Research in Next Generation Telecommunications

An Introduction to Research in Wireless Networking in Computer Science at UNB

prepared by

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Computer and Data Communications Group

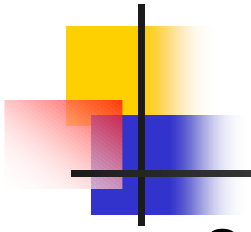
Faculty of Computer Science
University of New Brunswick

Started in 1978

Current members

John DeDourek, ***IP networking, QoS, performance, MM, security, CTI***
Weichang Du, ***Internet computing***
Bernd Kurz (retired), ***NG communications systems, wireless networking, protocol design, industrial and commercial applications, IVR***
Przemek Pochec, ***general data communications, simulation***

Located in ITC building at Windsor Street



Early Activities (1)

Selected research and development

1978 Start dedicated courses in telecommunications

delivered across Eastern Canada and world-wide

1980+ Research and development projects

- ATM AAL layer design (Cygnus, IRAP)
- WAN protocol design and development for harsh-error environments
- Satellite communications (Fundy Corp., Teleglobe Canada, inc.)
- Modeling, analysis, planning of corporate global land-sea network (PDV Marina Oil Corp., Venezuela)
- Voice-Mail Display system for Softworld'94 (NBTel)
- QoS-enabled handoff (TARA, NBTel Mobility)
- QBone Baseline Testing (Canarie, ITS, Bell Nexia)
- 'Essentials of VoIP' CBT CD (Learnstream, Nortel USA)
- CTI and IVR

Early Activities (2)

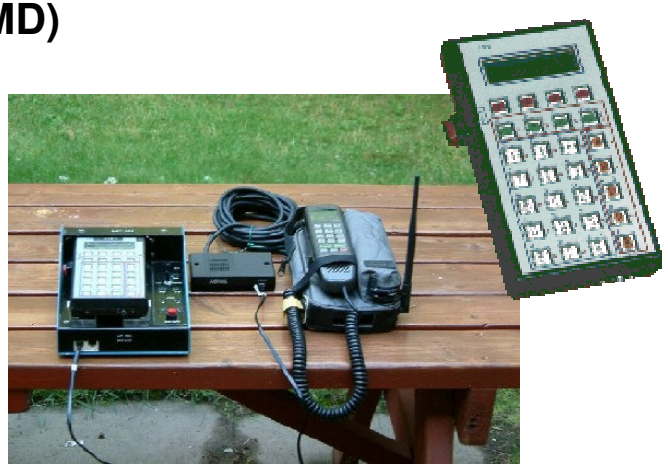
Selected industrial R&D collaborations

1980 3rd Gen. Wireless Sensor Network for subsidence measurement (BJK)
GGE UNB, Canmet, Sparwood, Syncrude Oilsands

1984 LOT-100 and 'From the Woods to the Office' suite (BJK)
Canadian and US lumber industry

1988 GEO-100 Geological data collection by handheld device (BJK)
Dept. of Natural Resources N.B. (IRAP)

1999 QBone Baseline Testing Project (JMD)



Next Generation Telecommunications

From legacy telecom to future unifying networks

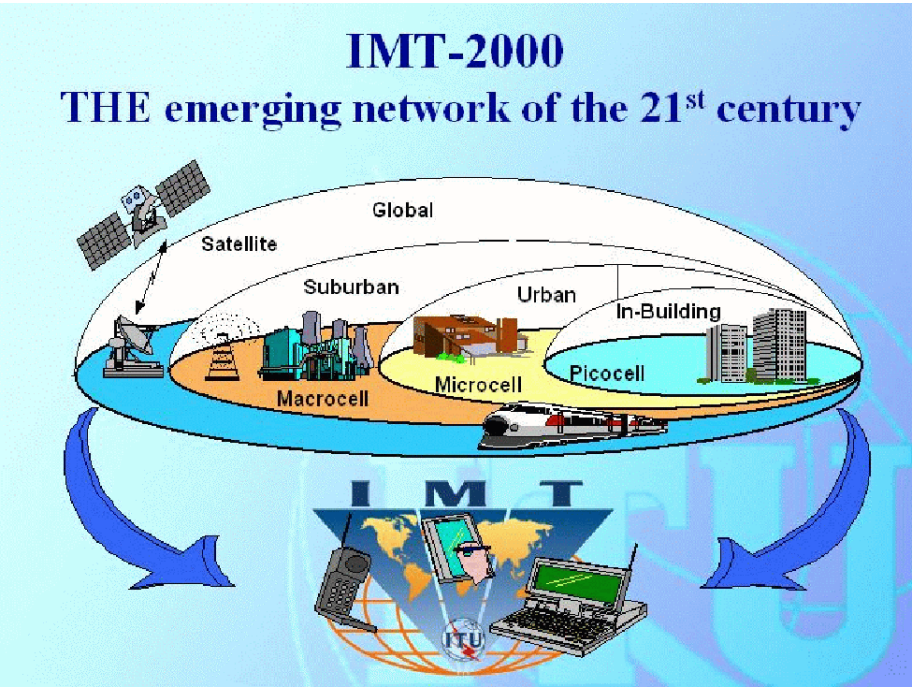
full multi-tier network integration
unrestricted mobility of users and services with single global user identifier
ABC – always best connected
VHE everywhere
any data on any end user device
converging services at IP layer
applications are mobile

