Firewalling beyond 10Gbps

Securing the LCG

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The security related aspects of this work have been co-funded by the European Commission ISSeG project, http://www.isseg.eu/

Content

- Network upgrade for the LCG
- Requirements for the CERN main firewall
- Hardware architecture
- The management framework
- Implementation experiences
- Conclusion

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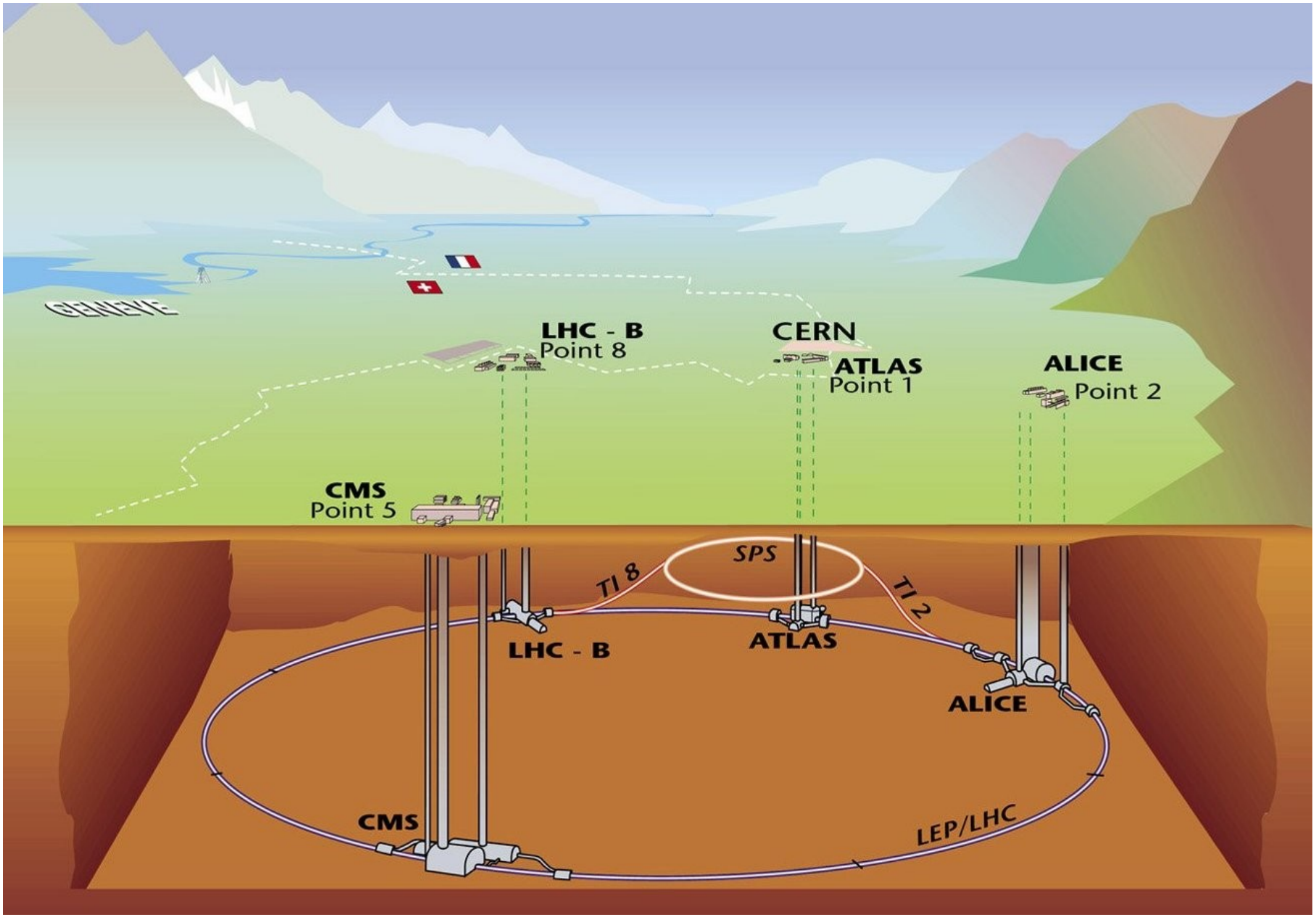
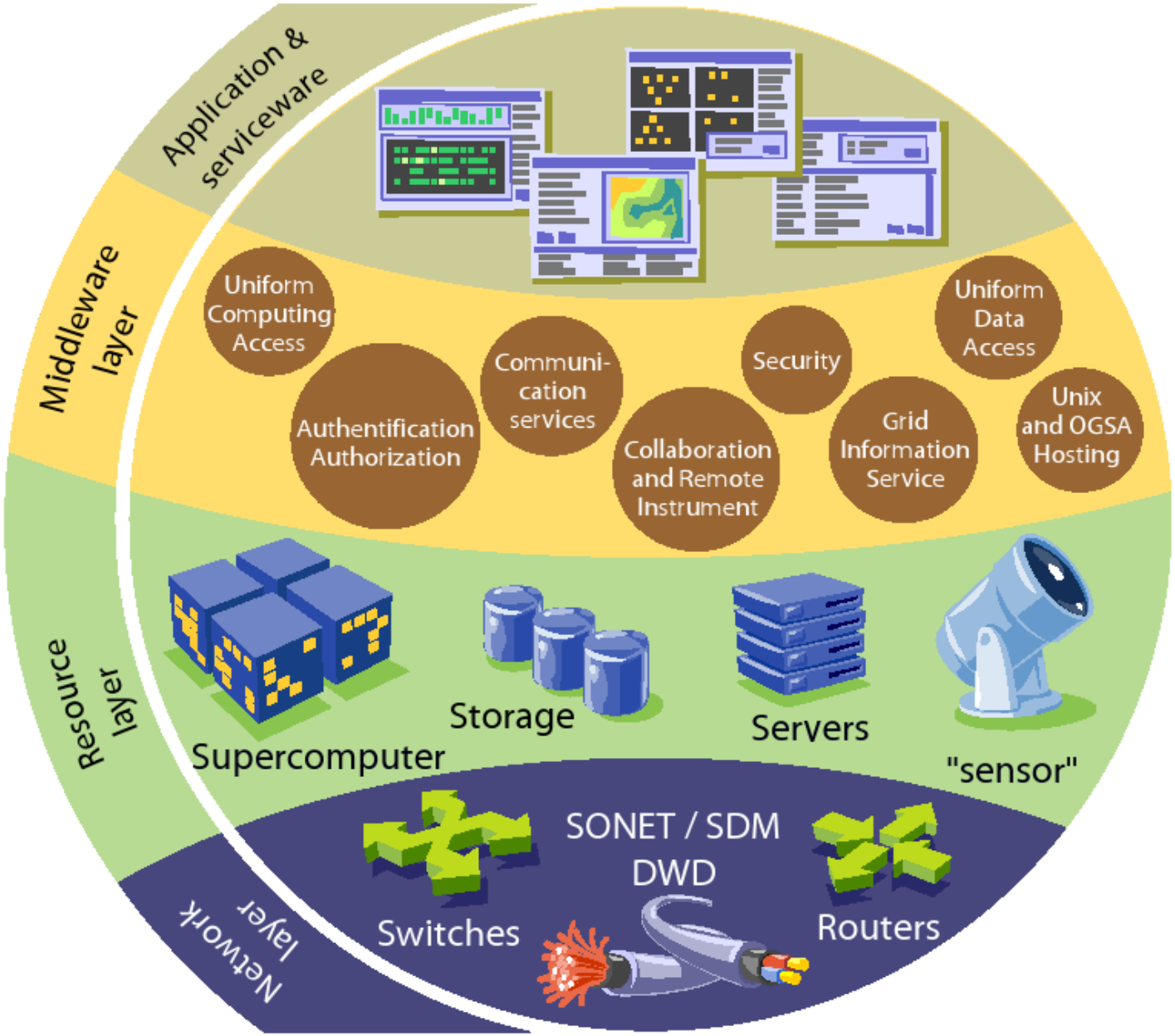
LHC: the Large Hadron Collider



LHC data

- 40 million collisions per second, of which only few hundreds will be kept
- 3-4 MB of data for each collision
- The four LHC experiments will generate over 10 Peta bytes of data per year [Peta = 10^{15}]
- The data analysis will require more than 100,000 of today's best CPUs.

