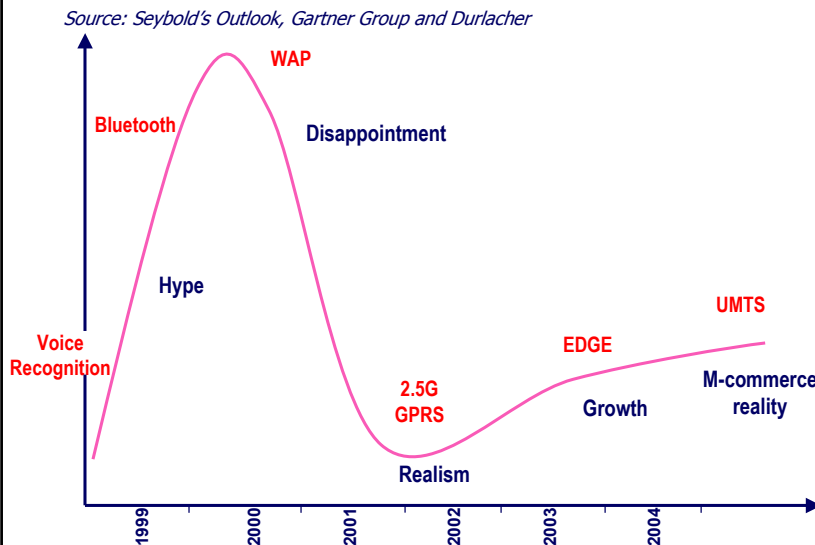


Open Issues in Content Distribution

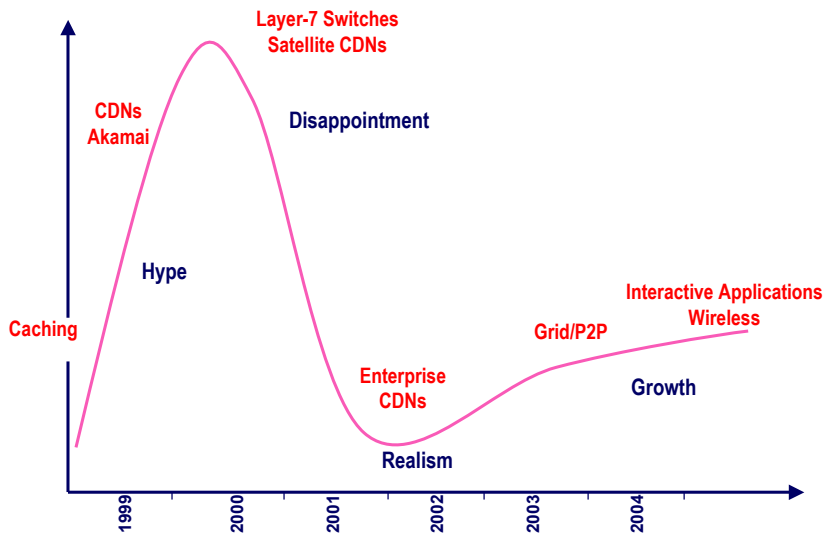
Pablo Rodriguez

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Wireless Data Evolution



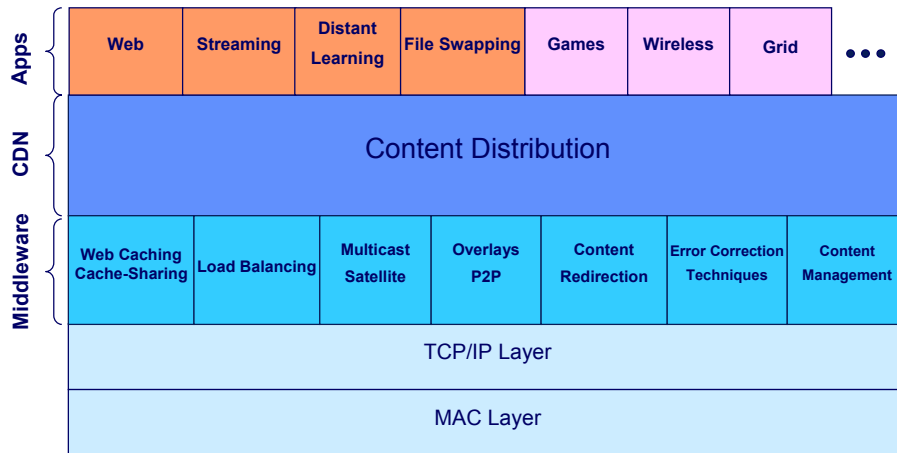
Content Distribution Evolution



Are CDNs still relevant?

- Adding resources in an arbitrary fashion is neither economical nor efficient long term.
- Content Distribution is about:
 - Bypassing/relieving bottlenecks
 - Cutting latency
 - Creating an application-purpose built overlay
 - Providing control, QoS, and application-level agreements
 - Economy of scale (sharing)
- CDNs are used to:
 - Relieve load in the most important Web sites
 - Minimize impact of flash crowds (e.g. Olympics)
 - Efficiently utilize enterprise resources

Content Distribution Middleware



Been there, done that...