Focus on two forces

Technology-push
Application-pull

IMT-2000 framework and beyond

by ITU 1988, 2003



Source: imt-2000.org

Wireless Technologies

WWAN - very large coverage 30km+, medium speed

10…144kbps…2Mbps, satellite, cellular data: CDPD, CDMA 1xEV, GSM, GPRS, EDGE, licensed

WMAN - large coverage 1…30km, high speed 10…75+Mps

Canopy, 802.16d,e (WiMax), 802.20 (MobileFi), (un)licensed FBWA, back-haul

WLAN - medium coverage 100m…1km, high speed

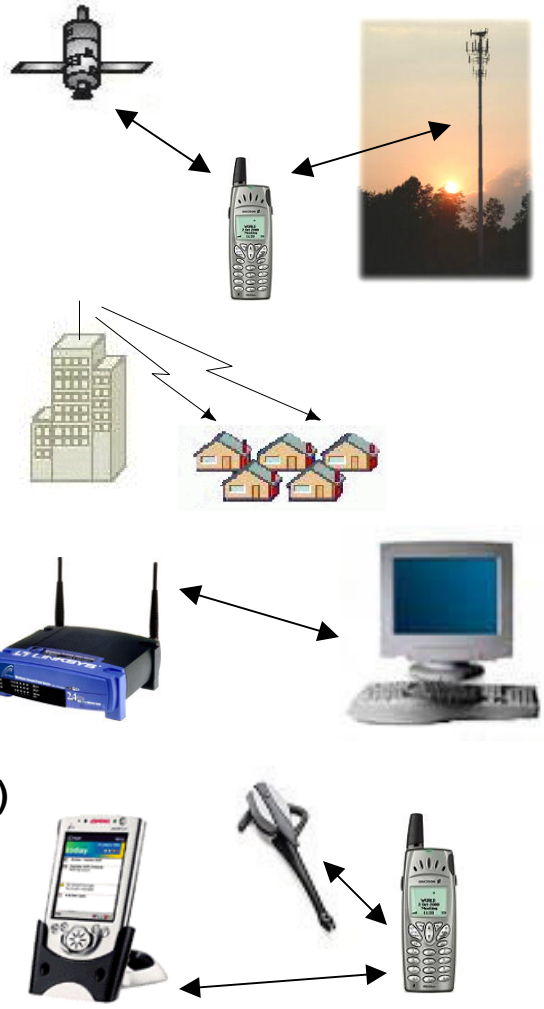
10…>100Mbps, 802.11a,b,g,n (WiFi), Hiperlan 2, DECT/GAP, IR-LAN, unlicensed office and home

WPAN - small coverage 10…100m, medium speed

to 1Mbps, 802.15.1 Bluetooth, IrDA, unlicensed, personal sphere

WBAN – very small coverage 1...10m, misc. speed

BT Class 3, 802.15.4 (ZigBee), 802.15.3 (UWB, …400Mbps, WiMedia)



Today: **loose horizontal integration**

Tomorrow: **tight vertical integration/convergence**

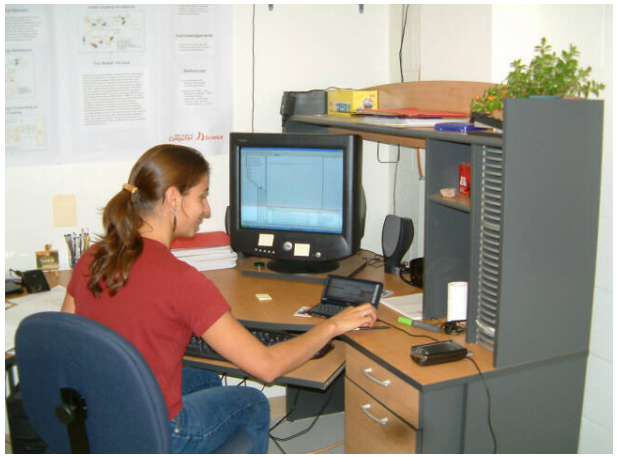
Sources: linksys.com, compaq.com, sonyericsson.com

