Network Infrastructure Security in Cellular Data Networks: An Initial Investigation

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Outline of the Talk

- **Motivation – why worry about *infrastructure security*?**
- **GSM /GPRS network architecture & critical interfaces**
- **Attacks exploiting security loopholes in GSM/GPRS**
- **Impact of unwanted traffic: viruses, worms, trojans, …**
- **Testbed setup and testing scenarios**
- **Methodology: nature of tests possible, what else is needed**
- **Tools for investigating network security**

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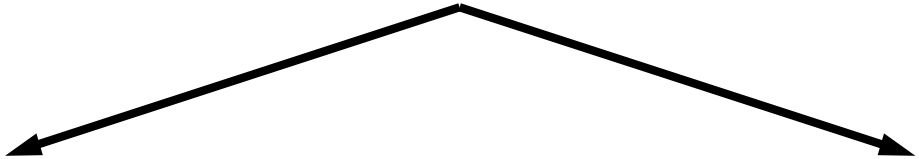
Why *Infrastructure Security* ?

Network Security



Information Security	Infrastructure Security
- Keeping user's info. protected	- Sustaining ability of network elements to provide connectivity between communicating entities
- Subject of cryptography	
- Not subject of this talk	- Subject of this talk

Cellular GSM/CDMA networks moving to an IP core …

- **Network increasingly open**
- **Control/data segregation inherently less stringent**
- **Increased threats! … Exposure to wireline-like security risks**

Motivation (contd)

- **Interplay of IP and complex structure of cellular networks**
  - ⇒ **Gives rise to subtle phenomena …**

    … that may not be easily conceived
  - ⇒ **Need to be found empirically via intelligent experimentation**

- **Provider *infrastructure* security becomes *key,* imperative to …**
  - **Investigate susceptibilities and risks**
  - **Evaluate options, fixes, and solutions**
  - **Propose techniques and tools for proactive/reactive action**

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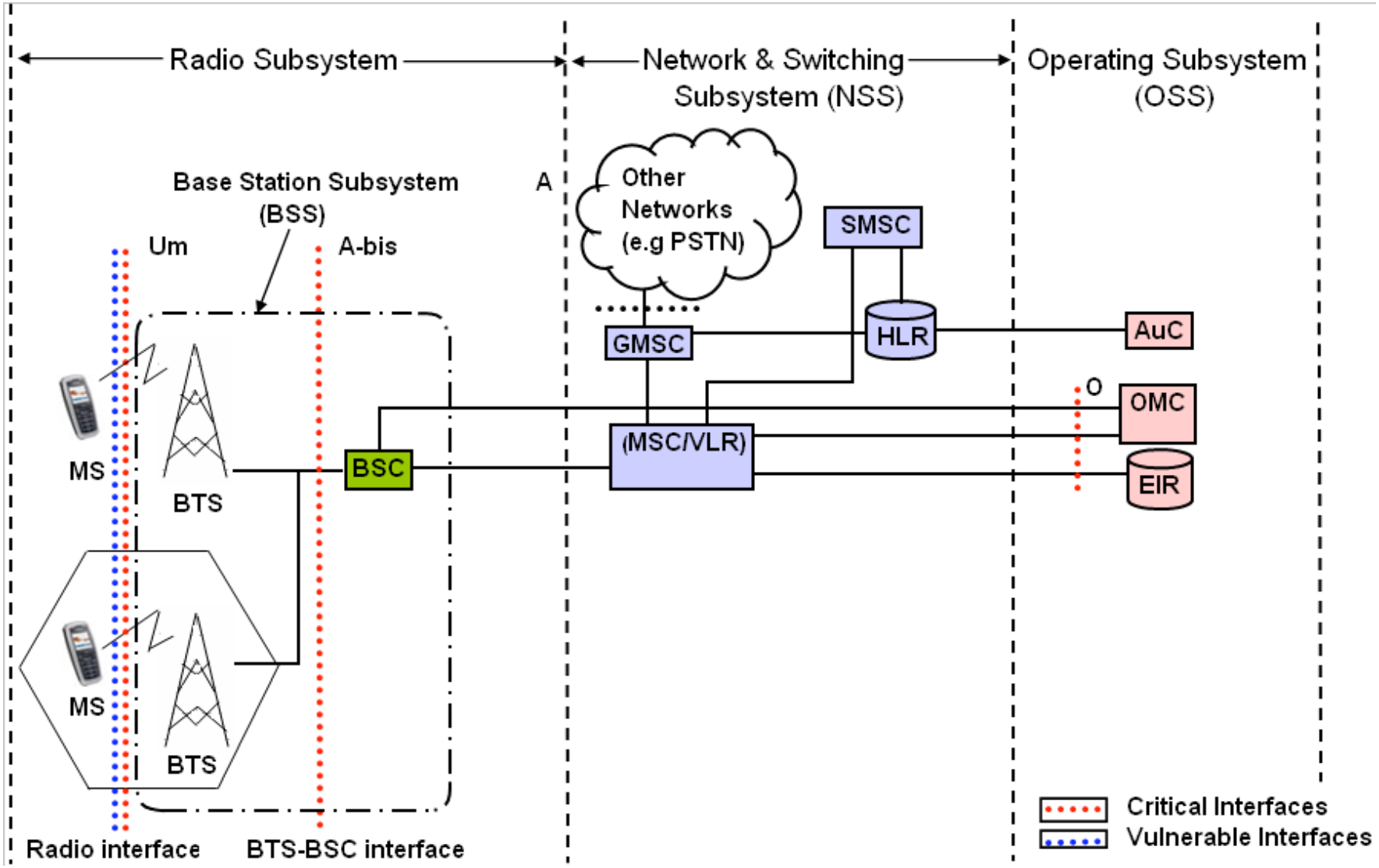
GSM Network Architecture