- Cache replacement policies
- Inter-Cache sharing protocols
- Redirection Mechanisms
- Content Management...

Several Possible Research Areas

- Distributing Dynamic Content
- CDNs for Interactive Applications
- Wireless Content Distribution
- Minimizing maintenance/deployment costs

Dynamic Content Distribution

- Past: Focus on Static Web pages
- Future: Distribute intelligence of e-commerce/dynamic sites
- Still no complete solution
 - IBM & Akamai have tried for sometime now
 - Netli proposed to work around the problem
- Most content is dynamic in nature



**Distributed Transactions, Consistency,
Security, Reconciliation, Economics?**

Interactive Applications

- CDNs focused on one-way content delivery
- Interactive applications require
 - Two way content delivery (control, data)
 - Real time constraints
- Possible applications are:
 - Gaming infrastructure
 - » Mobile devices require streaming of gaming content
 - Upload of content from mobile devices



Real-time issues (delays, fairness), efficient uploads, client-side proxies

Wireless Content Distribution

- CDMA/UMTS/GPRS/WLAN networks are being deployed to provide ubiquitous mobile data access
- Wireless Data Networks bring a new set of problems for content distribution
 - **Poor Link Properties**
 - **Mobility**
 - **Scarce Resources**
- Wireless Content Distribution can significantly enhance Wireless Mobile Data Networking

Wireless Link Properties: Delays

```

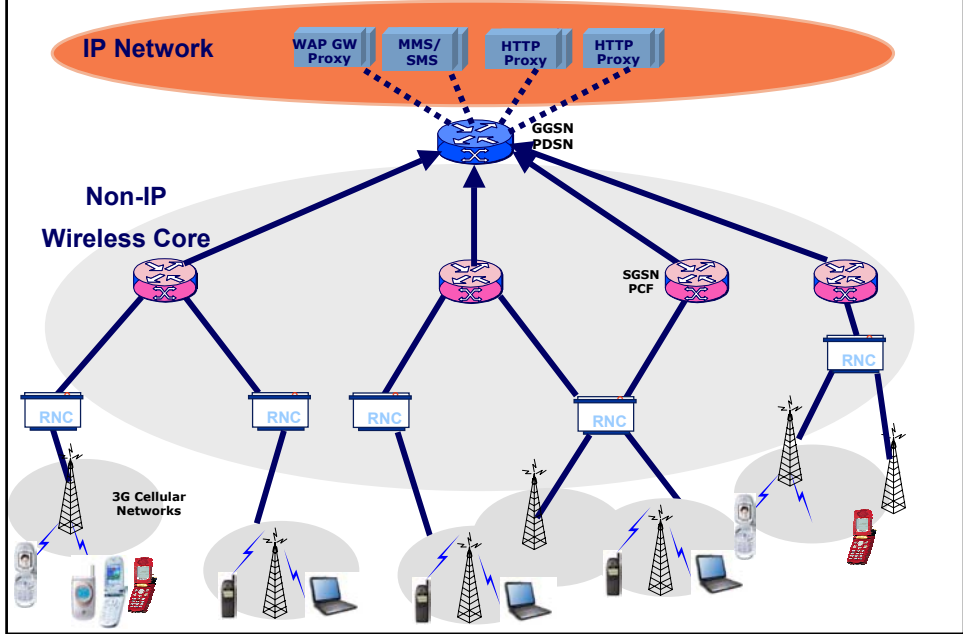
Pinging www.microsoft.com [192.11.229.2] with 32 bytes of data:
Reply from 192.11.229.2: bytes=32 time=885ms TTL=109
Reply from 192.11.229.2: bytes=32 time=1044ms TTL=109
Reply from 192.11.229.2: bytes=32 time=868ms TTL=109
Reply from 192.11.229.2: bytes=32 time=926ms TTL=109
Reply from 192.11.229.2: bytes=32 time=814ms TTL=109
Reply from 192.11.229.2: bytes=32 time=902ms TTL=109
Reply from 192.11.229.2: bytes=32 time=848ms TTL=109
Reply from 192.11.229.2: bytes=32 time=4954ms TTL=109
Reply from 192.11.229.2: bytes=32 time=870ms TTL=109
Reply from 192.11.229.2: bytes=32 time=830ms TTL=109
Reply from 192.11.229.2: bytes=32 time=821ms TTL=109
Reply from 192.11.229.2: bytes=32 time=912ms TTL=109
Reply from 192.11.229.2: bytes=32 time=761ms TTL=109
Reply from 192.11.229.2: bytes=32 time=874ms TTL=109
Reply from 192.11.229.2: bytes=32 time=838ms TTL=109
Reply from 192.11.229.2: bytes=32 time=852ms TTL=109
Reply from 192.11.229.2: bytes=32 time=826ms TTL=109
Reply from 192.11.229.2: bytes=32 time=842ms TTL=109
Reply from 192.11.229.2: bytes=32 time=1090ms TTL=109
Ping statistics for 192.11.229.2:
    Packets: Sent = 80, Received = 80, Lost = 0 (0% loss)
    Approximate round trip times in milliseconds:
        Minimum = 761ms, Maximum = 4954ms, Average = 1001ms

