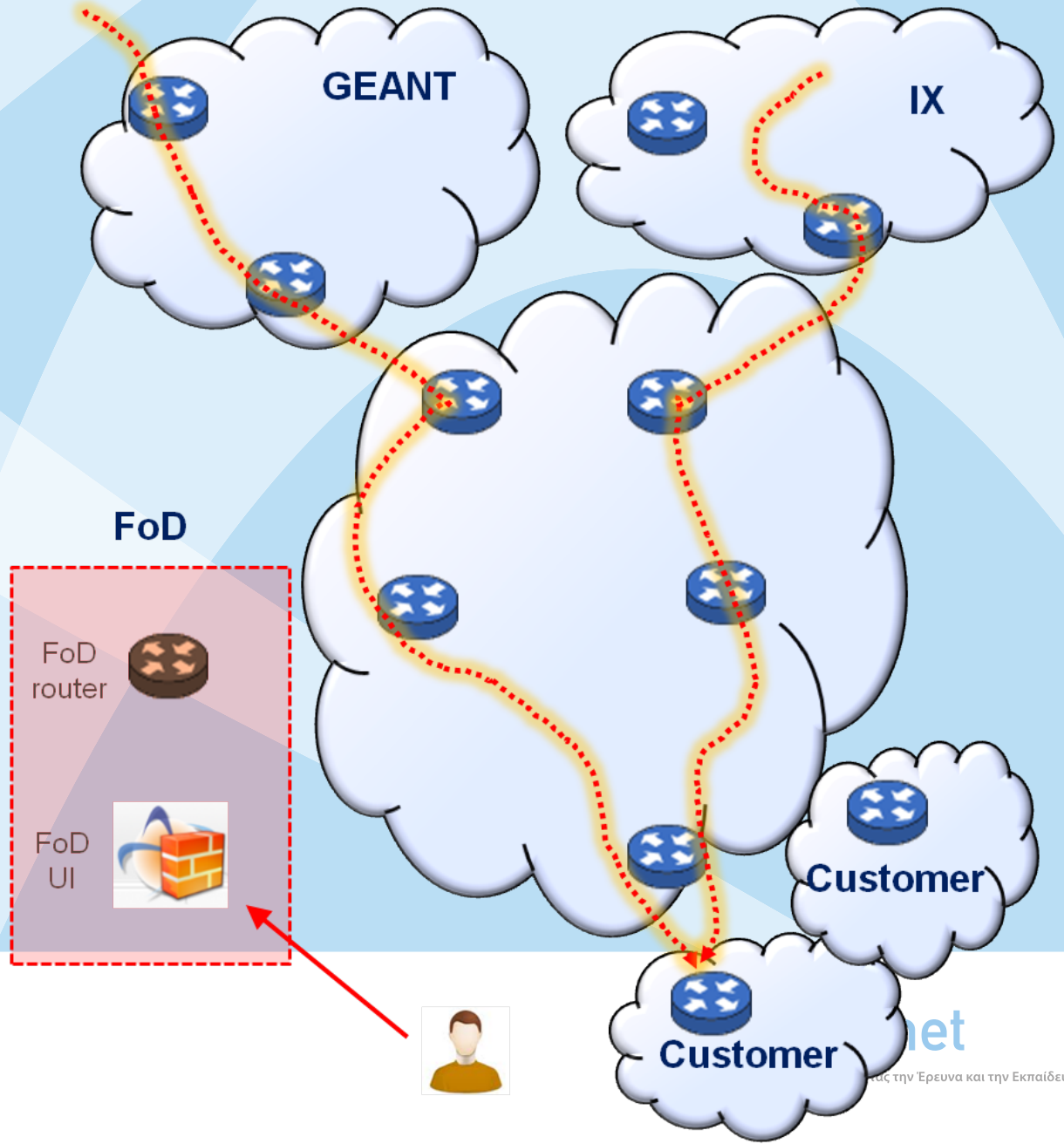

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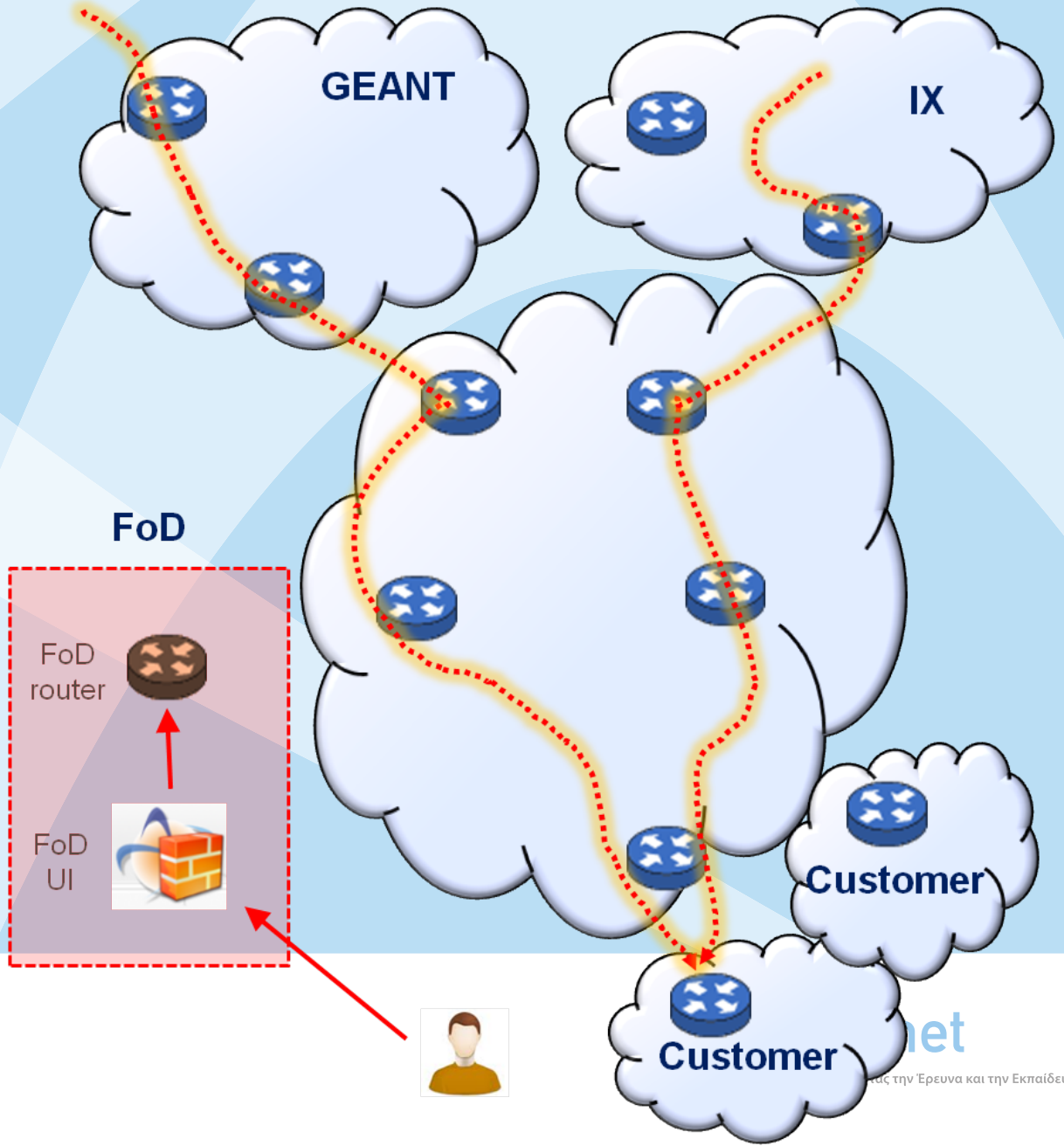