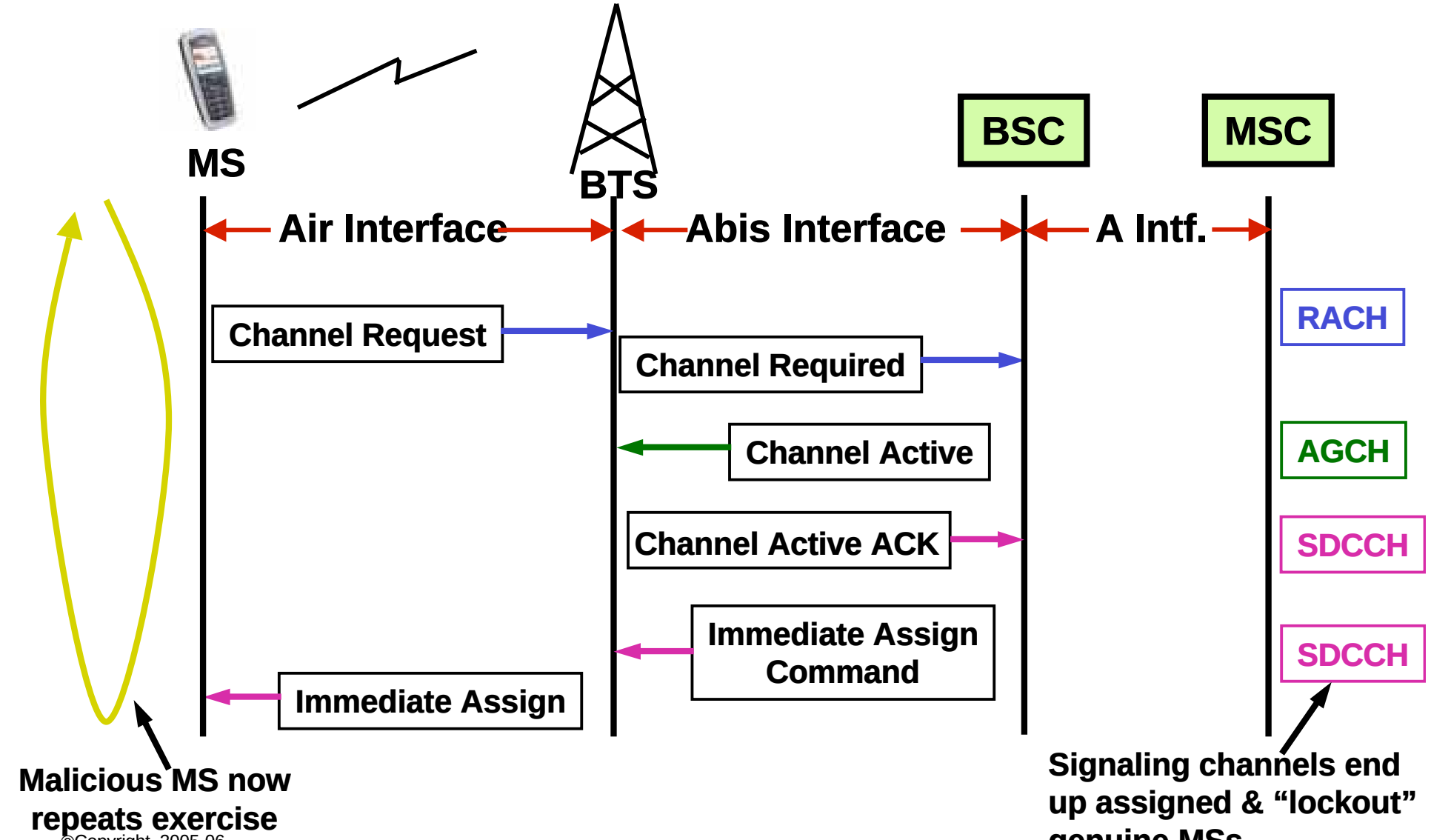


Vulnerabilities in GSM

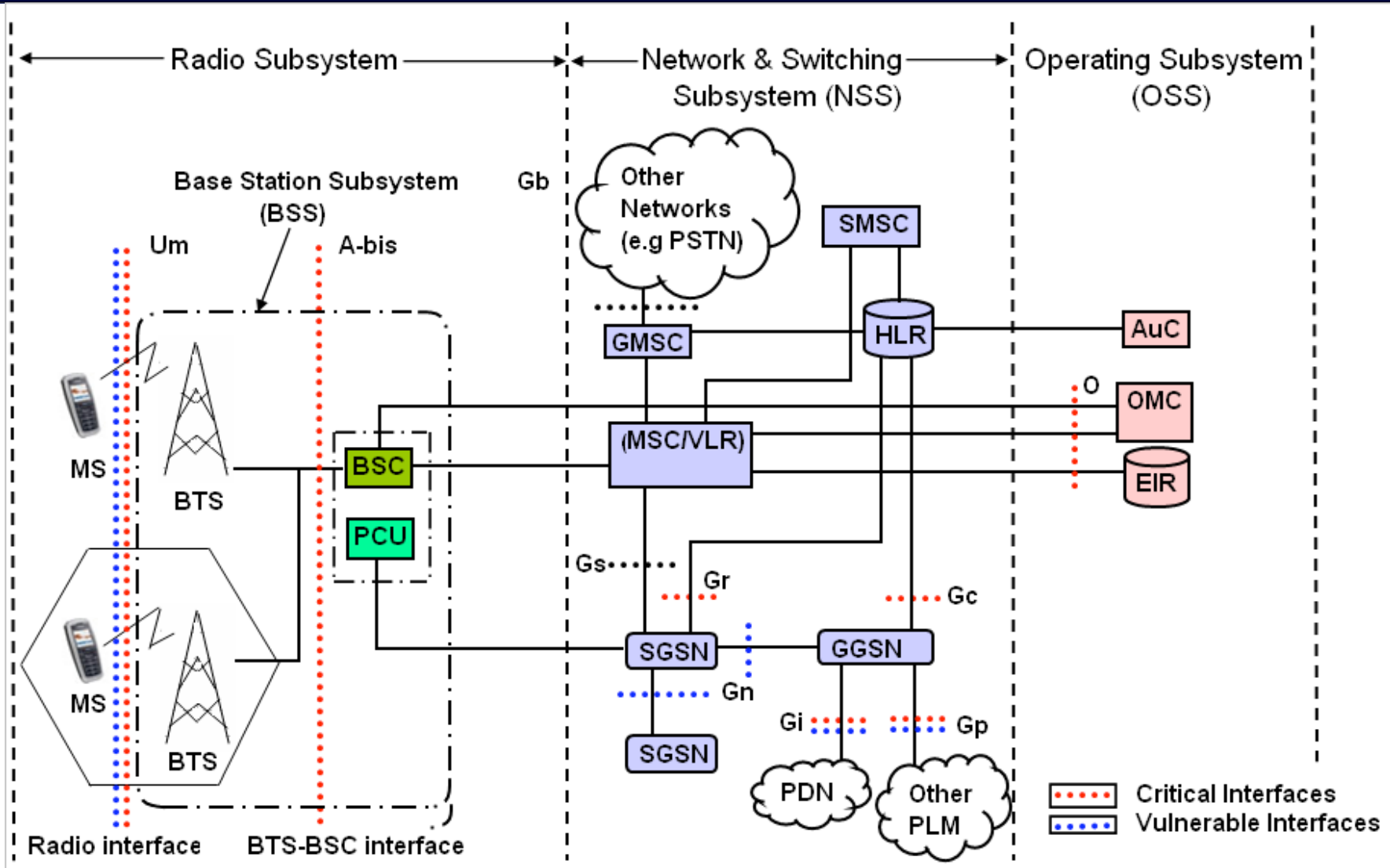
Flaws in authentication and encryption

- No subscriber auth. in initial part of mobile originated call
- Radio interface well protected, fixed infrastructure vulnerable
- Access to AuC allows attacker to obtain auth. key
  - Encrypted MS ↔ BS traffic can be captured & deciphered
- GSM encryption has been broken!
  - Large scale attacks can be launched with relatively small traffic vols.

A Signaling Channel DoS Attack in GSM



GPRS Network Architecture



Vulnerabilities and Criticalities in GPRS

Critical Interfaces

Gi: Exposed to Internet and corporate networks

Gp: Primary interconnection pt. between operator's n/w and untrusted external n/ws