LCG: LHC Computing Grid



LCG: the Tier model

Tier-0 – the accelerator centre

- **CERN**
- Data acquisition and pre-processing
- Long-term data storage
- Distribution of data to Tier-1 centres

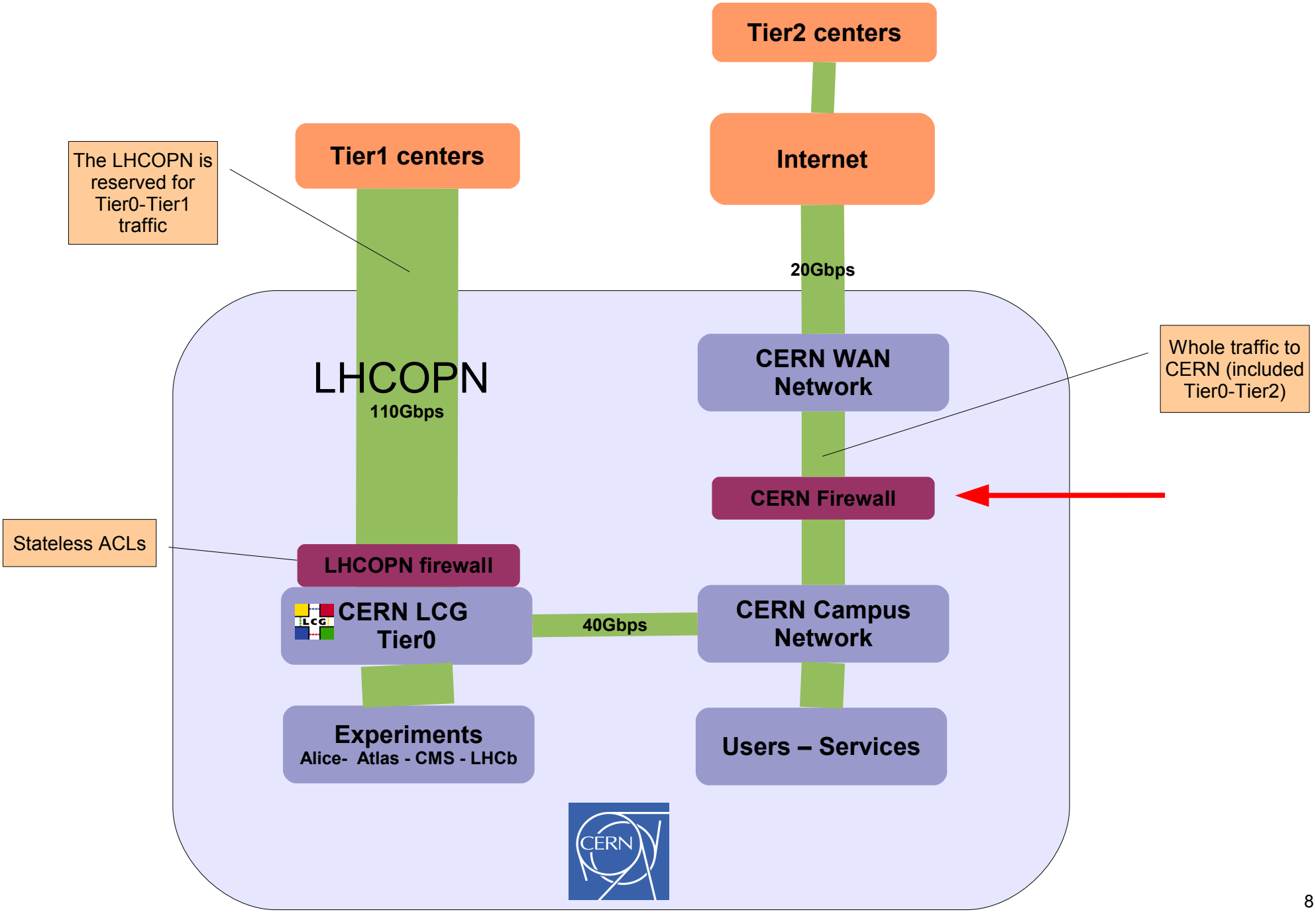
Tier-1 - data processing and distribution

- **11 computer centres directly connected to CERN**
- Managed Mass Storage
- Grid-enabled data service
- Heavy data analysis

Tier-2

- **more than one hundred centres around the world**
- Simulation
- End-user analysis
- batch and interactive

The CERN network



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Challenges

Allow easy sharing of data and services with any location on the Internet, but still guarantee protection and security

High throughput for the LCG and the hosted scientific community

Finite budget

Hardware requirements

Bandwidth, Reliability, Flexibility:

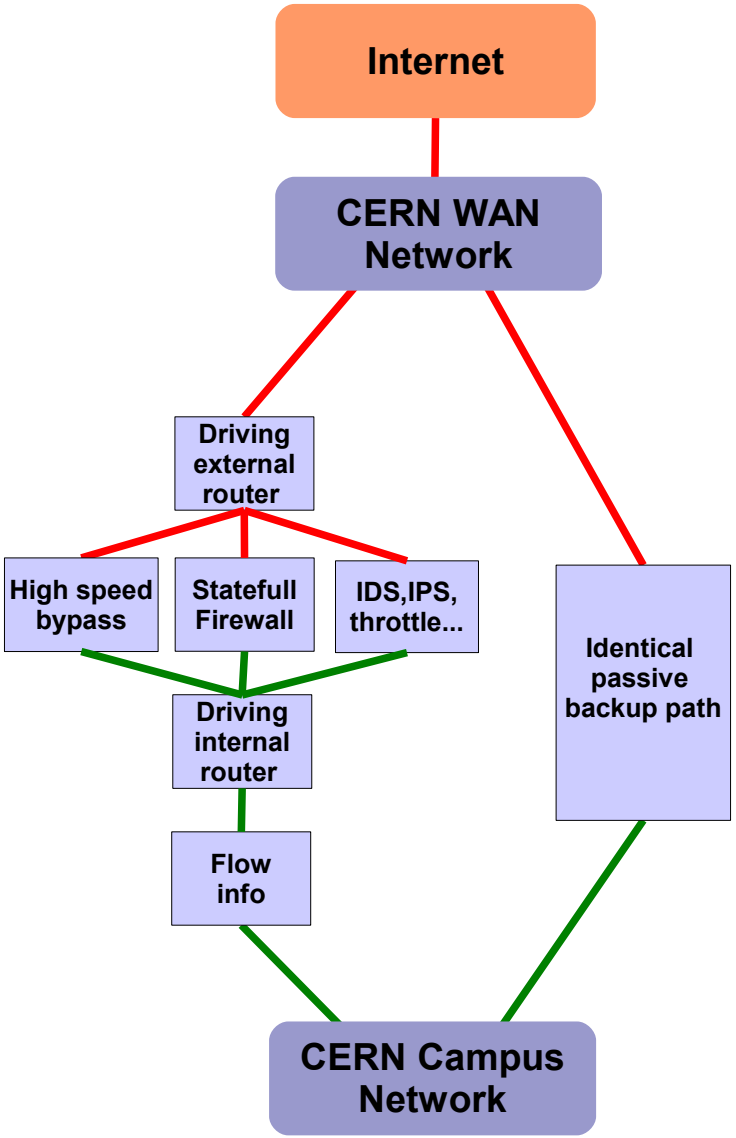
- at least 2Gbps of stateful inspection for generic traffic
- at least 20Gbps for high speed data transfer
- fully redundant system
- flexibility to add security features (IDS, tapping, throttling....)

Security requirements

Fine granularity, Full monitoring:

- possibility to filter down to the TCP/UDP port of every single host
- inspection of all the generic traffic
- full information about flows
- offload of well defined and trusted traffic

Architecture characteristics



Keys:

external link

internal link

Management framework requirements

Integrated, Automated, Flexible:

- fully integrated with the existing Network Management System and the Network Database
- hardware independent
- architecture independent
- automatic updates