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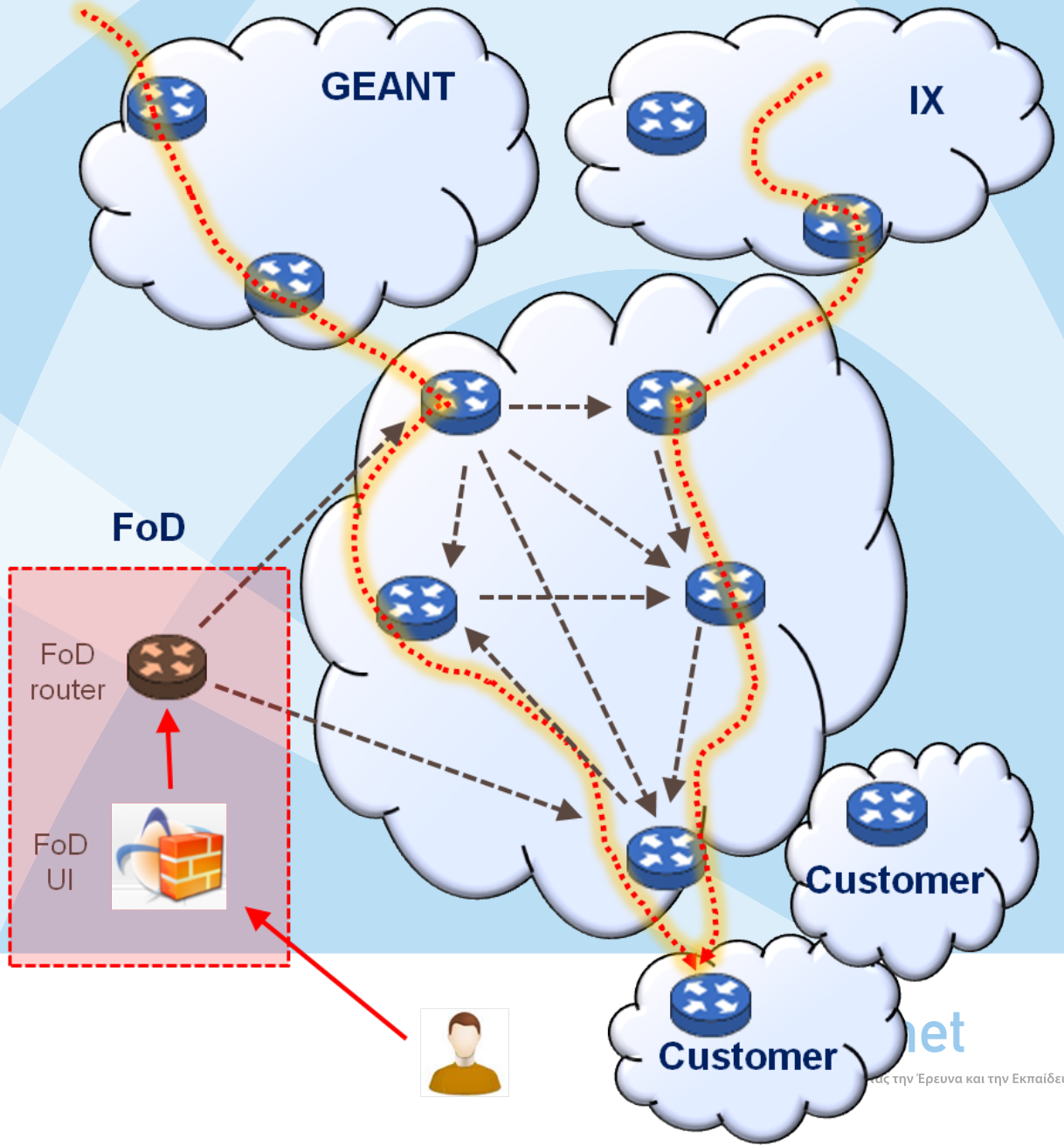

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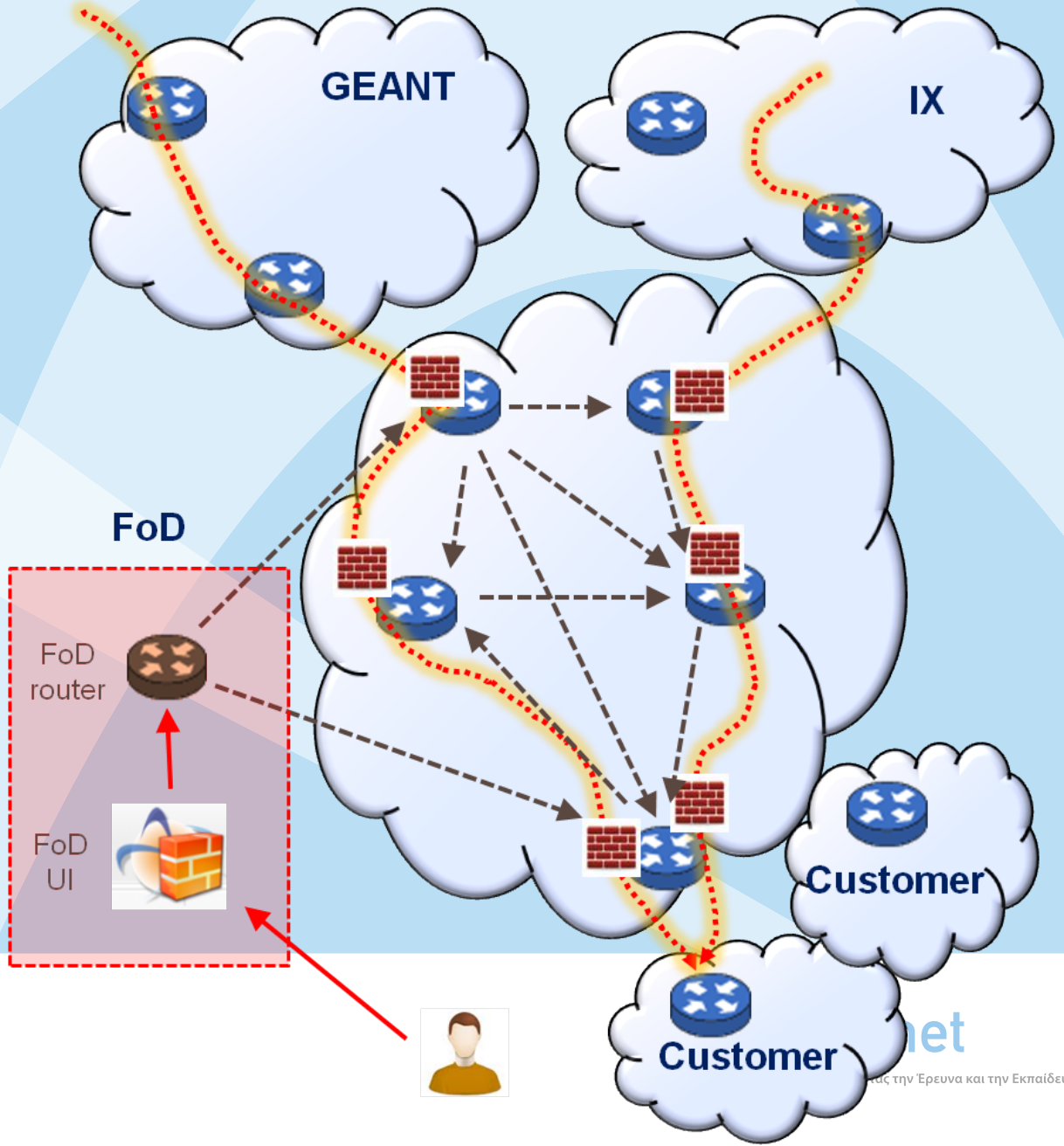