Current R&D Activities (1)

Focus is on wireless telecommunications in NG networks

2000 Investigation into current state of wireless telecommunications in New Brunswick and Atlantic Canada

- **one-year study with final report and recommendations on CD and IEEE NB website (Phase 1)**
- **collaboration with Fredericton Community Net**
  - **local WiFi hotspot**
  - **SOHO office for mobile applications**
  - **location-aware information push**
- **ongoing support by Business New Brunswick (Phase 2)**



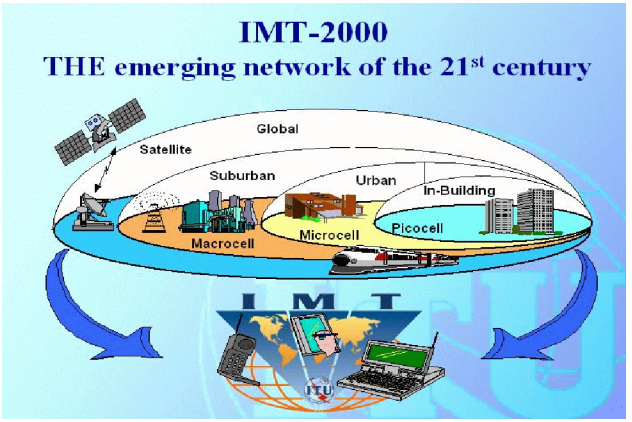
Current R&D Activities (2)

2003 Next Generation Telecommunication Systems for Mobility
part of CNSR, supported by Bell/Aliant and ACOA through AIF program

Integrated multi-tier network testbed
- **public cellular 1xEV – WLAN – WPAN tiers**
- **convergence of management and services at IP layer**
- **gateway and hotspot technology**
- **topology and bandwidth planning, fixed and mobile hotspots**

Mobility issues
- **unrestricted roaming from 1xEV to WPAN**
- **single-ID/single-account access with any terminal**
- **ABC anytime-anywhere, switching criteria**
- **VHE same feel-and touch UI**
- **QoS enabled horizontal and vertical handoffs**

QoS and multi-media transport
- **service classes**
- **QoS provisioning end-to-end**



Sources: imt-2000.org

Current R&D Activities (3)

Mobile Ad-hoc networking (Larry Hughes, HRA UNB, Dalhousie Univ.)

Mobile Applications over wireless networks

- new user patterns
- resource constrained networks and end user devices
- adaptive application environment and delivery
- context-aware information delivery
- adaptation and scaling of contents

- HCI for UI for hand held end user devices
- application design for wireless computing and HH devices

Physical Layer communications (ECE, UNB)

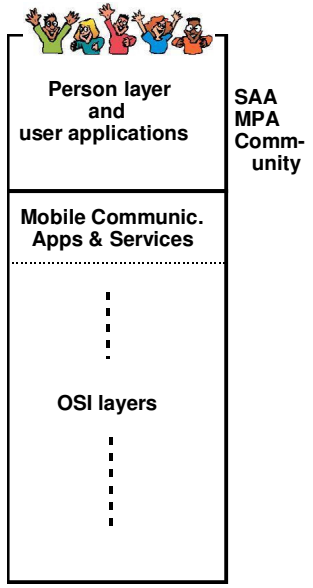
- air interface issues, RF propagation
- diversity, time-space decoding
- smart antennas
- power control
- hardware asymmetry

Sources: compaq.com, ericsson.com

Current R&D Activities (4)