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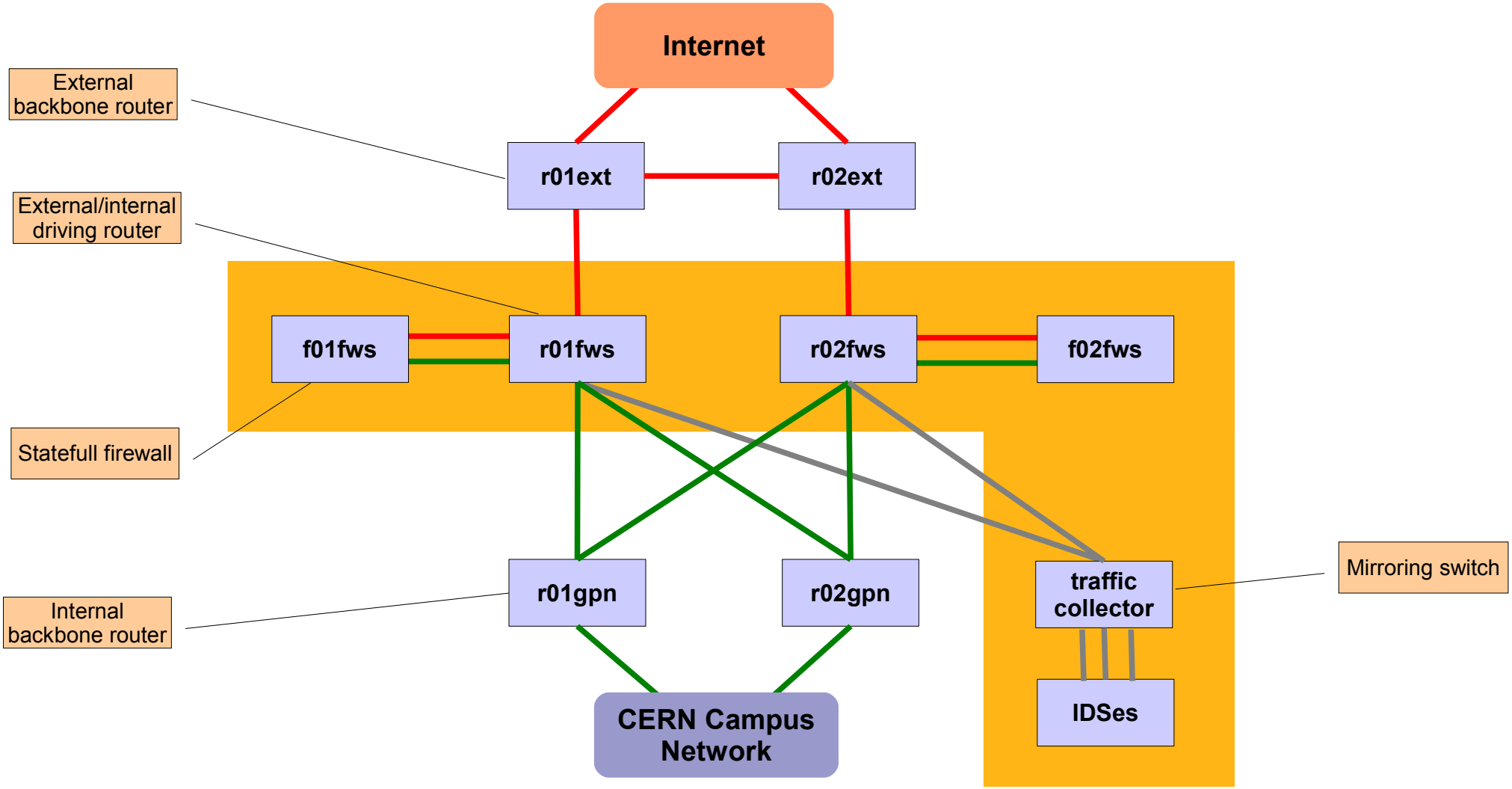
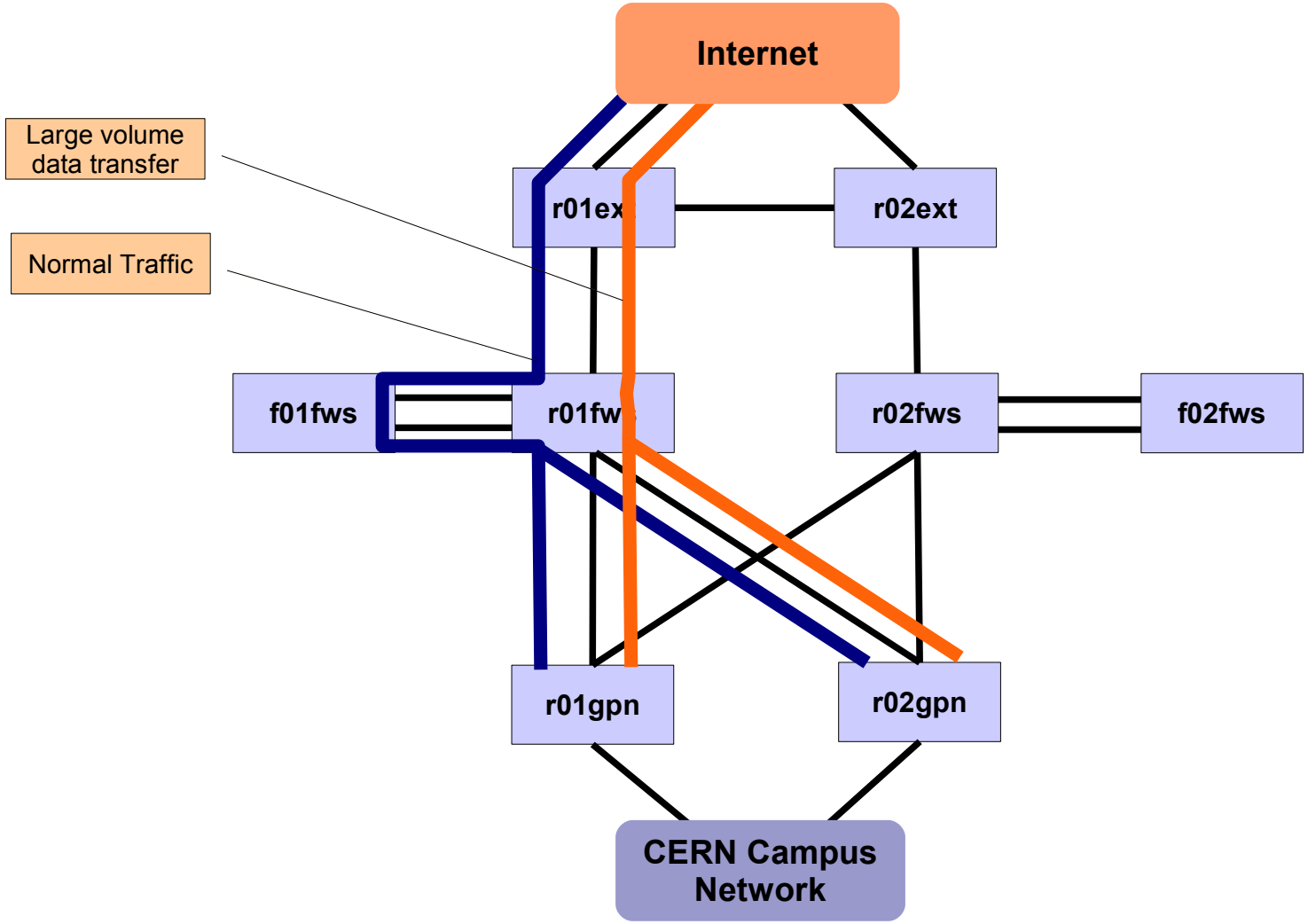
Architecture



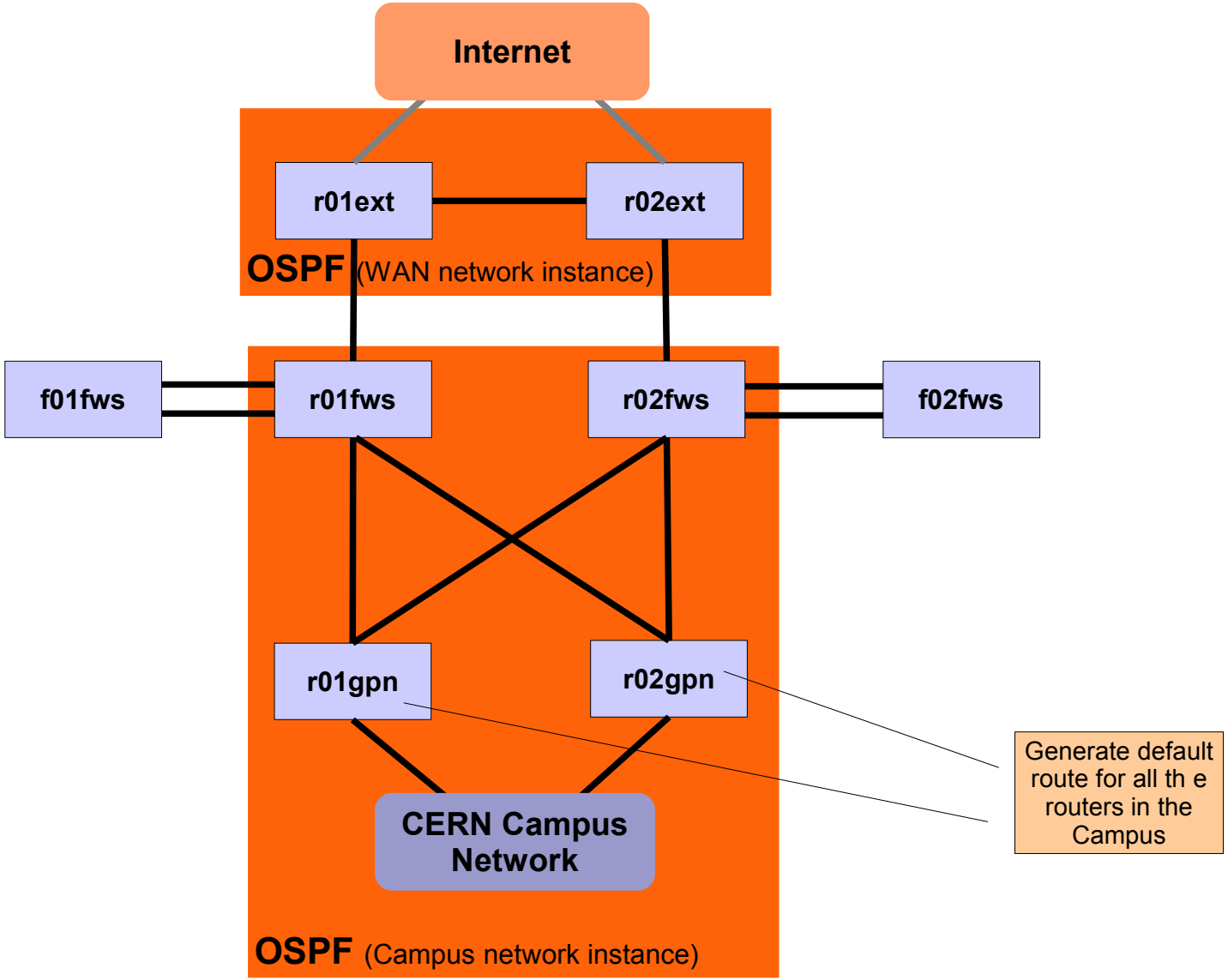
Keys:

- external link
- internal link
- mirrored traffic link

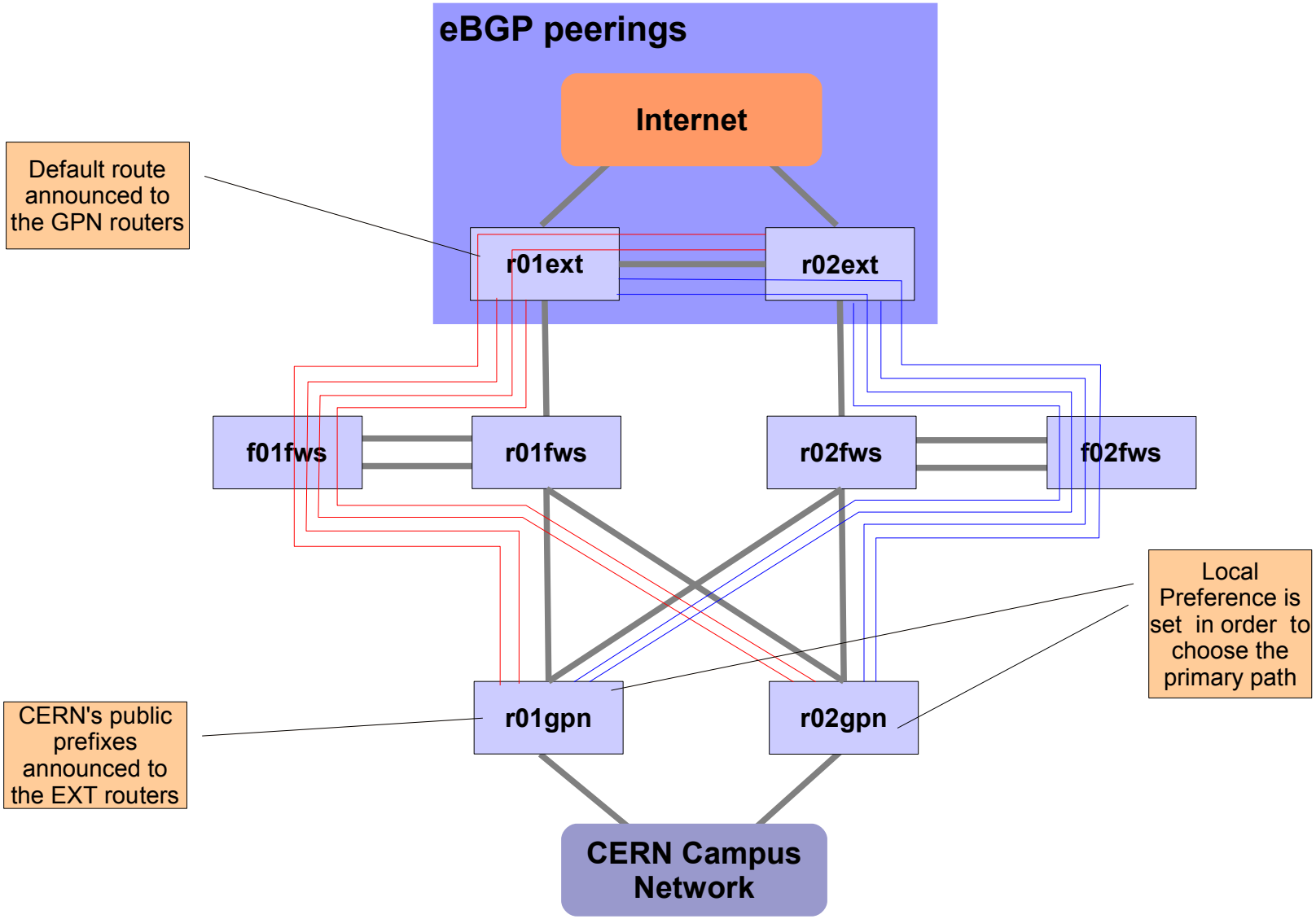
Traffic flows



Routing: OSPF



Routing: BGP

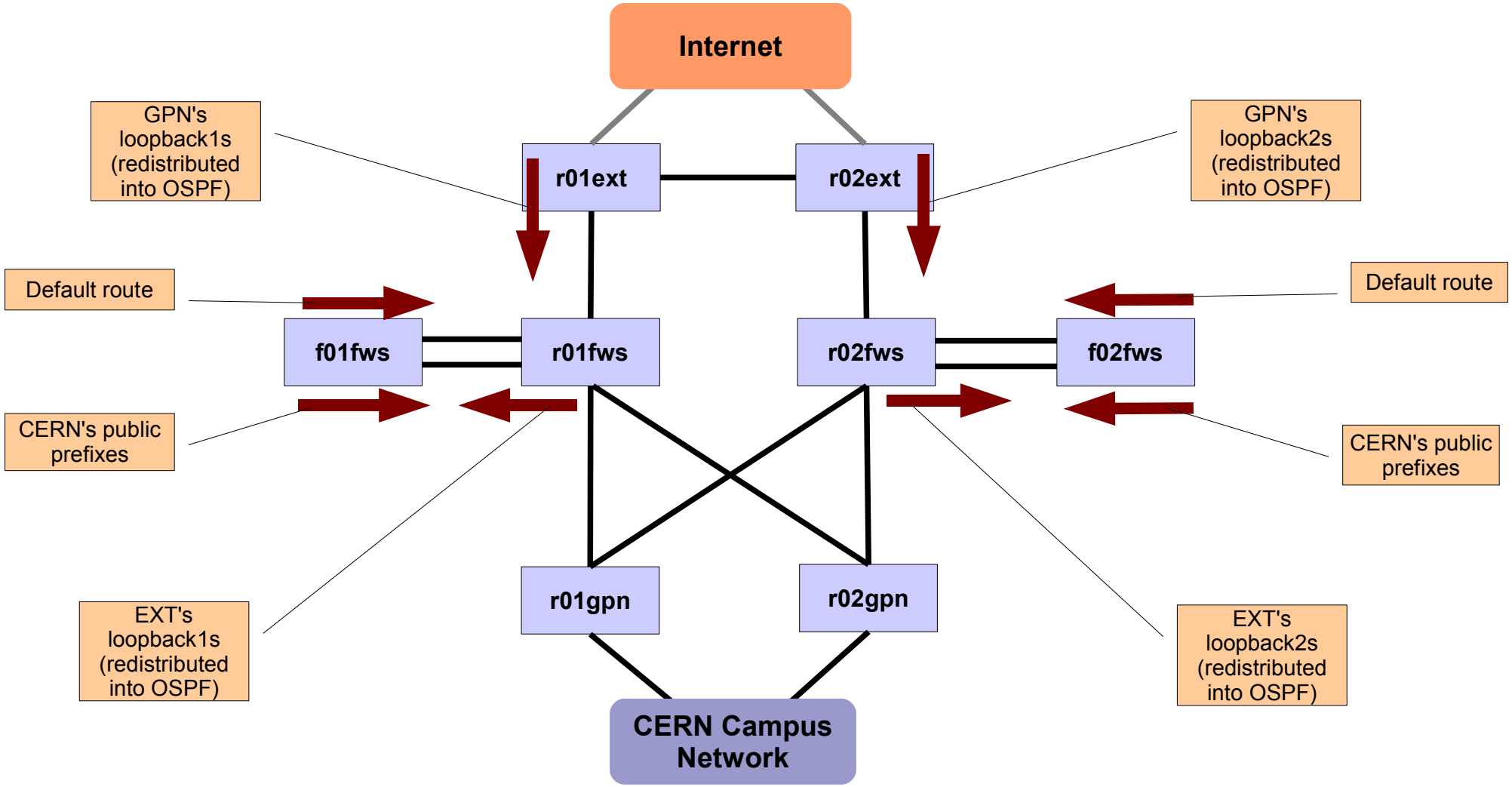


Keys:

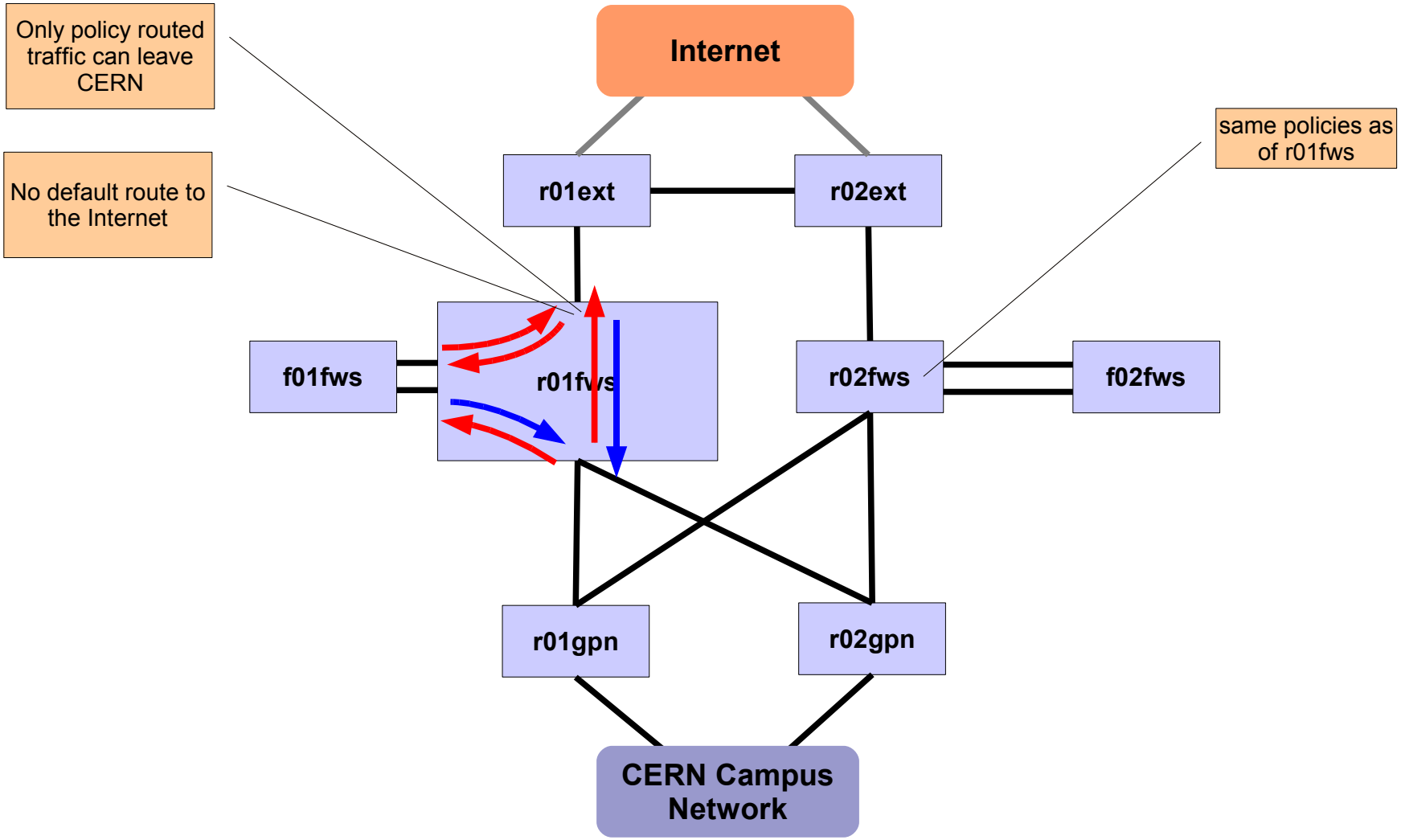
iBGP peerings between Loopback1s

iBGP peerings between Loopback2s

Routing: Static routes



Routing: Policy Based



Keys:

Policy Routed traffic

Routed traffic

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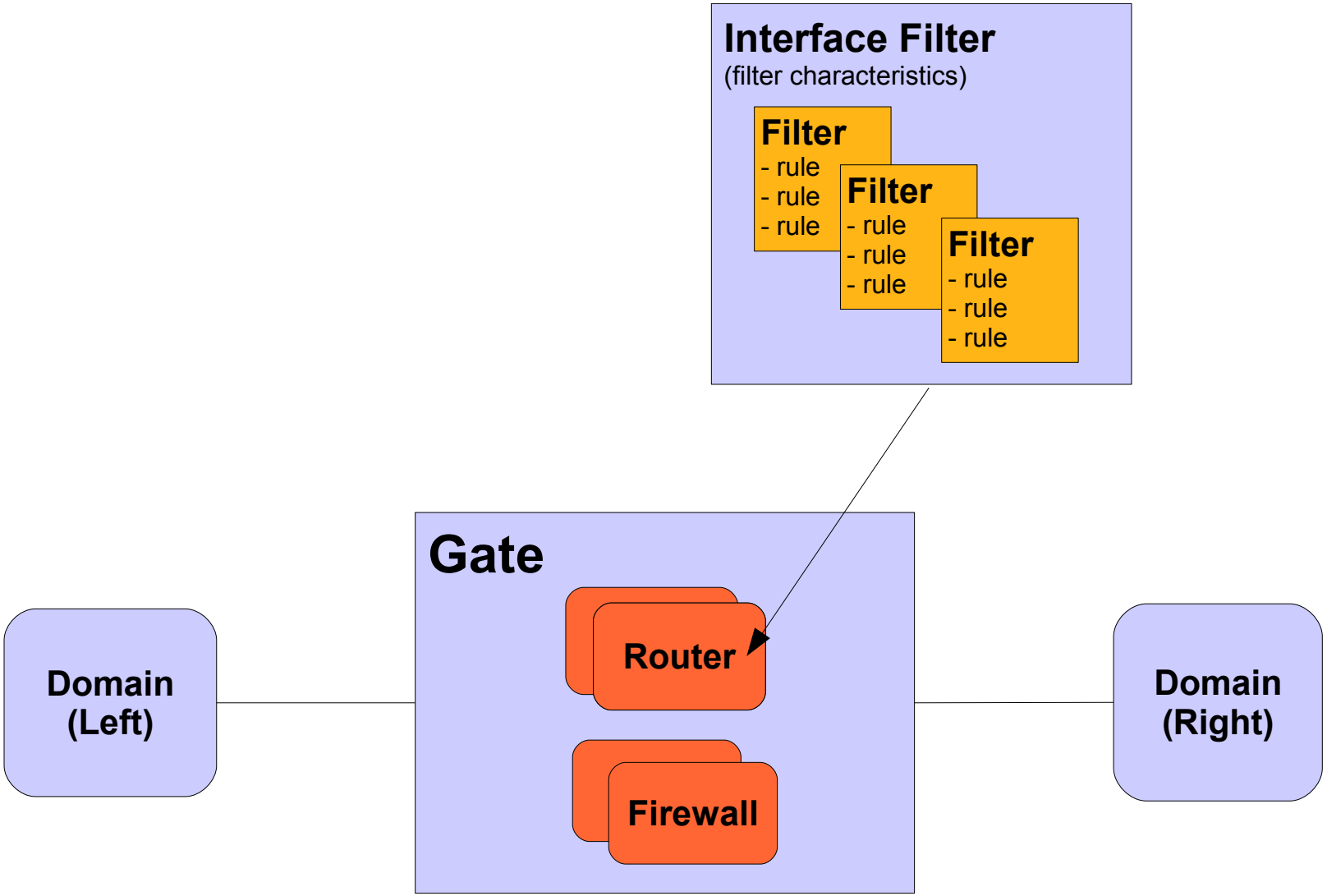
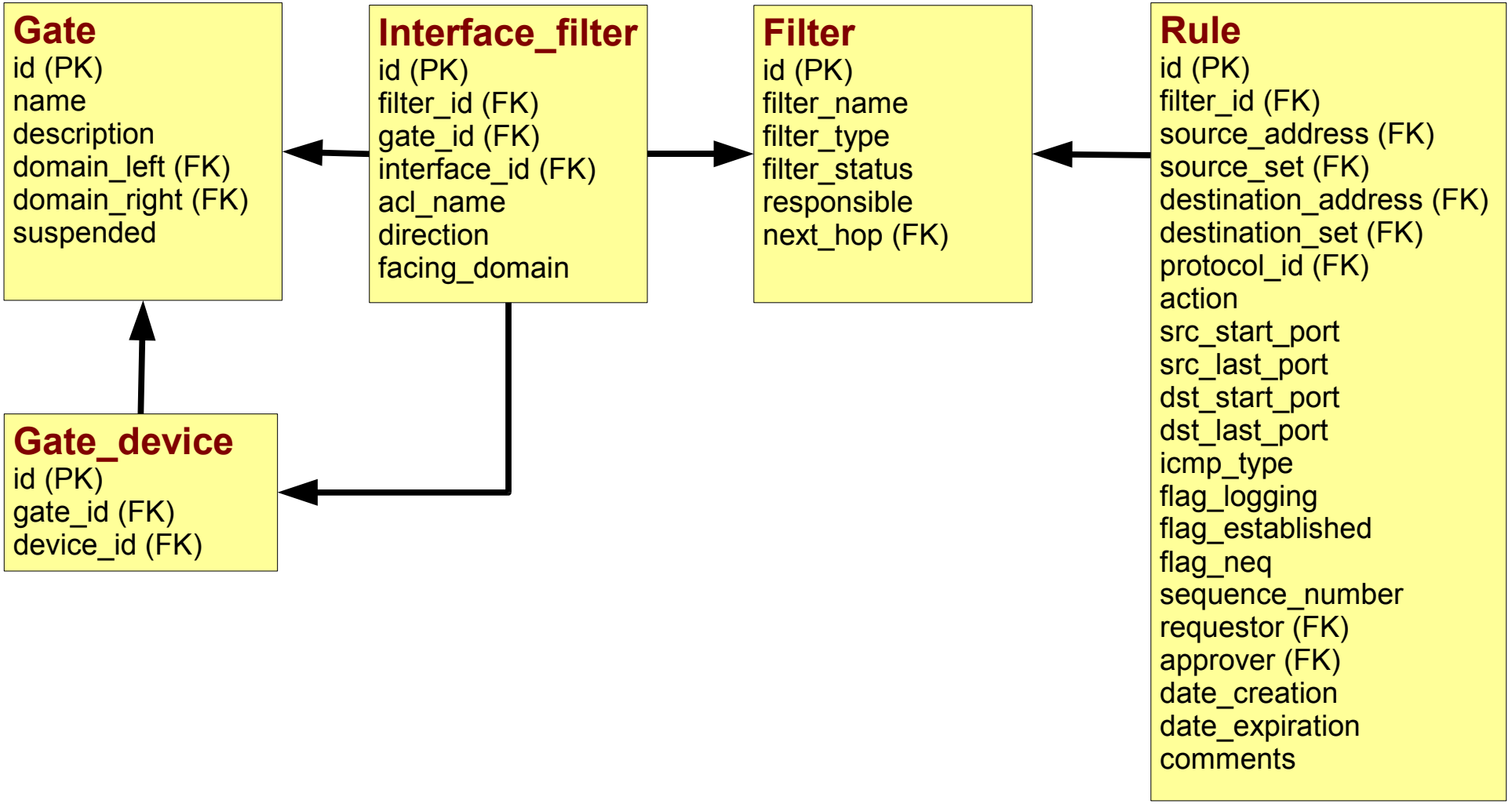
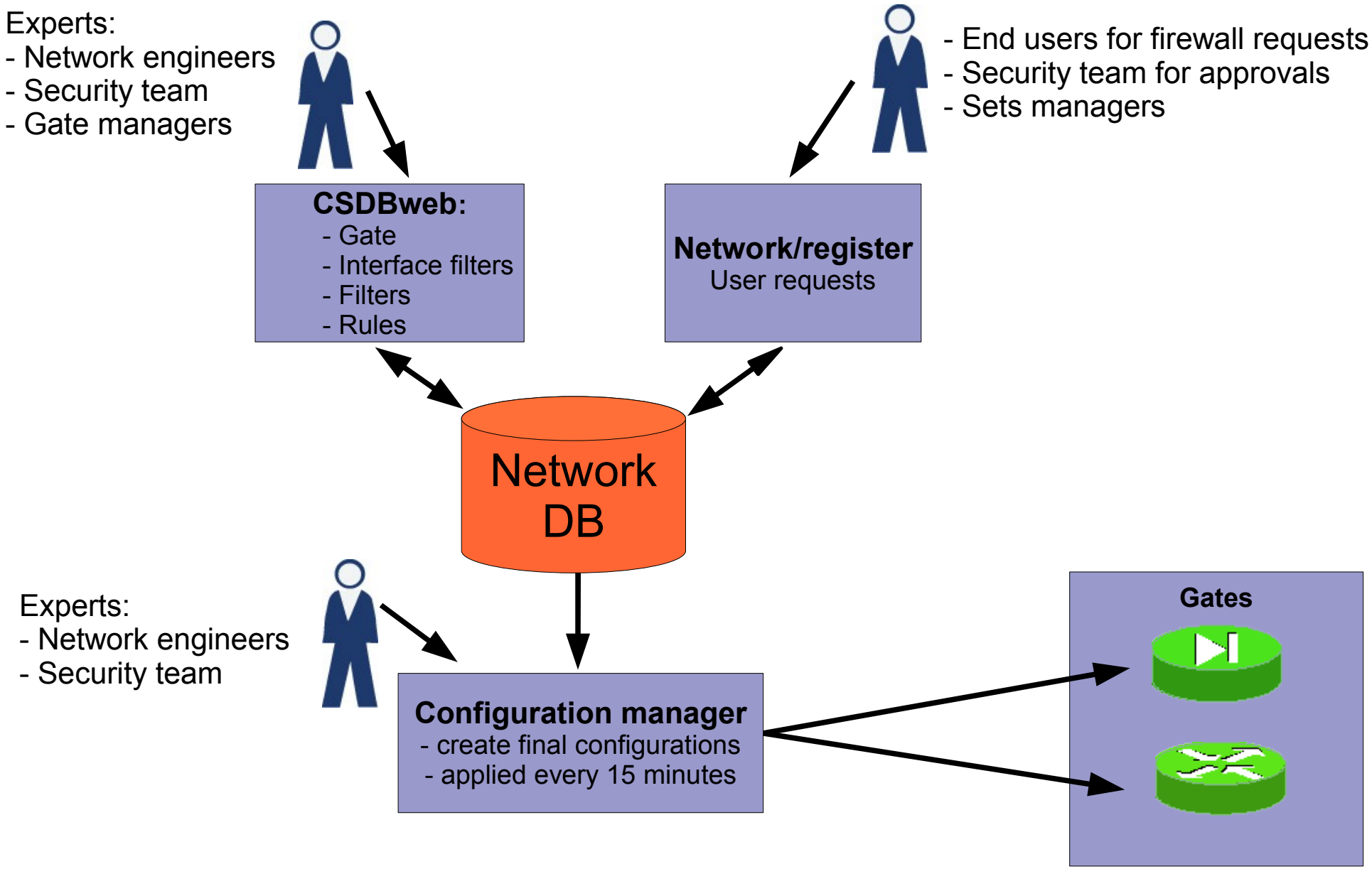
The Gate model