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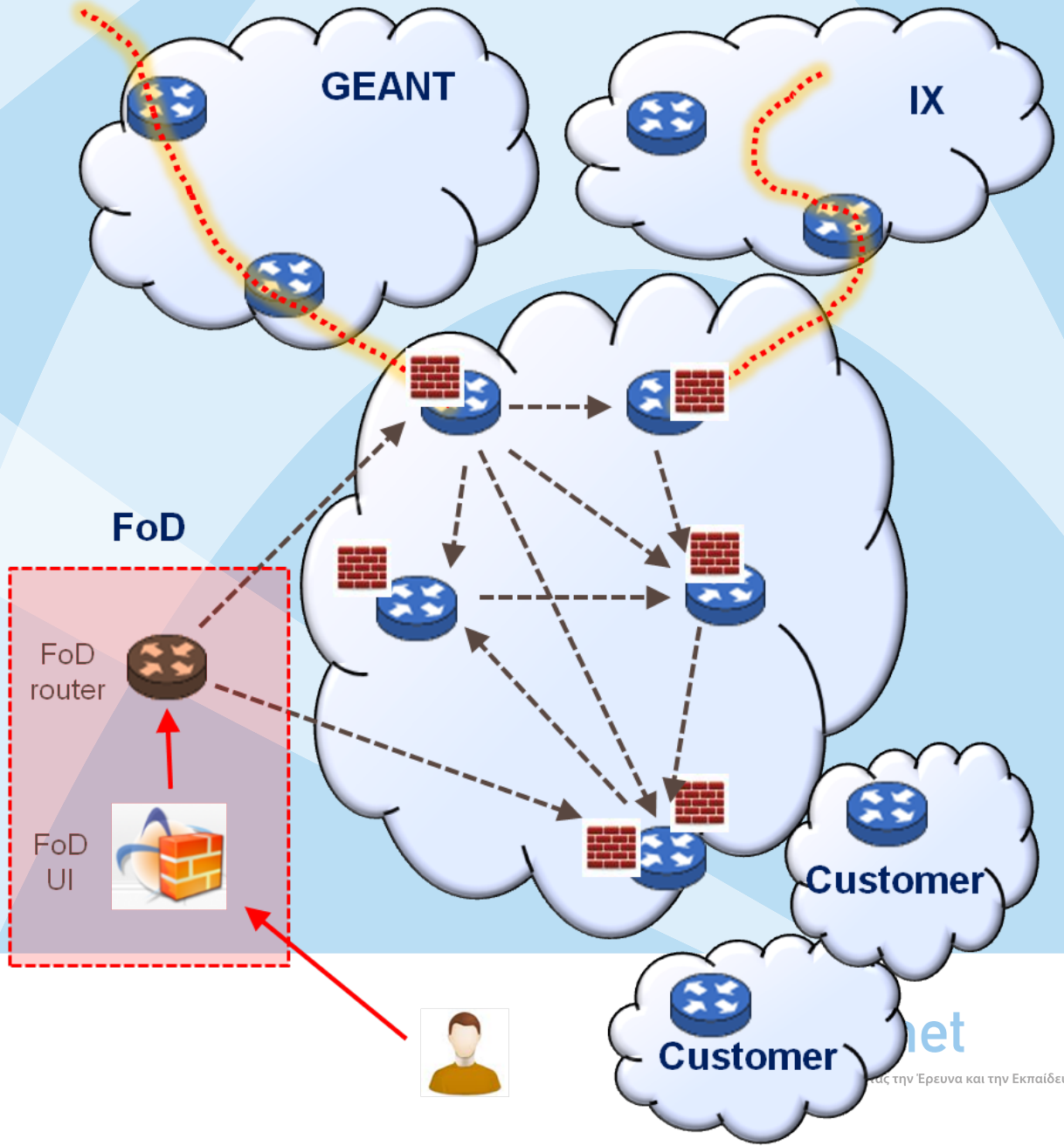

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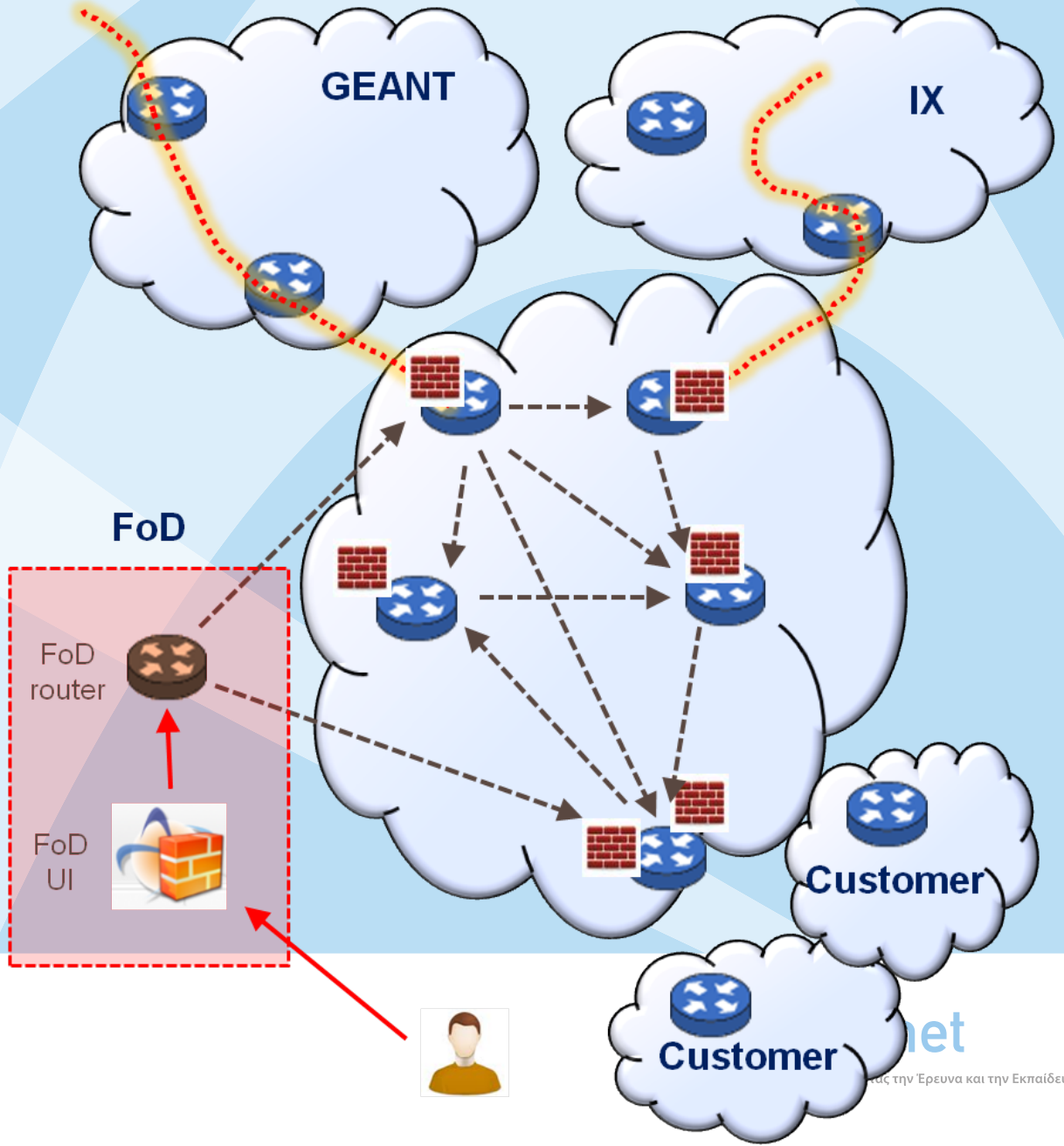
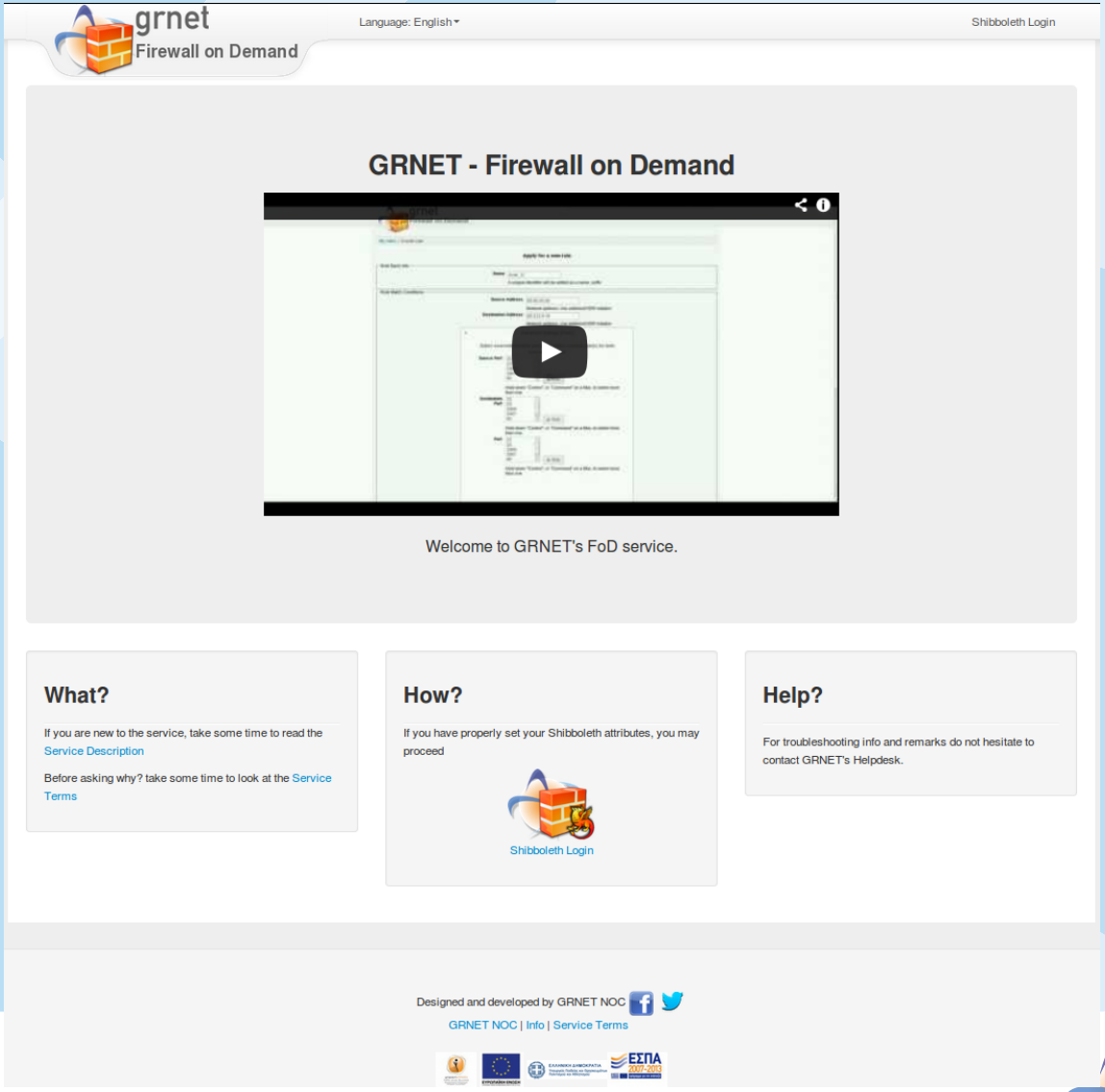
End of attack: Removal via the tool, or auto-expire