```

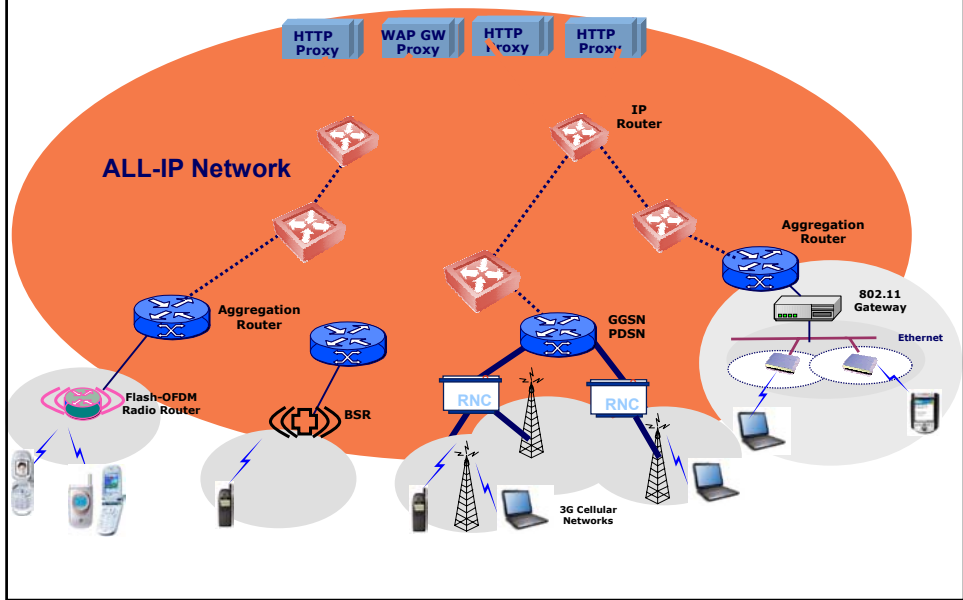
Wireless Link Properties: Throughput

- -2001 : Mostly GSM Circuit Switched Networks: **9.6 Kbps**
- 2002-03 : 2.5G GPRS Networks: **16-25 Kbps**
- 2004-2005? : 3G UMTS/CDMA Networks. **200-500 Kbps**
- User experienced throughput is much lower than expected
 - » e.g. CDMA 1xRTT
 - » Max. Expected Airlink Throughput: 153.6 kbps
 - » HTTP throughput: 50-70 Kbps

3G: Centralized, No Mobility



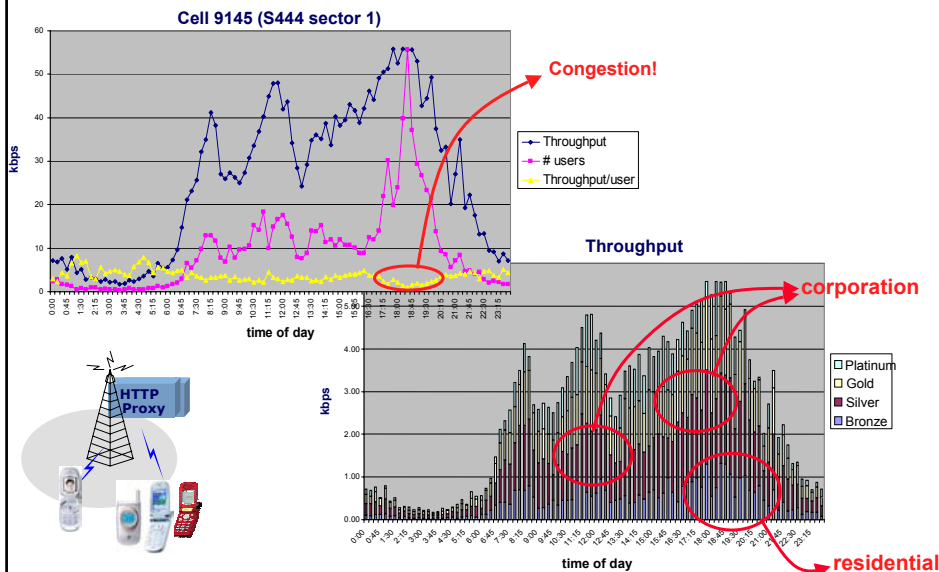
4G: ALL IP



Scarce Wireless Resources

- Links not easily upgraded or over provisioned
 - **Wireless Multicast** should be implemented to provide efficient Wireless Content distribution
- To relieve the scarce resources of Wireless links, CDNs can implement **QoS differentiation**
 - When proxies are embedded at the BS, they can see all traffic/users/applications
 - Proxies can make intelligent decisions about what and when to prioritize different users/traffic

Embedding Proxies in Base Stations



Deployment/Maintenance Costs

- CDNs require large number of computers/systems
- Current deployment and maintenance happens mostly manually and is very centralized
 - Increase costs
- CDNs would significantly benefit from lower deployment/maintenance costs



Self healing, self configuring, autonomic computing