The Database schema



Gates framework's components



CSDBweb Gates

Web interface to define the Gate, its Interface filters, Filters and Rules.

Developed in Java

For expert user

Gate

Gate

Gate Name: INTERNET_GPN_1 | Query | Record 1 of 2 | Reset | << | >>

Domain Left: INTERNET

Domain Right: GPN

Gate suspended: ☐

Devices:

Sel	Name
☐	[illegible]FCIFM-[illegible]
☐	[illegible]-RCI[illegible]

Interface Filters:

Sel	Name	Type	Interface
☐	IFW1_GPN_ACL_IN	ACL	[illegible]-FCIFM-[illegible]
☐	IFW1_GPN_ACL_OUT	ACL	[illegible]-FCIF[illegible]
☐	IFW1_INTERNET_ACL_IN	ACL	[illegible]FCIFM[illegible]1
☐	IFW1_INTERNET_ACL_OUT	ACL	[illegible]-FCIF[illegible]1-FE1
☐	IPR1_FW_GPN_ACL_IN	ACL	[illegible]RCI76-1[illegible]
☐	IPR1_FW_GPN_ACL_OUT	ACL	[illegible]-RC[illegible]1-FE1
☐	IPR1_FW_GPN_PBR_ANY	PBR	[illegible]-RC[illegible]
☐	IPR1_FW_INTERNET_ACL_IN	ACL	[illegible]-RC[illegible]1-FI1
☐	IPR1_FW_INTERNET_ACL_OUT	ACL	[illegible]-RC[illegible]
☐	IPR1_GPN1_ACL_IN	ACL	[illegible]RC[illegible]1-PG5
☐	IPR1_GPN1_ACL_OUT	ACL	[illegible]E-RCI[illegible]
☐	IPR1_GPN1_PBR_FW	PBR	[illegible]-RC[illegible]1-PG5
☐	IPR1_GPN1_PBR_HTAR	PBR	[illegible]E-RCI[illegible]1-PG5
☐	IPR1_GPN1_PBR_NULL	PBR	[illegible]RCI76-1-PG5
☐	IPR1_GPN2_ACL_IN	ACL	[illegible]E-RCI[illegible]1-PG6
☐	IPR1_GPN2_ACL_OUT	ACL	[illegible]-RC[illegible]
☐	IPR1_GPN2_PBR_FW	PBR	[illegible]-RC[illegible]1-PG6
☐	IPR1_GPN2_PBR_HTAR	PBR	[illegible]-RC[illegible]PG6
☐	IPR1_GPN2_PBR_NULL	PBR	[illegible]E-RCI[illegible]
☐	IPR1_INTERNET_ACL_IN	ACL	[illegible]-RC[illegible]PE1
☐	IPR1_INTERNET_ACL_OUT	ACL	[illegible]E-RC[illegible]1-P[illegible]
☐	IPR1_INTERNET_PBR_FW	PBR	[illegible]-RC[illegible]PE1
☐	IPR1_INTERNET_PBR_NULL	PBR	[illegible]-RC[illegible]1-P[illegible]

Add Device | Remove Device | Add I-Filter | Remove I-Filter

Description: Main CERN Gate

Interface Filter

Interface Filter

I-face Filter Name: GPN_TN_OUT_B513 [Query] Record 1 of 1 [Reset] [<<] [>>]