Hierarchy of Mobilities – Definitions

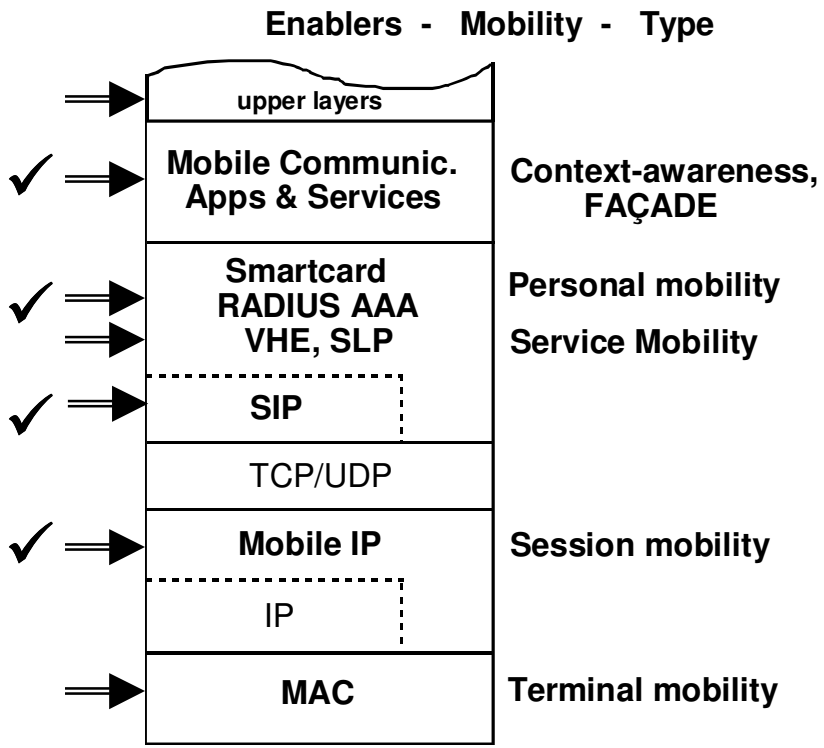
Mobility type	related to
Personal mobility	
ability to access and use a network anywhere with any device	authentication by credentials
Service mobility	
ability to use the subscribed services anywhere	service discovery and authorization
Session mobility	
ability to maintain ongoing IP sessions across networks	IP address management
Terminal mobility	
ability of end user device to physically connect to any network	physical air or wired interface



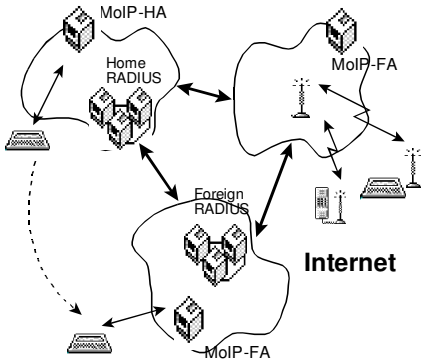
Higher layer mobilities require lower layer mobilities

Current R&D Activities (5)

Global Mobility in IP Networks (Personal, Service, Session, Terminal mobility)



Sources: compaq.com
ericsson.com



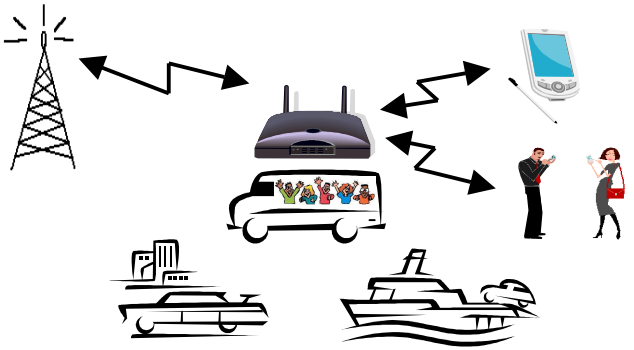
A potential path to 4G networks with data and voice integration

Current R&D Activities (6)

Inter-tier Mobile Gateway - Hotspot

3G/WLAN mobile Hotspot

- device-native access (e.g. WiFi) to 3G services
- extends 3G services into confined spaces
- mobile vehicles or fixed temporary sites



Source: Troy Nelson

Gateway with unique capabilities:

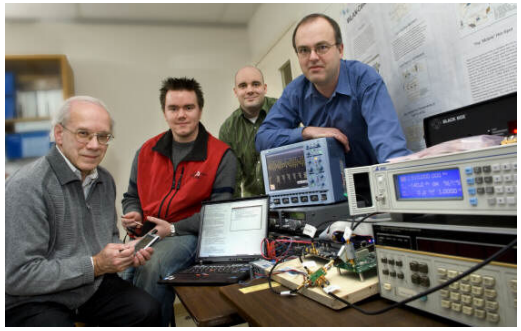
- local and through registration
- local accounting, RADIUS and MySQL
- end-to-end security, RADIUS and EAP
- flexible upper and lower tier media
  - 1xEVDO, GPRS/EDGE, UMTS – WiFi, Bluetooth
- stackable multi-tier gateways possible

Opens new market for cellular service providers

Several pre-production prototypes in operation.