Gc: Allows access (via HLR) to key user info. from remote network during roaming

Vulnerable Interfaces

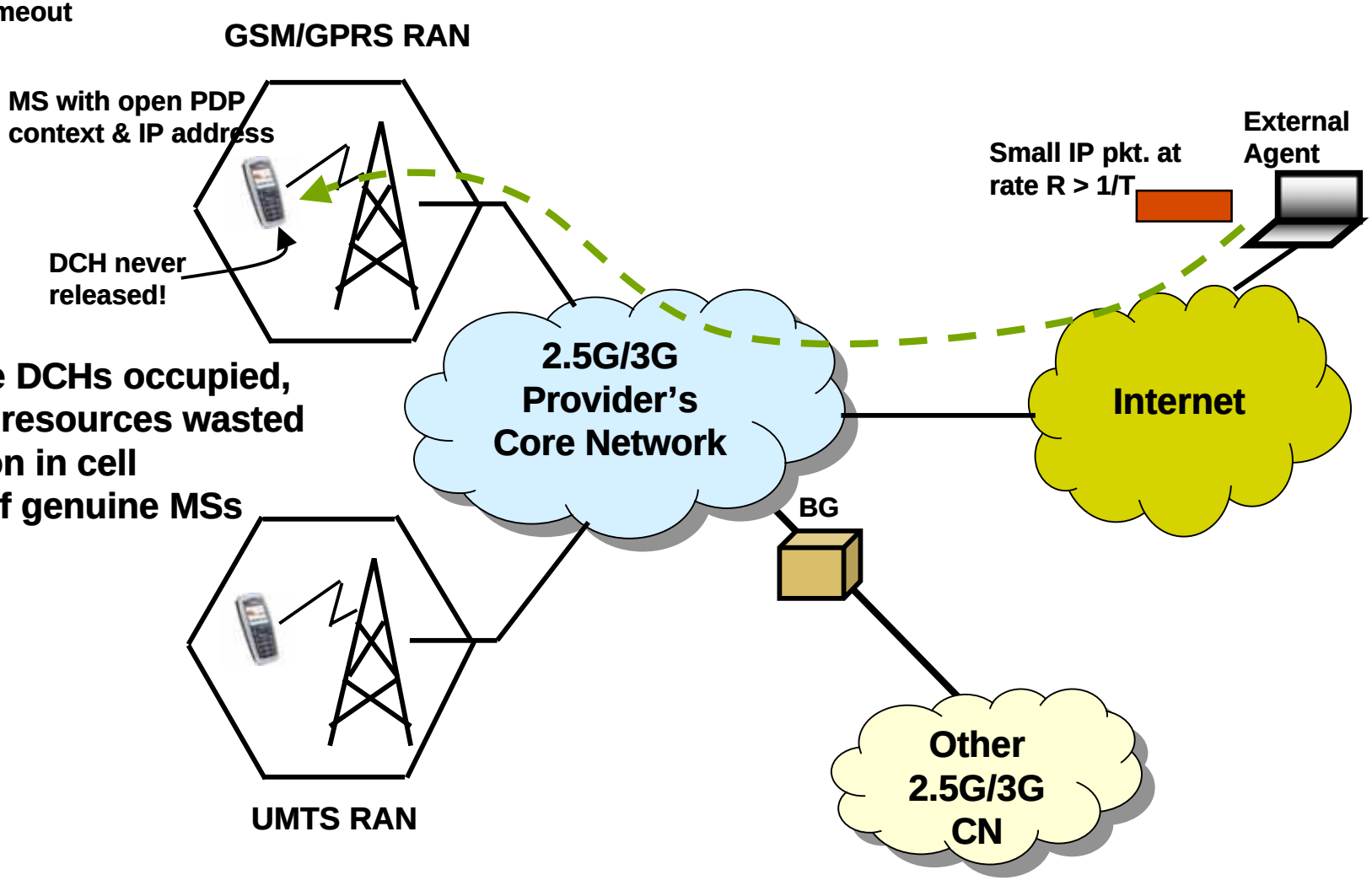
Gi: Exposed to all threats from Internet: viruses, DoS, and malicious network traffic