Gate: TECHNET-GPN
Direction: OUT
Type: Acl
Status: Active
Interface: T[illegible]-R[illegible]0-2-IB1
Facing Domain: Left
ACL Name: TN-GPN
Default Action: permit any any
[Responsible:] TECHNICAL-NETWORK ADMINISTRATOR

Description: GPN-TN filter router in the CC

[Insert I-Filter] [Update I-Filter] [Remove I-Filter]

Filters

Sel	Filter	Type	Status	Responsible
☐	CNIC-TN	NORMAL	ACTIVE	TECHNICAL-NETWORK ADMINISTRATOR

[Add Filter] [Remove Filter] [Move Up] [Move Down]

Filter

Filter

Filter Name: L2E_PERMIT_SERVERS_DELEGATED | Query | Record 1 of 1 | Reset | << | >>

Type: Normal | Status: Active

Responsible: COMPUTER SECURITY

Description: Permit packets sent to authorised servers

Insert Filter | Update Filter | Remove Filter

Rules

Sel	SeqNo	Action	Protocol	Left Address	Ports	Right Address	Ports
	20	PERMIT	TCP	0.0.0.0/255.255.255.255 [Any]		.../... [IT CC LXPLUS]	eq 22
	40	PERMIT	TCP	0.0.0.0/255.255.255.255 [Any]		.../... [IT CC CASTOR ALICE DISKSERVER]	eq 2811
	45	PERMIT	TCP	0.0.0.0/255.255.255.255 [Any]		.../... [IT CC CASTOR ATLAS DISKSERVER]	eq 2811
	50	PERMIT	TCP	0.0.0.0/255.255.255.255 [Any]		.../... [IT CC CASTOR CMS DISKSERVER]	eq 2811
	55	PERMIT	TCP	0.0.0.0/255.255.255.255 [Any]		.../... [IT CC CASTOR ITDC DISKSERVER]	eq 2811
	60	PERMIT	TCP	0.0.0.0/255.255.255.255 [Any]		.../... [IT CC CASTOR LHCB DISKSERVER]	eq 2811
	65	PERMIT	TCP	0.0.0.0/255.255.255.255 [Any]		.../... [IT CC CASTOR PUBLIC DISKSERVER]	eq 2811
	70	PERMIT	TCP	0.0.0.0/255.255.255.255 [Any]		.../... [IT CC CASTOR ALICE DISKSERVER]	range 20000-21000
	75	PERMIT	TCP	0.0.0.0/255.255.255.255 [Any]		.../... [IT CC CASTOR ATLAS DISKSERVER]	range 20000-21000
	80	PERMIT	TCP	0.0.0.0/255.255.255.255 [Any]		.../... [IT CC CASTOR CMS DISKSERVER]	range 20000-21000
	85	PERMIT	TCP	0.0.0.0/255.255.255.255 [Any]		.../... [IT CC CASTOR ITDC DISKSERVER]	range 20000-21000
	90	PERMIT	TCP	0.0.0.0/255.255.255.255 [Any]		.../... [IT CC CASTOR LHCB DISKSERVER]	range 20000-21000
	95	PERMIT	TCP	0.0.0.0/255.255.255.255 [Any]		.../... [IT CC CASTOR PUBLIC DISKSERVER]	range 20000-21000

Rule

Traffic Rule

Filter Name: L2E_PERMIT_SERVERS_DELEGATED_LOW_PORTS — Reset — Show Ga es

Action: permit — Protocol: UDP

Rule Seq. No: 25 — App Type:

ICMP Type: — Code: — Connection established: ☐ — Logging On: ☐

Rule Commented: ☐

Left:

Type: Any — Name: — Find

Address: 0 . 0 . 0 . 0 — Mask: 255 . 255 . 255 . 255

Ports: 0 - 65535 NEQ ☐

Right:

Type: Set — Name: IT SECURITY FIREWALL DEBUGGING — Find

Address: — Mask:

Ports: 55 5 NEQ ☐

- Network
- Set
- Service
- Host
- Unknown
- Any

Metric:

Requestor: CURITY — Approver:

Creator: R SECURITY

Create Date: 05-MAR-2007 — Effective Start Date: 05-MAR-2007

Expiration Date: — Reconfirmation Date: 23-FEB-2007

Justification:

http://Network/Register

Web form to request firewall openings.

Developed in Java

For end users

Network/register for End-Users

End Users can request firewall openings for their devices:

Network Connection Request Form V 9.0 .

Main Menu	Update Information	New Connection	New Terminal Connection	Move System	Disconnect/Delete
Display Information	ServiceChange	Register Portable	New Portable Outlet	Disconnect Portable Outlet	Last Operation

emartell logged in
Logout
Visitor Requests
Procedure
Submit
Sign
Blocked Systems
By IP
By Hardware
Register
About
Problems?
SOAP access
MIKE
Set Mgmnt
Admin Requests
FAQ
News Subscribe
HELP!!!
Topology
By Building
By StarPoint
Apropos...
Portables
DHCP

Network Connection Request Forms - Update Information

The following information about a device which is already connected to the CERN Computer network corresponds to what we have in our databases at the moment. Please modify this information if necessary.
However, for modifications to the CERN Network Domain or Medium, please go back and select the appropriate option.
Mandatory fields are marked with (*). Please do not forget to submit your request by selecting the **'Send Request'** button at the end of this page. HELP is available by selecting the links on this page.
For any questions or comments, please contact NETOPS.

The fields have been filled with the information we have in our databases. Please change them as desired.

Update PCITCSEM

- **Device Name:** PCITCSEM [Last Operation] — Rename To: PCITCSEM
- Location: 0031 R-0024 — (Zone:)
- Outlet: 0024/04 (This plug connects a fan-out)
  (To change location, use "Move System")

- Manufacturer: (*) IBM
- Model/Type:(*) THINKPAD T42
- Generic Type: COMPUTER
- Operating System:(*) WINDOWS XP + LINUX
- Op. Syst. Version:(*) DEBIAN

Central Firewall Configuration (connections from outside CERN)

This device has a default firewall configuration which allows connections from CERN to the Internet. Requests for additional firewall access **are not** normally accepted. If you have a justified request endorsed by your Group Leader or Experiment technical Coordinator then please select the box below.

Make Firewall Request >>>
(Please note that firewall configurations can be overriden for devices which are members of a SET.)

Network/register for End-Users

Standards request might be approved more quickly

Firewall Authorisation Requests - New Request

You are requesting direct Internet access for your machine in the main CERN Firewall.

Please be aware that machines directly exposed to the Internet will be continually attacked and create a risk for the rest of the site. To avoid this you should access your machine from off-site using an intermediate gateway system as decribed at http://cern.ch/security/Internet.

Note that direct off-site SSH access is not normally accepted. You should reach your system via LXPLUS which has additional intrusion checks.

If the methods described above cannot be used and you still wish to request direct Internet access then complete the following form:

Mandatory fields are marked with (*). Please do not forget to submit your request by selecting the **'Send Request'** button at the end of this page. HELP is available by selecting the links on this page.
For any questions or comments related to this firewall request form please contact the CERN Computer Security Team · computer.security@cern.ch.

Request Information

- **Interface name:**(*) PCITCSEM
- **Service:**(*) Other

If Other, then please specify:

- Port number:
- Protocol:
- Application:

Hint: Give the name of the application

SSH server on port 22/tcp
Web server on port 80/tcp
Secure web server on port 443/tcp
Dual Web server (HTTP and HTTPS) on ports 80/tcp and 443/tcp
Alternate Web on tcp/8080
Alternate Secure Web on tcp/8443
MySQL server on port 3306/tcp
GridFTP on tcp/2811
Globus TCP Port Range on tcp/20000-25000
Globus UDP Port Range on udp/20000-25000
Oracle TNSLSNR on tcp/1521
CVS Server on tcp/2401
Other

- **Expiry date:**

Use this date when firewall access is needed on this date.

- **Describe the professional requirement for which direct Internet access is required.**(*)

Network/register for End-Users

Any request can be submitted:

- **Interface name:**(*) POITGSEM

- **Service:**(*) Other

If Other, then please specify:

- Port number: 179
- Protocol: TCP
- Application: BGP peerings

Hint: Give the name of the application listening on the port.

- **Expiry date:** / / (DD/MM/YYYY)

Use this date when firewall access is needed for a known duration. The firewall authorisation will be automatically removed on this date.