- in-house alpha testing complete (1xEVDO, WiFi, Bluetooth).

Field tested at NBLA/EMO cross-border NB/Maine health pandemic birdflu exercise, March 2007



Current R&D Activities (7)

Vertical Network Tier Switching

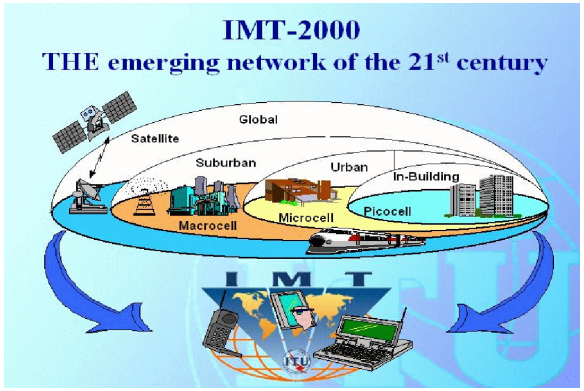
Always-best connected (ABC) paradigm
- **in multi-tier networks (3G, WLAN, …)**
- **vertically integrated, service convergence**
- **move end users to most beneficial tier**

Switching decisions by multiple criteria
- **current user mobility (fixed, slow, fast)**
- **network load & status**
- **service availability**
- **connection cost**

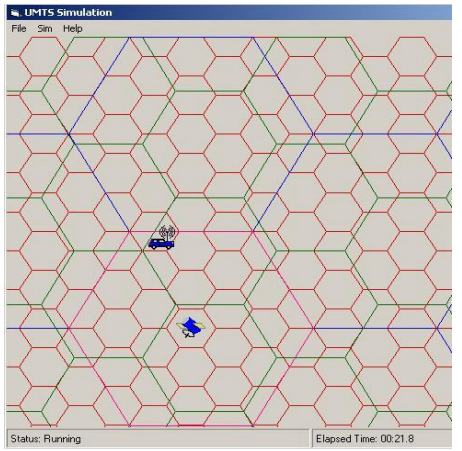
Requires multi-mode terminals for seamless roaming

Benefits
- **Cost-effective always-connected user services**
- **Network load balancing**

Switching Criteria selection and switching decision engine complete. Software simulation in progress



Sources: imt-2000.org



Current R&D Activities (8)

Session Mobility Enabler in IP Networks

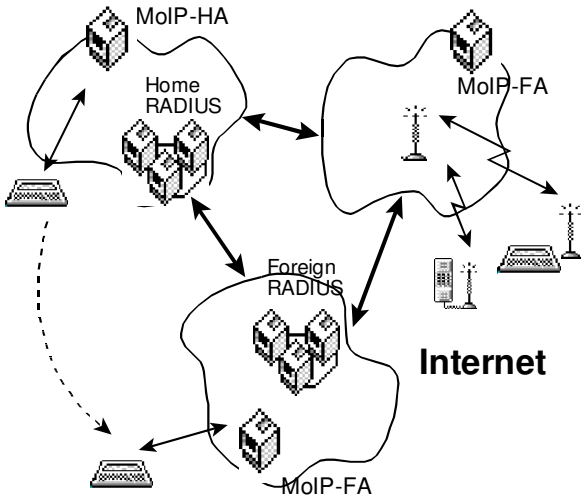
Mobility enabler
- **IP address management by Mobile IP**
- **scalable by central authentication**
  - **RADIUS AAA (later DIAMETER)**

Standard for 3G systems, mature and widely used

Clear separation of personal and session mobility
Does not provide full personal mobility

Mobility testbed is in operation
- **HUT Dynamics MoIP, FreeRadius**
  - **(or MyRADIUS, our own experimental RADIUS server)**