Gp: Connection hijacking, over-billing from a roaming network during handover

Gn: Not encrypted by default

A DCH "Lockout" Attack in GPRS

T = DCH release/dynamic reassignment timeout

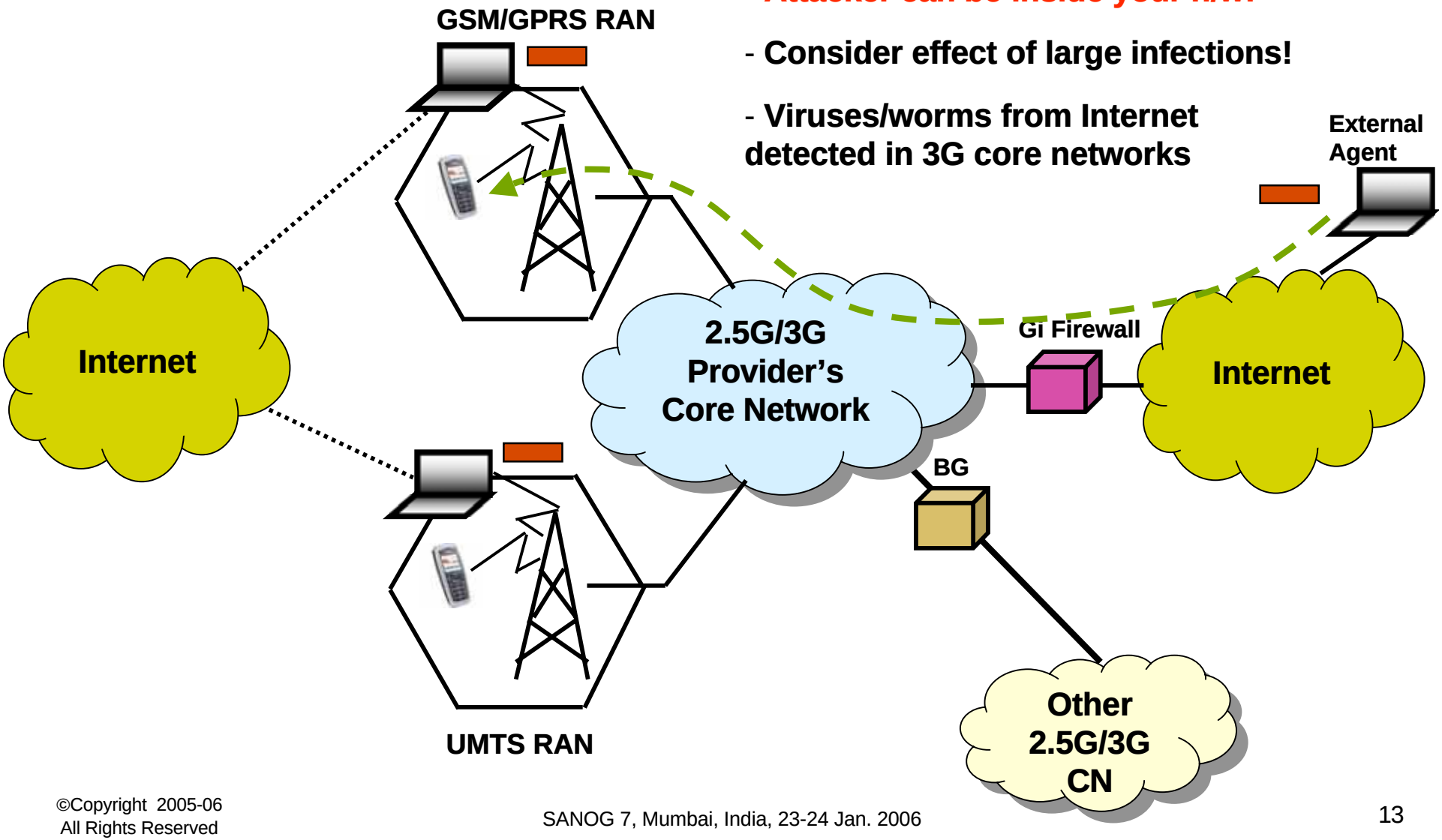


With multiple DCHs occupied, logical radio resources wasted

➔ **Congestion in cell**

➔ **Lockout of genuine MSs**

Impact of Unwanted Traffic: Viruses, worms, trojans, …



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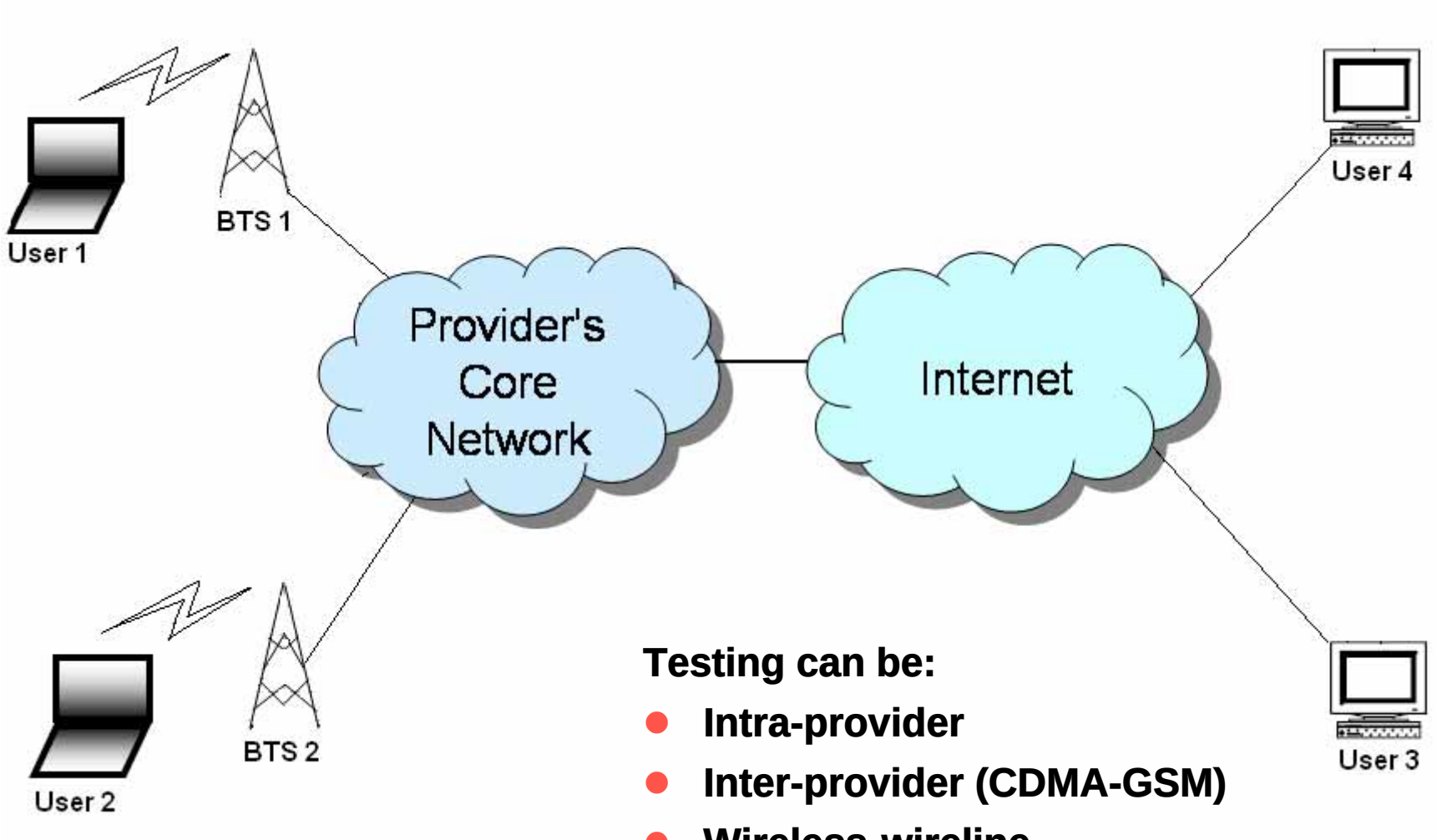
Experimental Test-bed Setup & Testing Scenarios



Testing can be:

- **Intra-provider**
- **Inter-provider (CDMA-GSM)**
- **Wireless-wireline**

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Testing Methodology

Taxonomy of Tests

Active Probing

Direct malicious generated traffic to SP's network or to a remote m/c on network. E.g.

- **SYN attack**
- **Tear-drop attack**
- **Smurf attack**

Exploit various types of commun.