User Interface #1



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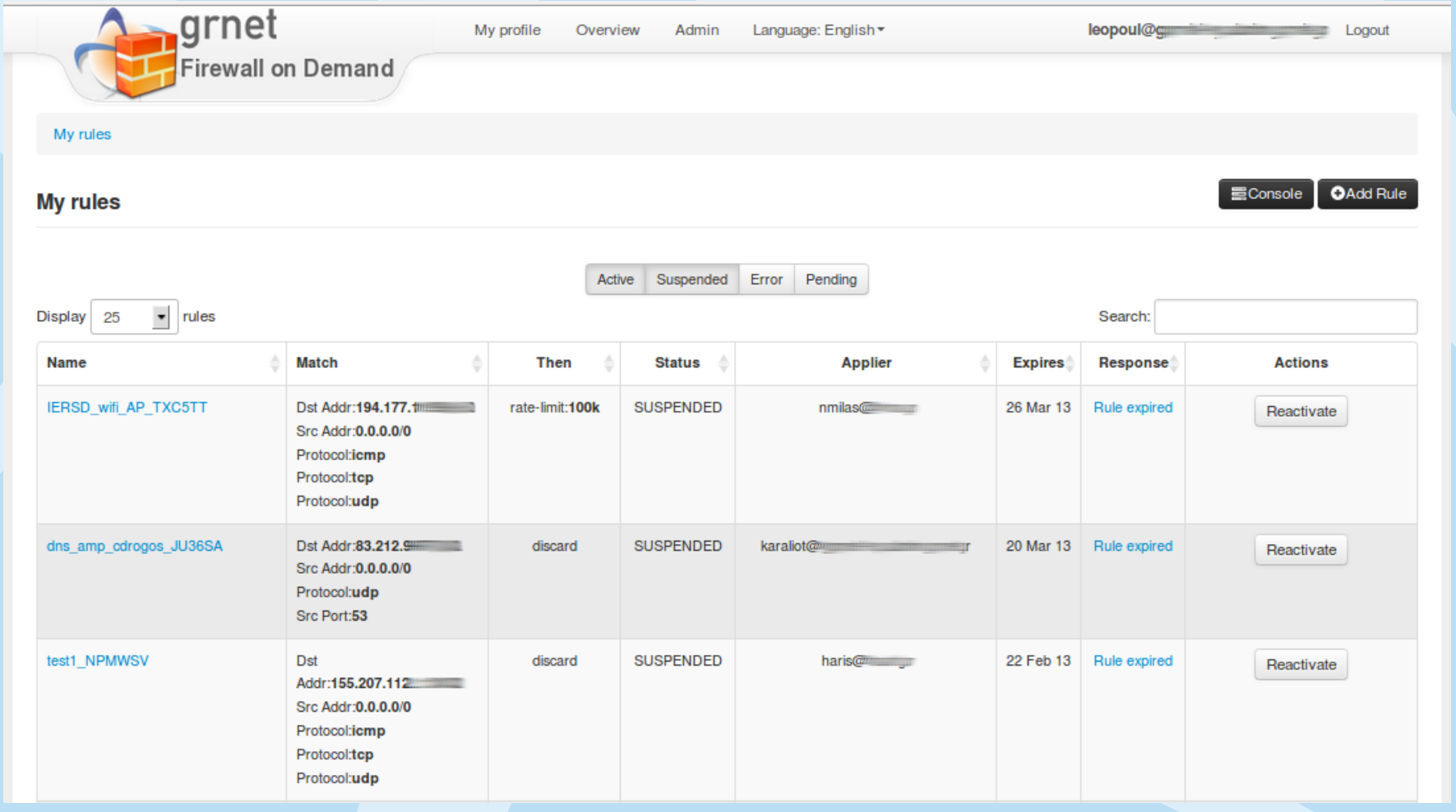
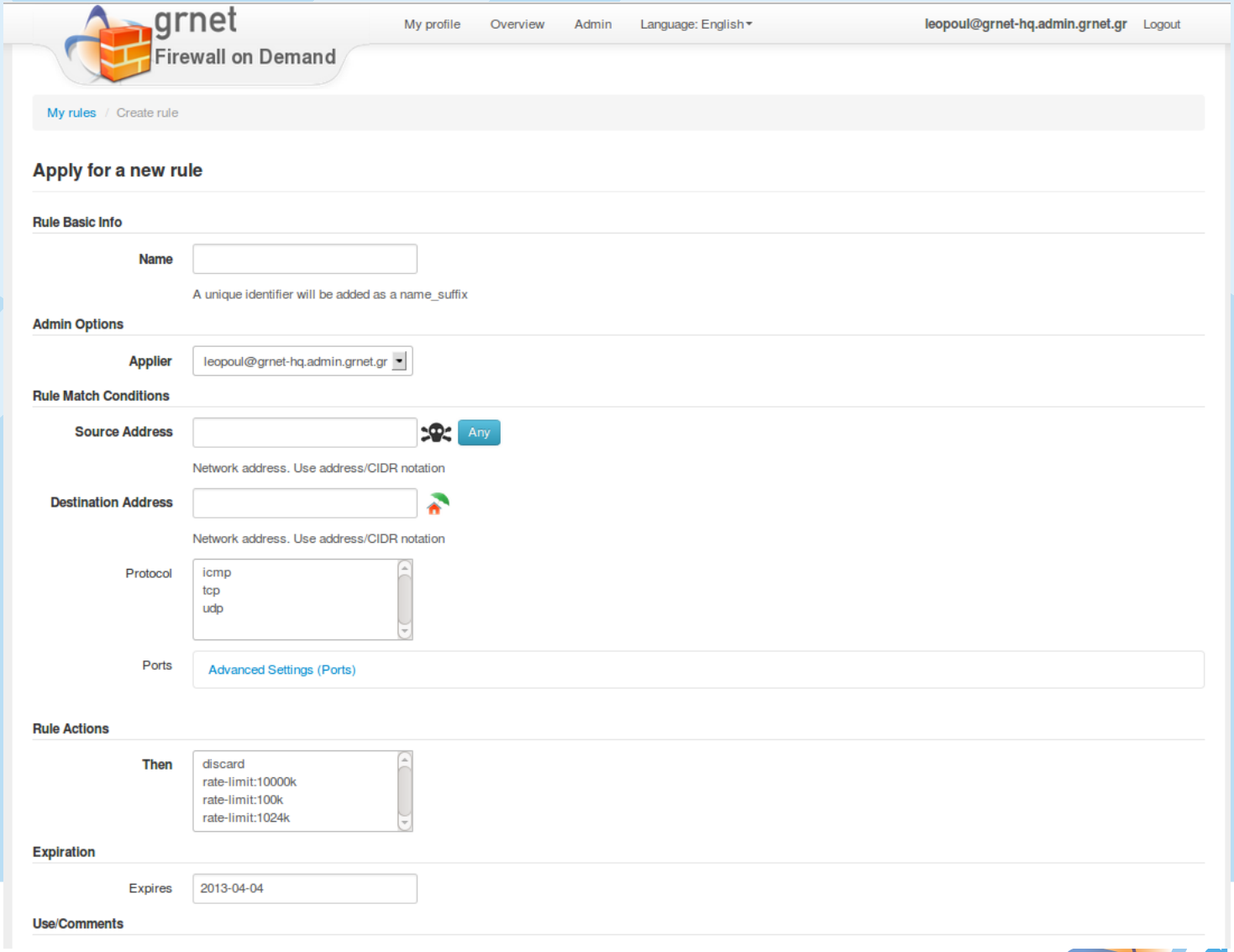
User Interface #2