- **Describe the professional requirement for which direct Internet access is required.**(*)

BGP peering with external network

- **Explain why the recommended methods for accessing CERN from the Internet, as described at http://cern.ch/security/Internet, cannot be used.** If appropriate, explain why CERN's central services (e.g. web, J2EE, CVS, ...) cannot be used.(*)

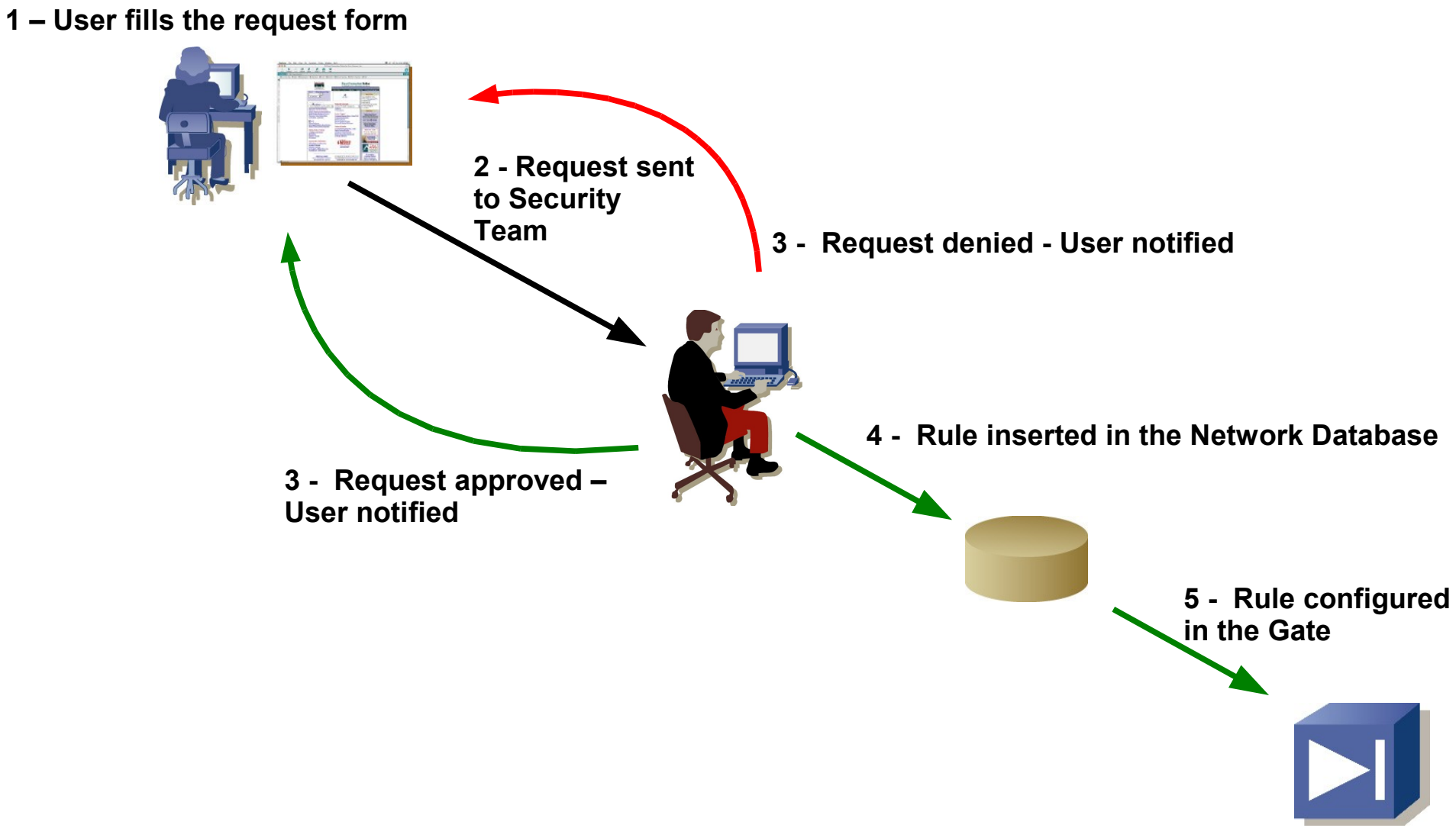
CERN doesn't provide this service

- **Explain how you ensure that the device for which firewall access is requested will be kept pro-actively secured for security updates.** (This includes the operating system and all installed applications).(*)

Machine centrally managed

- Enter the name of the Group Leader or the Experiment Technical Coordinator who has endorsed this request. If this request is related to an experiment then please also enter the experiment name.(*)
  - Name:(*) Jouanigot
  - First Name:(*) Jean-Michel
  - Department:
  - Group:
  - Experiment Name (if relevant):

Approval procedure



Network/register for End-Users

Users can check their current firewall openings

Interface(s) Information >>Network Service HELP<< >>Network Interface Card(s) HELP<<

Interface Name	IP Address	Service Name	External TCP/IP Connectivity
PCIT[illegible].CERN.CH	137.138.[illegible]	S31-S-AN5	OUTGOING

Subnet Mask: 255.255.0.0
Default Gateway: 137.13[illegible]

Name Servers: 137.138.[illegible], 137.138.1[illegible]
Time Servers: 137.138.[illegible], 13[illegible].130.[illegible]

IP Aliases: NONE

Interface belongs to set(s): TESTECS

Bound Interface Card(s): NONE

Outlet	CERN Network Domain	Medium
0020/04	GPN	FASTETHERNET

Central Firewall Configuration (connections from outside CERN)

Application	Port or Port Range	Protocol	Justification	Expiration date
GLOBUS-TCP	20000 - 25000	TCP	TEST	12-DEC-2009
SSH	22	TCP	SADC	
OTHER	4443	UDP	TESTDES	
HTTP	80	TCP	CASD	12-DEC-2010
GRIDFTP	2811	TCP	SADC	12-DEC-2030

(Please note that firewall configurations can be overriden for devices which are members of a SET.)

Network/register for Set Managers

Set-managers can control their sets and have firewall openings automatically applied:

Sets sub-menu

Display Set | New Set | Update or Delete Set

Update Set >>Sets HELP<<

Set Name:(*) IT CC CASTOR ATLAS DISKSERVER

Domain:(*) GPN

Responsible:(*) MANAGERONDUTY

CCSERVICE

Department: IT Group:

Description:(*) CASTOR ATLAS DISK SERVERS

Project Url: http://

INFO: You DO NOT have privileges to change set IT CC CASTOR ATLAS DISKSERVER

Set Type

This is an Inter-Domain Set (Domain filters)

Contents(*) (Click here for a list of all computers in set)

LXF[illegible]1.CERN.CH
LXF[illegible].CERN.CH
LXF[illegible].CERN.CH
LXFS[illegible].CERN.CH
LXF[illegible].CERN.CH
LXF[illegible].CERN.CH
LXFS[illegible].CERN.CH

Search for Device, Service

Device Name:

IP-Service:

Inter-Domain Set:

Traffic Rule

Filter Name: L2E_PERMIT_SERVERS_DELEGATED Reset Show Gates

Action: permit Protocol: TCP

Rule Seq. No: 45 App Type:

ICMP Type: Code: Connection Established: Logging On:

Rule Commented:

Left:

Type: Any Name: Find

Address: 0 . 0 . 0 . 0 Mask: 255 . 255 . 255 . 255

Ports: 0 - 65535 NEQ

Right:

Type: Set Name: IT CC CASTOR ATLAS DISKSERVER Find

Address: . . . Mask: . . . .

Ports: 2811 - 2811 NEQ

Metric:

Requestor: JAN VAN ELDIK Approver:

Creator: COMPUTER SECURITY

Create Date: 23-FEB-2007 Effective Start Date: 23-FEB-2007

Expiration Date: Reconfirmation Date: 10-OCT-2006

Justification:

Comments: Contact: (castor-operations@cern.ch)

Sets are also managed using SOAP interfaces.

Configuration manager

cfmgr-gates creates and applies the configuration

Developed in Perl

For expert users

cfmgr-gates

Every 15 minutes:

- extracts all the Gate information and rules from the Network Database

- builds the configurations for all the devices

- optimizes access lists

- checks consistency

- estimates hardware resource utilization

- if everything is OK, automatically downloads every configuration that needs to be updated

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ACL's memory depletion

Powerful software framework with almost no limitation in term of number of rules, but the policies have to be implemented in real hardware

```
cfmgr gate check> aclresources

*** Routers ACL resource consumption ***

 Router  Used resources

 F01FWS  ACL entries 3831 (5%)
 F02FWS  ACL entries 3831 (5%)
 R01EXT  Masks 1008 (24%), entries 3775 (11%), LOUs 18 (14%)
 R02EXT  Masks 1008 (24%), entries 3775 (11%), LOUs 18 (14%)
```

ACL's memory depletion (2)

Caution: depending on the hardware, some ACL operators can use a huge amount of ACLs memory:

30 lines like this:

```
permit tcp src range 2000-20000 dst range 2000-10000
```

can use all the available memory

PBR and CPU utilization

Caution: some policy operators are executed in the Route Processor's CPU and not in the line cards' network processor (and such behavior is not always documented).

Other BGP configurations

Several possibilities:

eBGP:

- public AS in the WAN network, private AS in the Campus.
- BGP confederation.

pro: eBGP requires less peerings

cons: too many changes in the live WAN network

iBGP:

pro: easily implemented in the live network

cons: many more peerings, the full-mesh must be preserved

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Conclusions

Stateful firewall

- ready for increasing traffic load
- easily expandable when the market will be ready

Overall bandwidth

- matches the CERN Internet connectivity
- can scale beyond 80Gbps

Management framework

- fully use of the Network database
- manages any gate

Automatic Gate updates

- in case of any change in the database

A complex system that makes everybody's life simpler

Questions?