- **Port-to-port**
- **IP address spoofing**

Infer network parameters: RTT, buffers

Passive Listening

Provoke remote attacker(s) to attack m/c under observation

- **Invoke attacks, HoneyD as "bait"**
- **Run intrusion detection systems on attacked m/c**
- **Apply intelligent algorithms for proactive threat inference**

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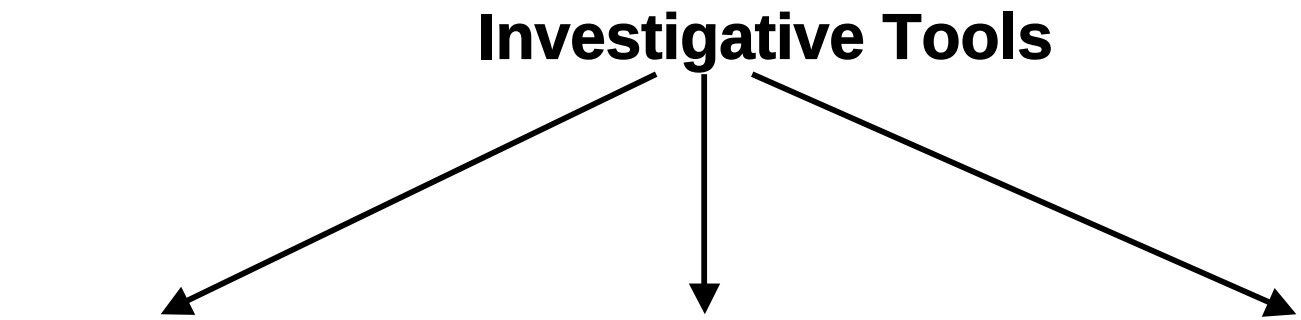
Network Security Investigation



Detect

- NMAP
- Netcat

Exploit

- Honeyd
- PackEth

Analyze

- Snort
- NTOP

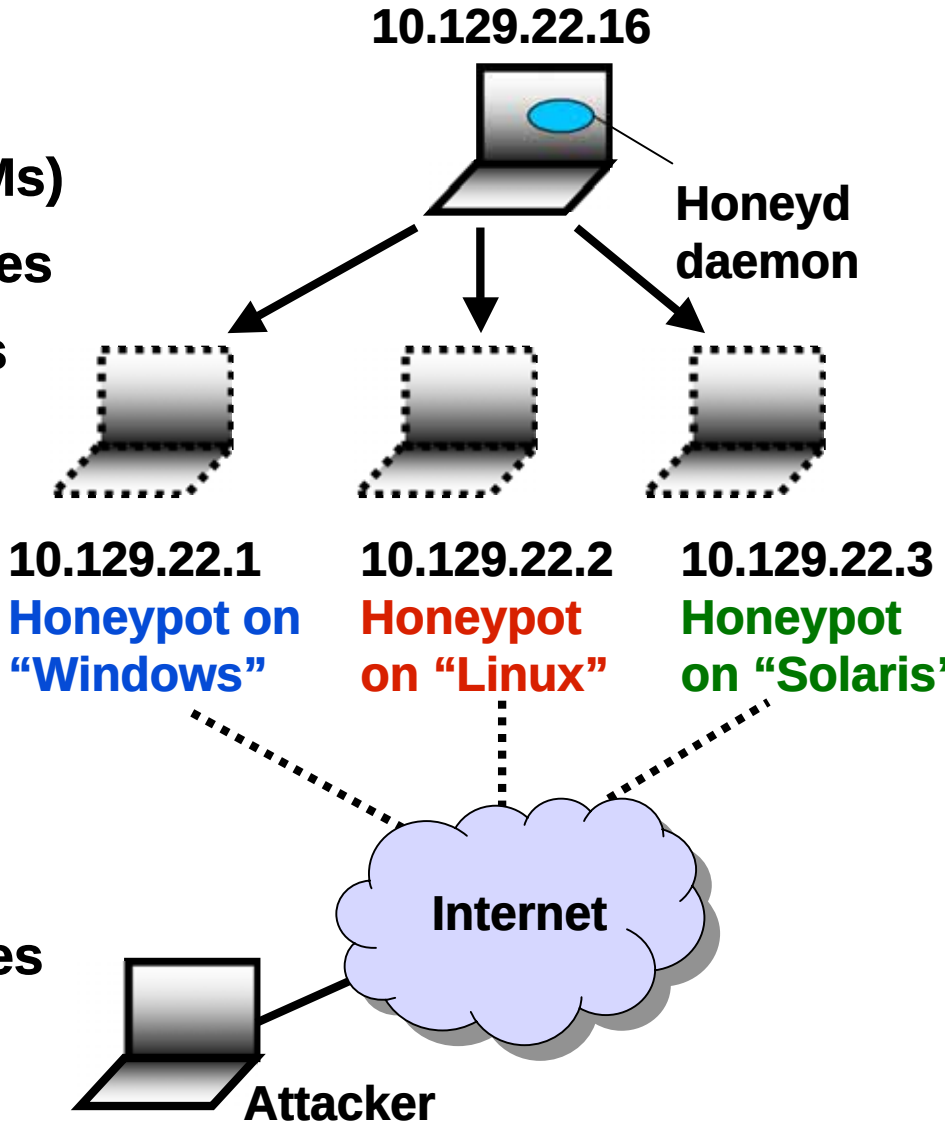
Tools for Detecting Vulnerabilities

- **Network MAPper (NMAP)**
  - **Determines running apps. on target m/c**
  - **Identifies open ports, OS, firewalls used by remote host(s)**