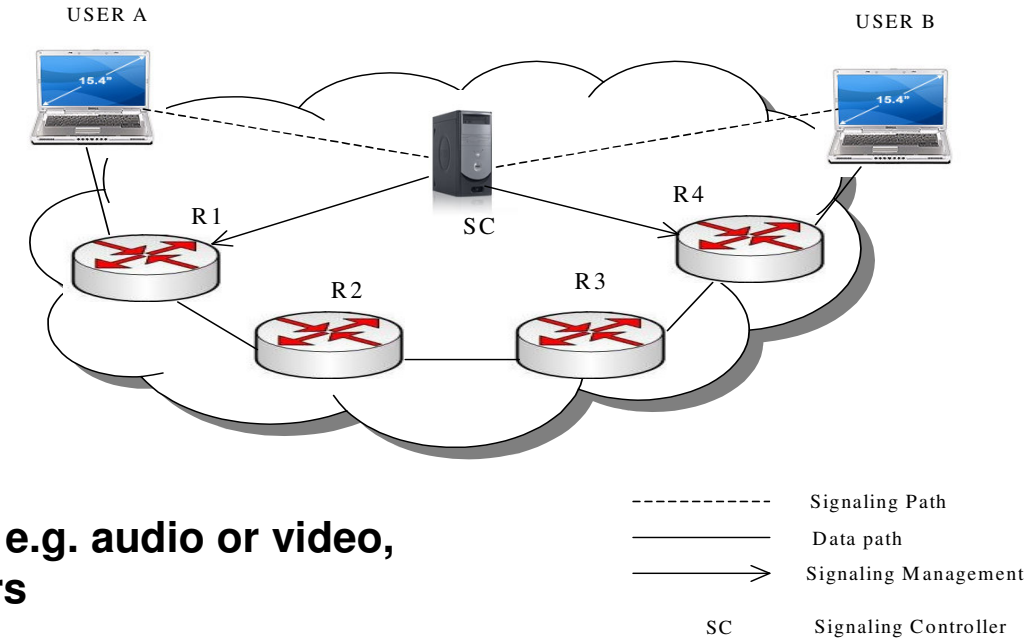
Integrated with SIP, addition of FAÇADE to follow



Current R&D Activities (9)

Quality of Service (J. DeDourek)

- User application sends QoS request to QoS agent
- Agent responds yes/no based on availability of resources
- If request granted, agent configures routers to allow the flow and grant priority
- User then sends data stream, e.g. audio or video, via data path through routers

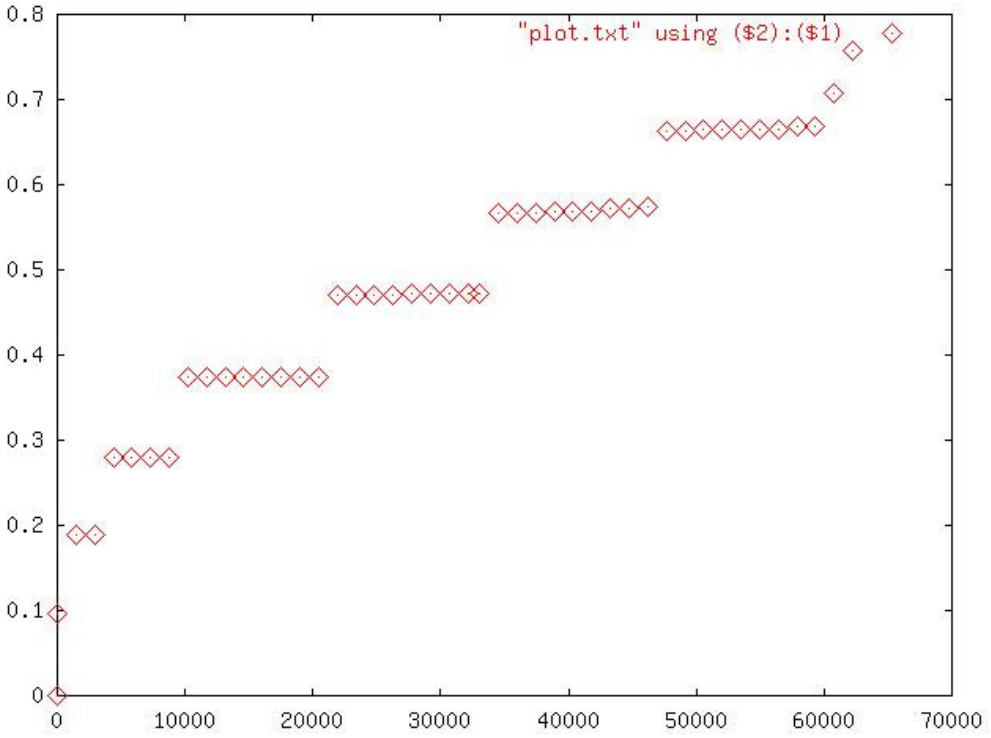


Current R&D Activities (10)

Performance of TCP (J. DeDourek)