User Interface #3



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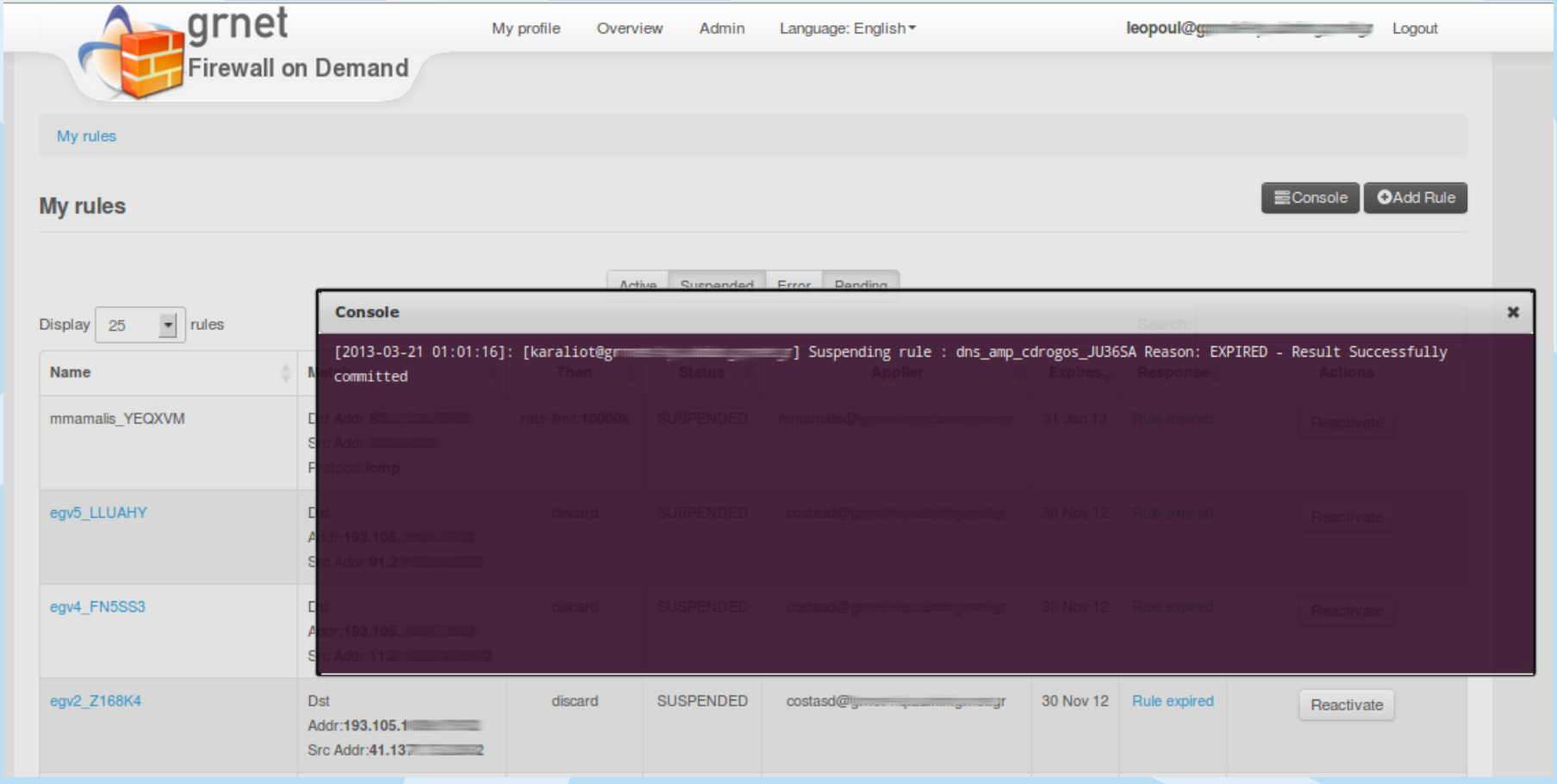
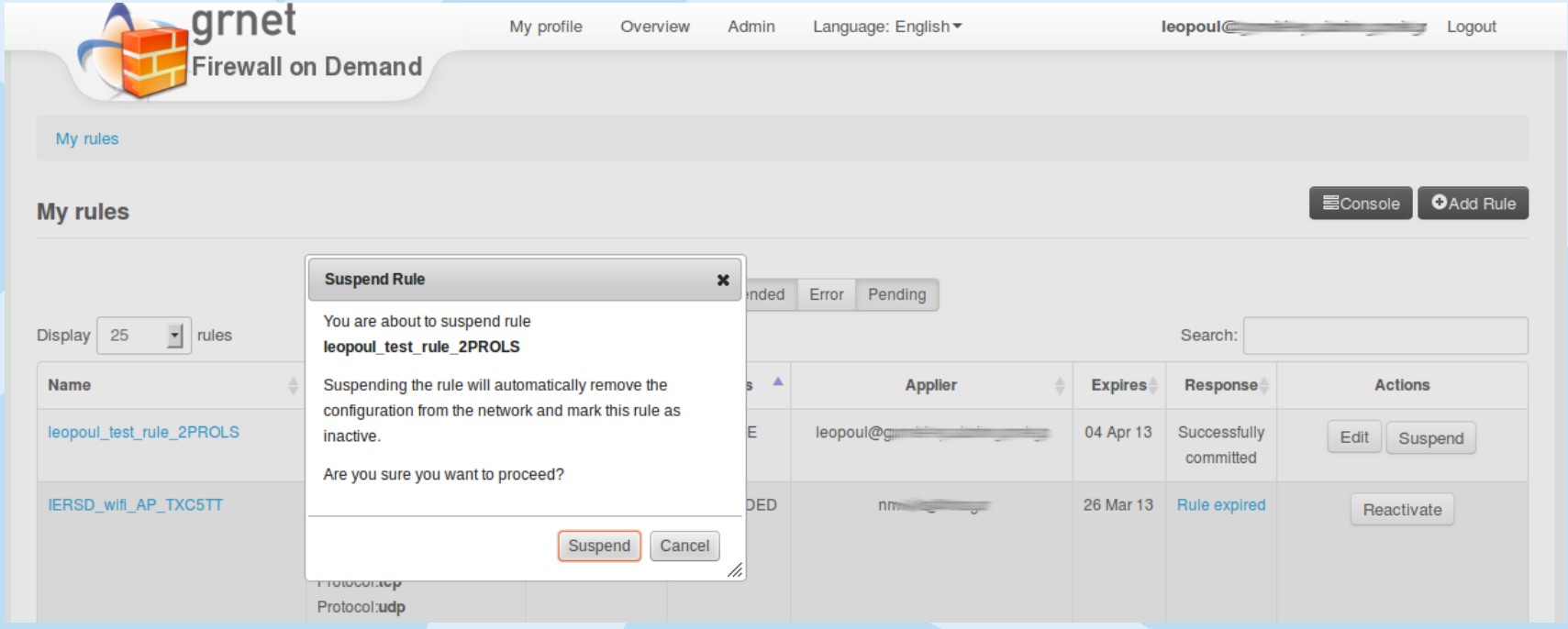