- **Netcat**
  - **Utility used to read/write across network connections using TCP/UDP protocol(s)**
  - **Feature-rich, network debugging and exploration tool**

Tools for Exploiting Vulnerabilities

- **HoneyD:**
  - Creates virtual machines (VMs)
  - VMs have unique IP addresses
  - Lure attackers to themselves
  - Can be Windows or Linux
- **PackETH**
  - Packet generator
  - Generates packets of any protocol - ARP, TCP, UDP, ...
  - User configurable pkt. profiles



Tools for Analyzing Vulnerabilities

- **Snort**
  - **Real-time traffic analysis & packet logging**
  - **Usable in multiple modes:**
    - **Packet sniffer**
    - **Data logger**
    - **Intrusion detection**
  - **Generates variety of alerts – usable for proactive detection**
- **NTOP**
  - **Traffic usage monitor & packet analyzer**
  - **Supports mgt. activities: planning, opt., detection**
  - **Tracks ongoing attacks, generates alarms**

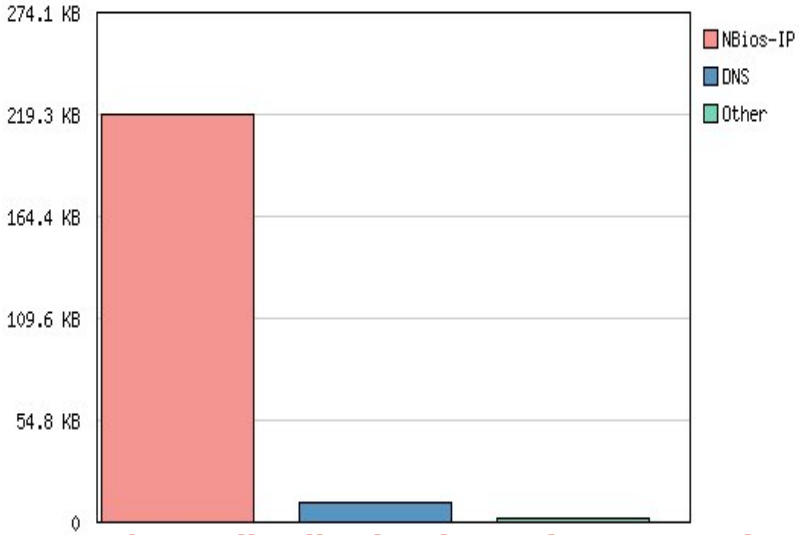
NTOP at Work

Host	Domain	IP Address	MAC Address	Other Name(s)	Bandwidth
dnscache.iitb.ac.in		10.200.1.11			
10.11.1.99		10.11.1.99	00:03:0D:32:1B:85		
10.11.201.89		10.11.201.89	00:13:20:2A:25:85		
10.11.100.70		10.11.100.70	00:11:11:8C:3E:CA		
10.11.201.54		10.11.201.54	00:50:BF:62:F9:7B		
bridge sp. tree/osi route:00:00:00			01:80:C2:00:00:00		
d-link systems, inc.:00:00:00			00:80:C8:00:00:00		
10.11.11.16		10.11.11.16	00:03:47:6B:AA:98		
10.11.200.65		10.11.200.65	00:08:A1:7B:AD:81		
router.hostel11.iitb.ac.in		10.11.250.1	00:04:96:10:4A:00		
extreme networks:00:00:00			00:E0:2B:00:00:00		

Traffic breakdown by hosts seen

Packets			
	Longest		1,514 bytes
	<= 64 bytes	38.9%	2,625
	64 to 128 bytes	42.4%	2,856
	129 to 256 bytes	14.9%	1,005
	257 to 512 bytes	1.2%	80
	513 to 1024 bytes	1.2%	79
	1025 to 1518 bytes	1.5%	98
	> 1518 bytes	0.0%	0

Packet size distribution



TCP/UDP distribution by major protocols

NMAP and Snort Working in Conjunction

root@localhost:~

File Edit View Terminal Tabs Help

```
[root@localhost ~]# nmap 10.129.33.19

Starting nmap 3.70 ( http://www.insecure.org/nmap/ ) at 2006-01-07
Interesting ports on bluechip.it.iitb.ac.in (10.129.33.19):
(The 1648 ports scanned but not shown below are in state: closed)
PORT     STATE    SERVICE
22/tcp   open     ssh
25/tcp   filtered smtp
53/tcp   open     domain
111/tcp  open     rpcbind
135/tcp  filtered msrpc
136/tcp  filtered profile
137/tcp  filtered netbios-ns
138/tcp  filtered netbios-dgm
139/tcp  filtered netbios-ssn
445/tcp  filtered microsoft-ds
631/tcp  open     ipp
3000/tcp open     ppp

Nmap run completed -- 1 IP address (1 host up) scanned in 1.553 sec
```