TCP congestion avoidance

- **Transmit only a limited number of bytes in a Round Trip Time**
- **Start with one full packet of bytes and increase by one packet for each packet correctly received**
- **Ultimately, send what the receiver allows during each RTT**



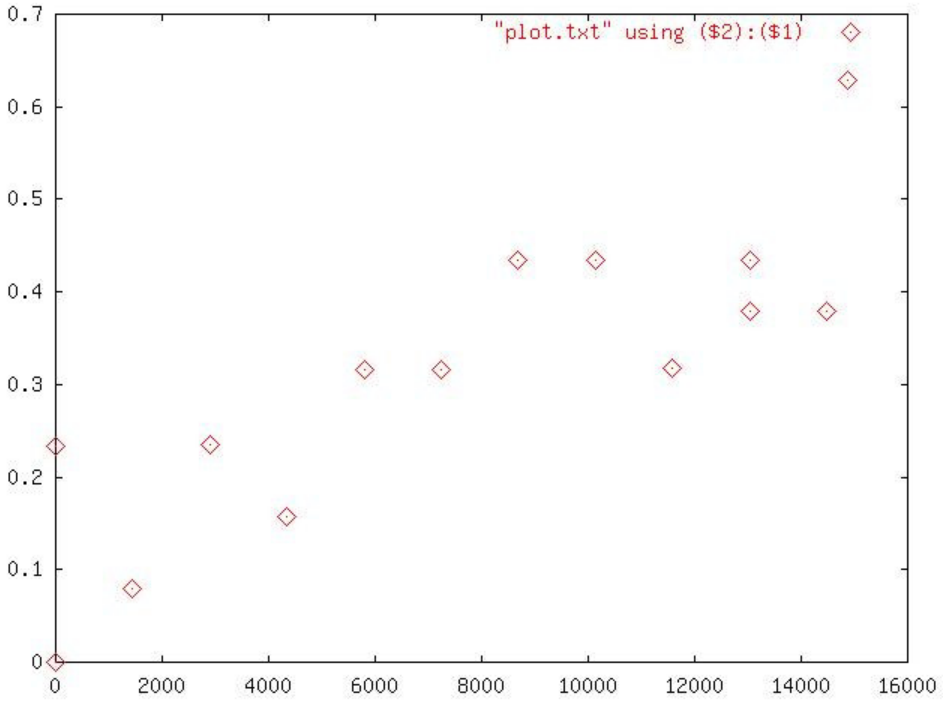
Relative byte number received

Current R&D Activities (11)

Performance of TCP with Packet Loss (J. DeDourek)

TCP will resend packets

TCP will reduce number of bytes sent per RTT

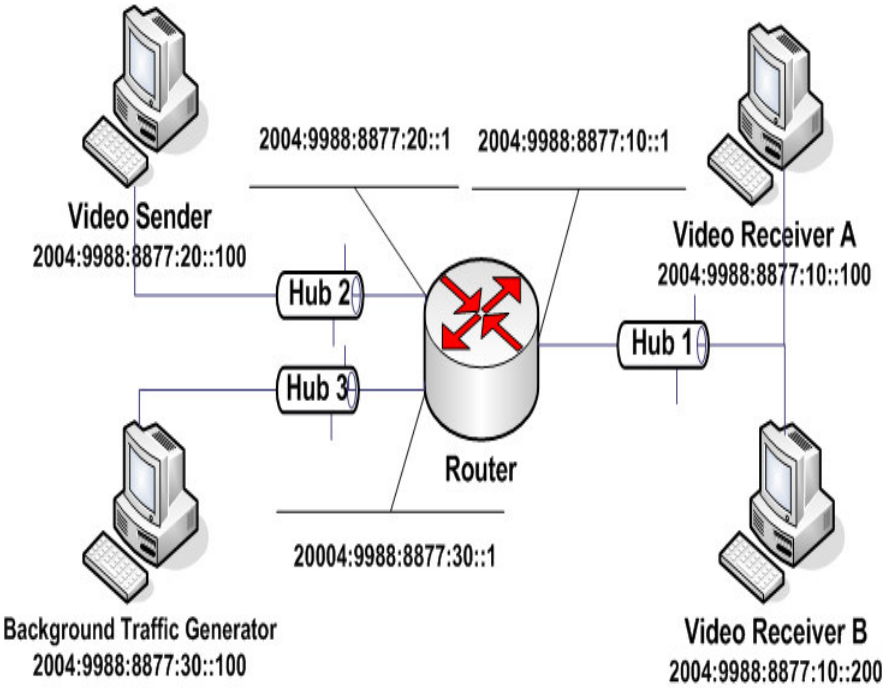


Relative byte number received

Current R&D Activities (12)