User Interface #5



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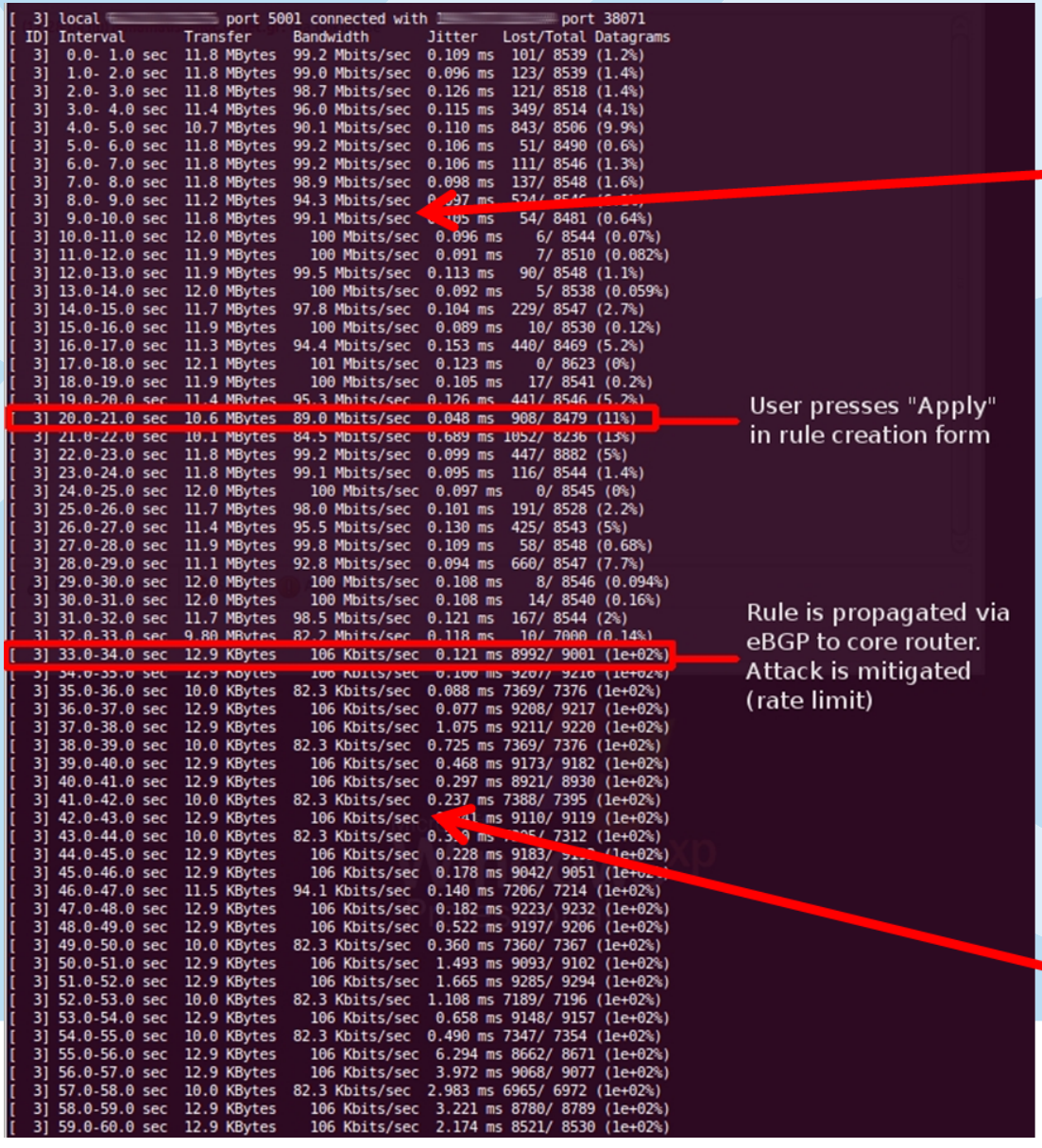
Demo (iperf simulated attack)



A 100Mbps attack

User presses "Apply" in rule creation form

Typically less than 15 seconds

Rule is propagated via eBGP to core router. Attack is mitigated (rate limit)

Flow limited to 100Kbps

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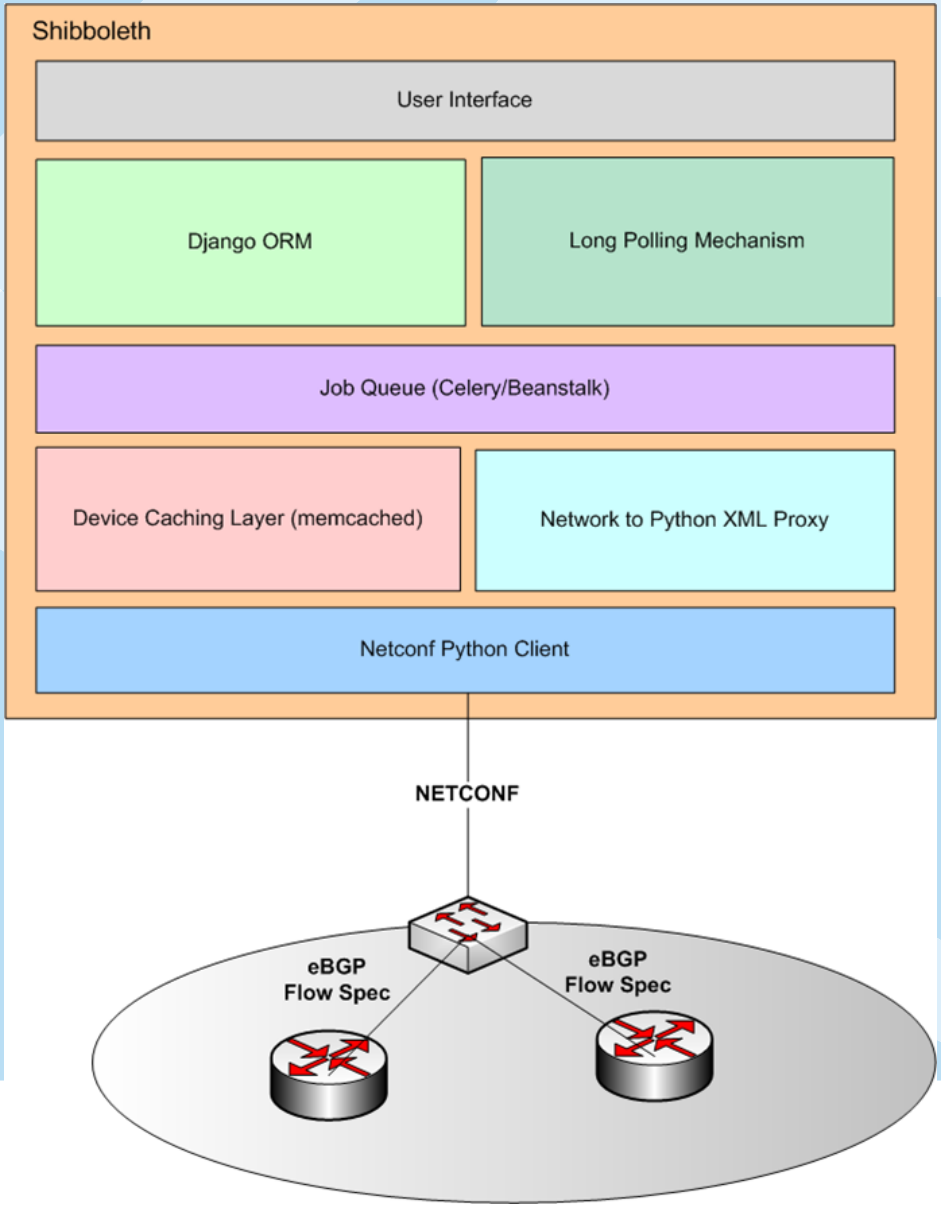
Implementation - Architecture



Implementation - Technologies

- Open Source project
  - Python Django ORM
  - jQuery Javascript lib, Bootstrap CSS
- Multicomponent architecture
  - Shibboleth: User authentication based on special attribute
  - Django: UI rendering & db modeling
  - Long polling: fetch updates without reloading
    - used in: facebook chat, twitter updates
  - Celery/beanstalk: apply configuration without locks
  - nxpy: Network XML to python classes proxy
    - Dev & maint by GRNET NOC delevoper (Leonidas Poulopoulos)
  - Ncclient: python netconf client (ncclient)
    - Maintained by GRNET NOC delevoper (Leonidas Poulopoulos)
  - Caching, cron jobs

Information Flow

- User login
- Rule management (Creation, removal)
- Notifications, status

- Transform rules to python objects
- DB operations
- Transform python objects to netconf XML configuration
- Apply XML configuration via NETCONF to device

- Save received configuration to device (switch)
- Propagate rule via eBGP to peer routers
- Rule filters and acts on matching flows

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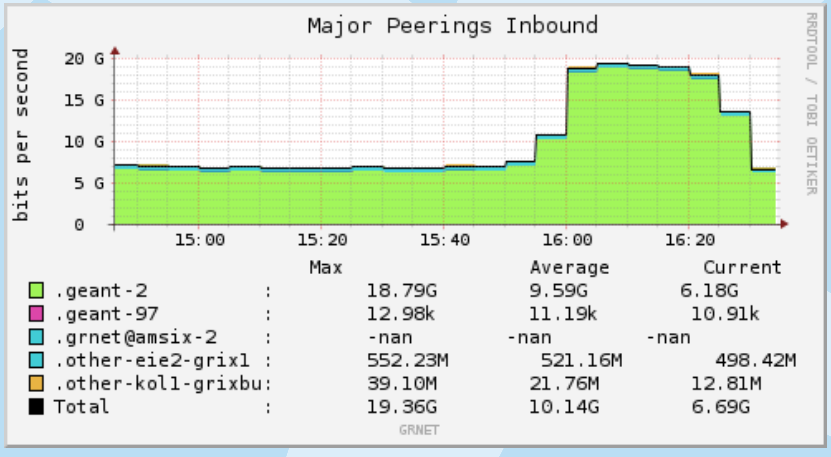
Status