Attacking m/c: scans using NMAP

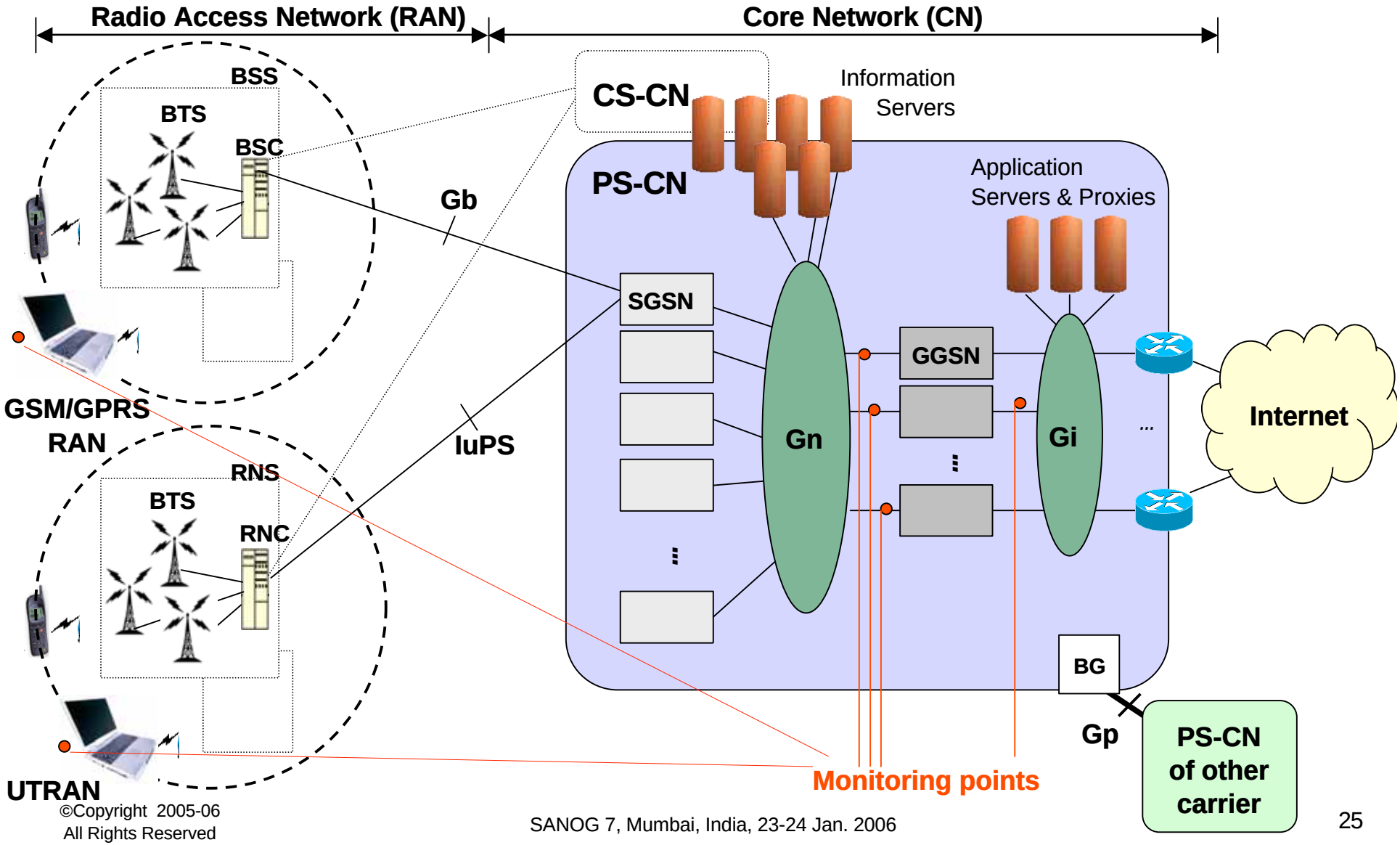
root@kavita: /home/kavitha

File Edit View Terminal Tabs Help

```
01/09-17:40:25.165892  [**] [1:524:8] BAD-TRAFFIC tcp port 0 traffic [**]
 [Classification: Misc activity] [Priority: 3] {TCP} 10.11.1.99:3815 -> 1
0.129.33.19:0
01/09-17:40:25.165915  [**] [1:524:8] BAD-TRAFFIC tcp port 0 traffic [**]
 [Classification: Misc activity] [Priority: 3] {TCP} 10.129.33.19:0 -> 10
.11.1.99:3815
01/09-17:42:07.267353  [**] [100:2:1] spp_portscan: portscan status from
10.11.1.99: 2 connections across 1 hosts: TCP(2), UDP(0) STEALTH [**]
01/09-17:40:32.375553  [**] [122:1:0] (portscan) TCP Portscan [**] {PROTO
255} 10.11.1.99 -> 10.129.33.19
01/09-17:40:32.457295  [**] [1:1421:11] SNMP AgentX/tcp request [**] [Cla
ssification: Attempted Information Leak] [Priority: 2] {TCP} 10.11.1.99:3
3984 -> 10.129.33.19:705
01/09-17:40:33.571994  [**] [1:1420:11] SNMP trap tcp [**] [Classificatio
n: Attempted Information Leak] [Priority: 2] {TCP} 10.11.1.99:33984 -> 10
.129.33.19:162
01/09-17:40:33.786574  [**] [122:17:0] (portscan) UDP Portscan [**] {PROT
0255} 10.11.1.99 -> 10.129.33.19
```

Exposed m/c: performs analysis via Snort

What More is Needed



Summary

- Cellular infrastructure security … critically important in future
- Analyzed GSM /GPRS from a vulnerability standpoint
- Highlighted key aspects, such as
  - Critical interfaces
  - Sample attacks
  - Effects of unwanted traffic!
- Presented our testbed setup and testing scenarios
- Focused on nature and types of test portfolio
- Reviewed tools and techniques to assess security

References and Glossary