- Latest stable
- Production GRNET network
- http://fod.grnet.gr/
- Successful mitigation of aprox. 20 attacks in 2 months
  - 

- Source code:
  - http://code.grnet.gr/

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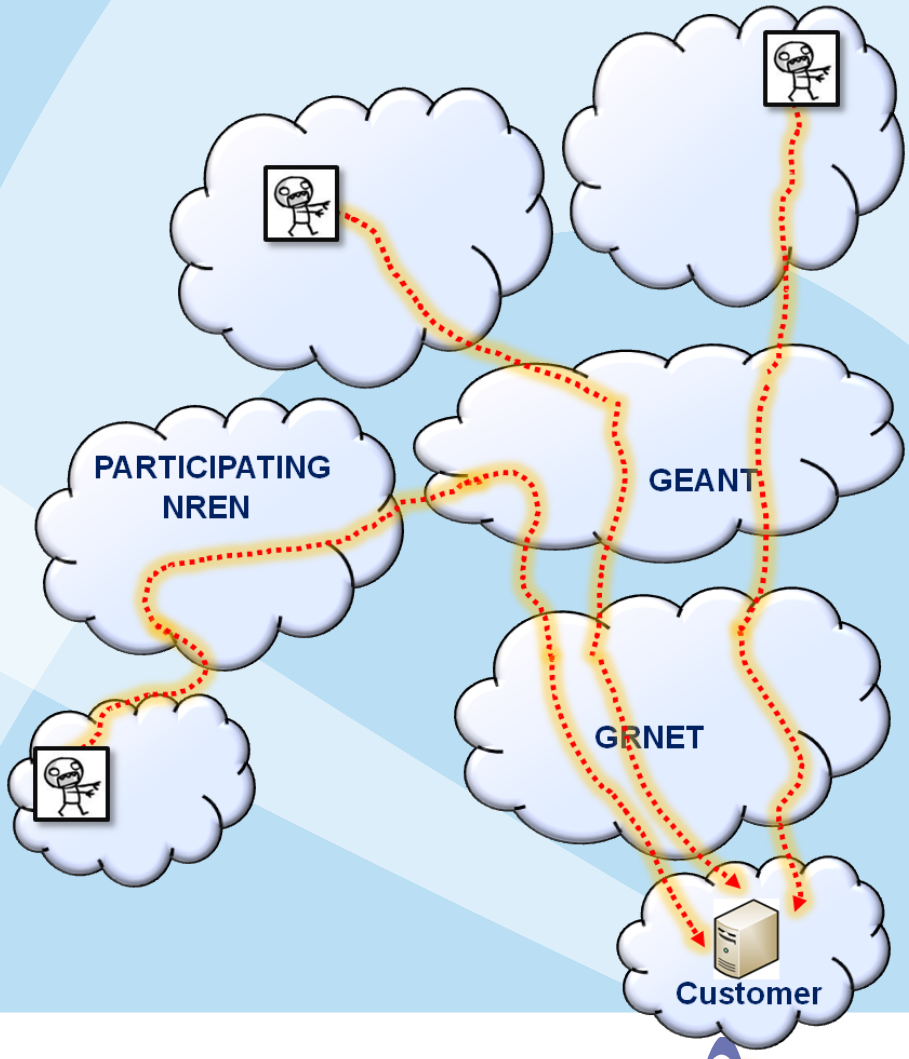
Expanding the service to the GEANT community



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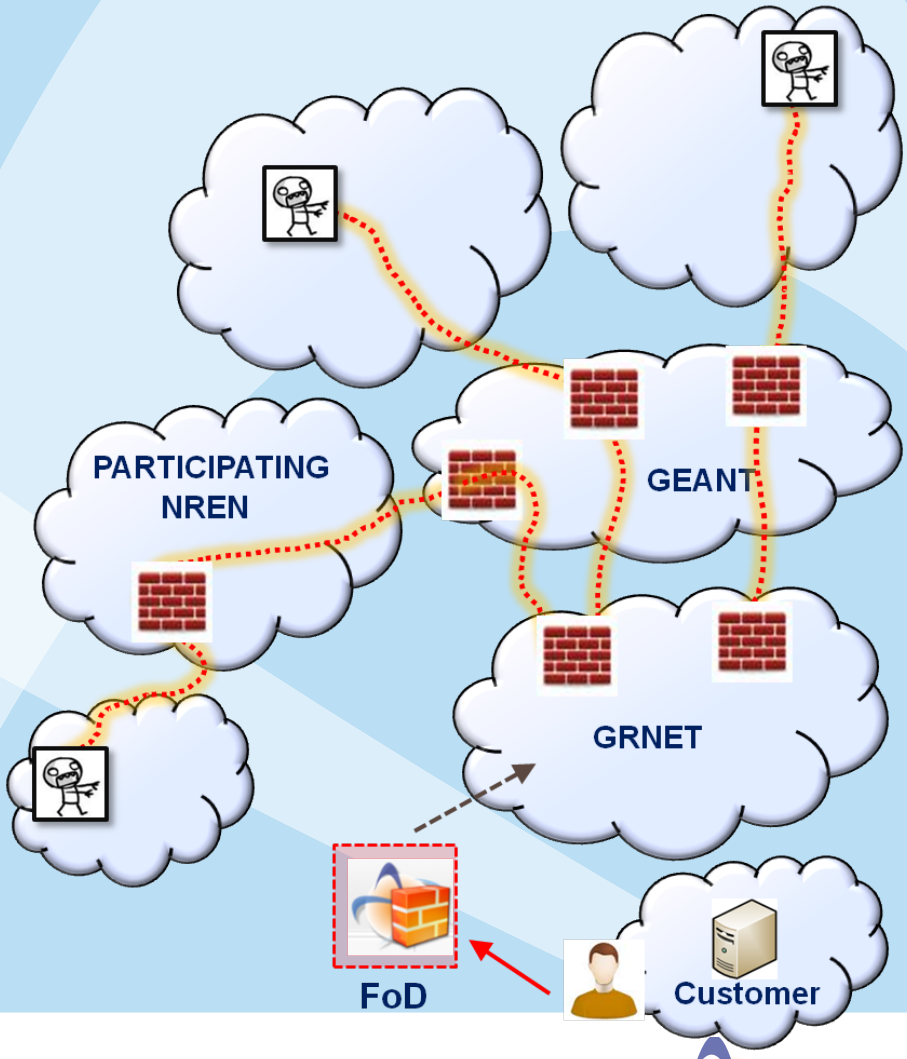

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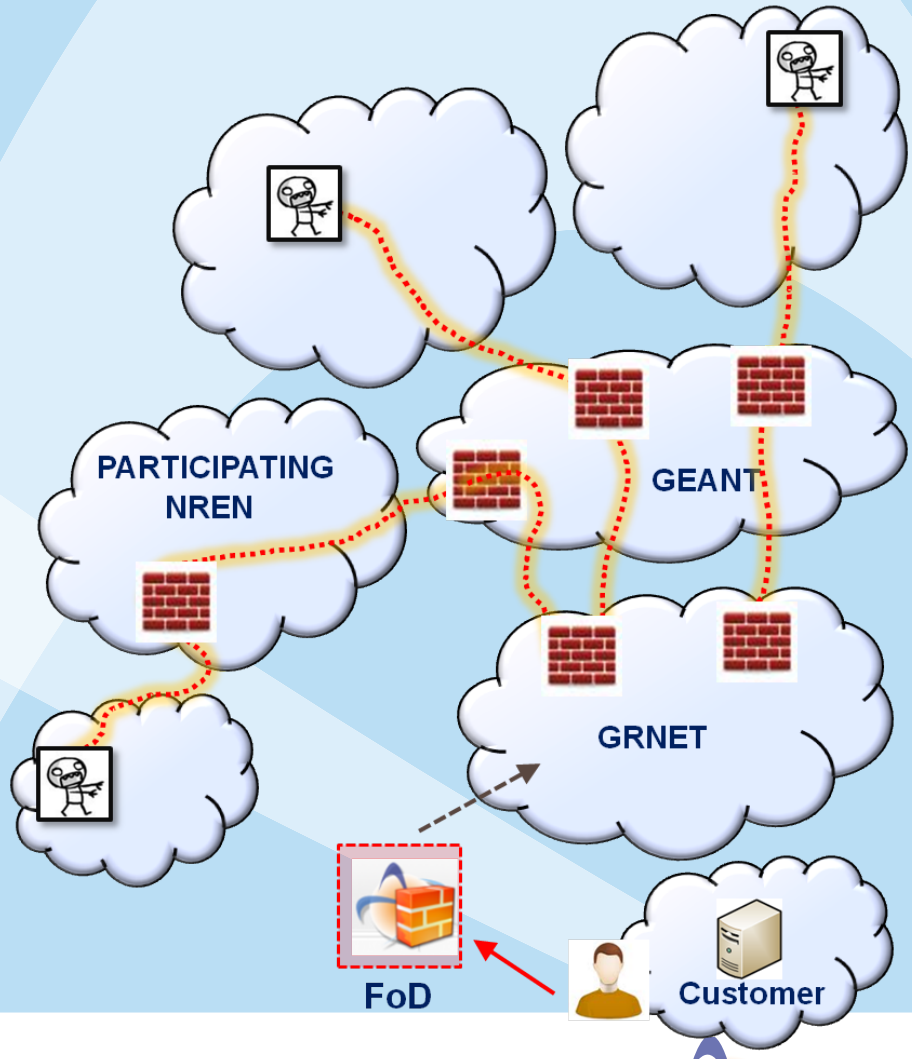
Phase 1: GEANT participation

- Routers accept BGP flowspec NLRI
- Establish BGP peerings with GRNET (protected by route-maps)



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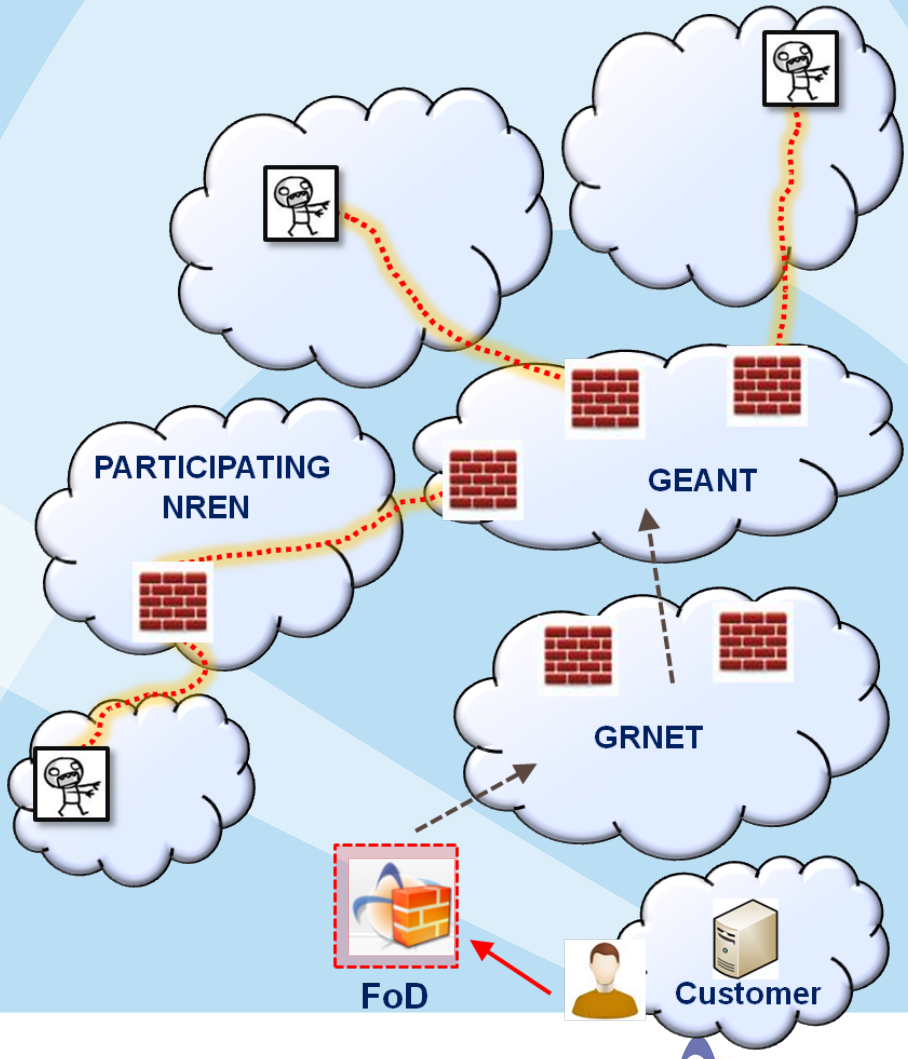

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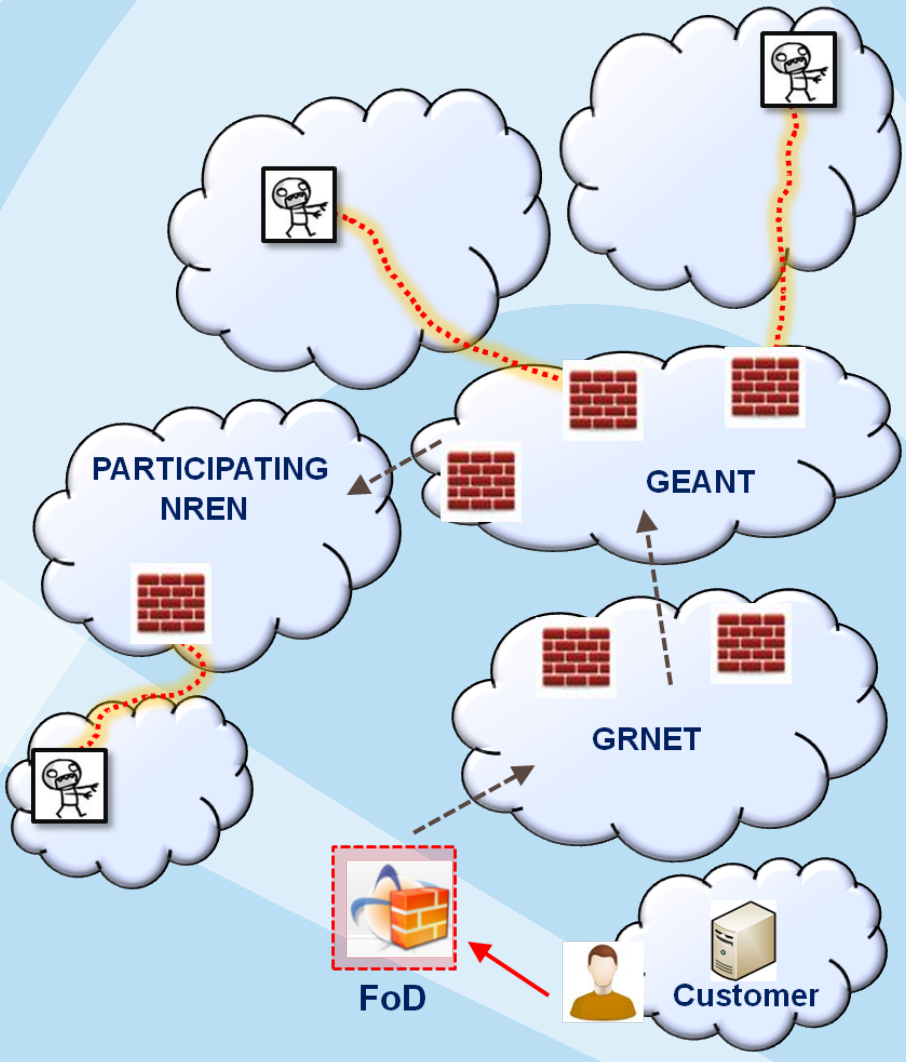
Phase 2: NREN participation

- NRENs → propagate filters through bgp peerings instead of UI



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Synergies with security team

- Connect to the domain's IPS/IDS, honeypots, ...
- Connect to GEANT anomaly detection tool
- Connect to any CERT/CIRT team that we trust

"Soft" actions can make adoption easier

- Rate-limit instead of drop

Service Outreach

Project is open-source

Requirements to run the service:

- Juniper on your network
- A vm to host the service
- A juniper router, dedicated to the service
  - L3 switches are sufficient
  - A "virtual router" (olive VM) could also be used
- Shibboleth recommended (but can be ommited)
- DB: customers $\rightarrow$ IP space (auth)
  - whois $\rightarrow$ DB is implemented

Still in doubt?

- Try the existing instance of the service (@GRNET) on **your** network
- Multihop-BGP peering between our service and your routers
- BGP filters (on your side) can be used to restrict the effects on a specific "testing" IP range.

Thank you

Questions?

Work carried-out by Leonidas Poulopoulos, Michalis Mamalis & Andreas Polyrakis

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