Performance of the next generation of Internet protocols IPv6 (J. DeDourek)

Use of a test bed of IPv6 machines to investigate video transmission over IPv6 as compared with transmission over the present protocol IPv4



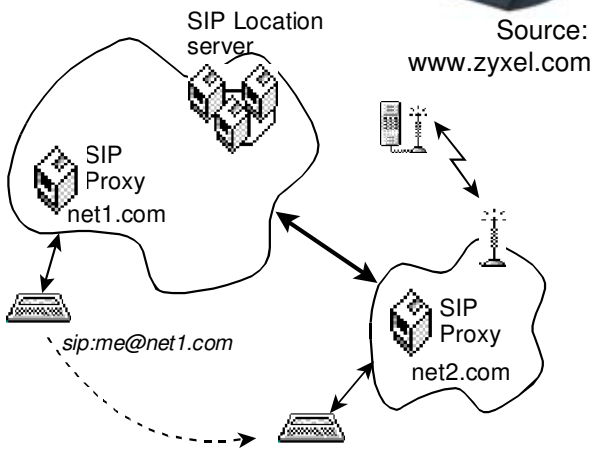
Current R&D Activities (13)

Personal Mobility Enabler in IP Networks

Source: www.zyxel.com

Mobility enabler

- **Session Initiation Protocol, SIP**
  - **reaching critical mass for IP telephony (VoIP)**
    - **Net2phone, Delta3, AT&T, Primus, Vonage, Telus ...**
  - **Leverage the expanding IP VoIP infrastructure**
    - **may need new SDP types for data**
  - **Enable single personal lifetime global ID**
    - ***sip:myname@mylocation.com***



SIP can act as a common wrapper protocol
for many services to establish global reachability and connectivity for personal mobility

Dual-network mobility testbed with SIP and MoIP servers is in operation for proof of concept

Current R&D Activities (14)

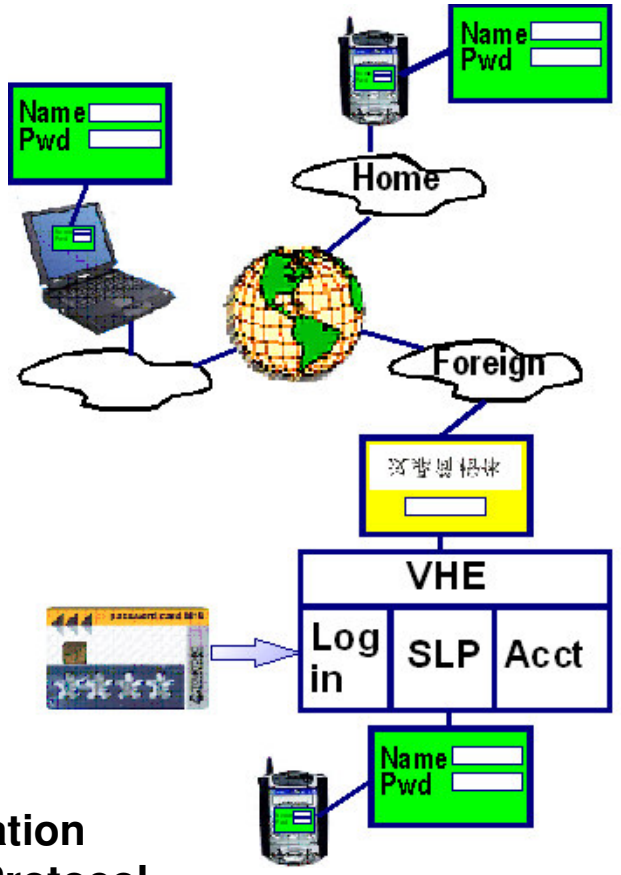
Virtual Home Environment – VHE

A shell between end user and network
- same feel-and touch user interface
- at networks anywhere, foreign or home

VHE handles
- secure login
- service location & provisioning
- accounting
- by foreign-home network negotiations

Login using Smartcard, SIM, RFID, biometrics
- user profile & credentials
- subscribed services

Benefits
- personalized global mobility
- user satisfaction by consistency



VHE framework partially complete (Login, Authentication and Authorization, Service negotiation). Novel VHE Protocol completed (SIP style).

Current R&D Activities (15)

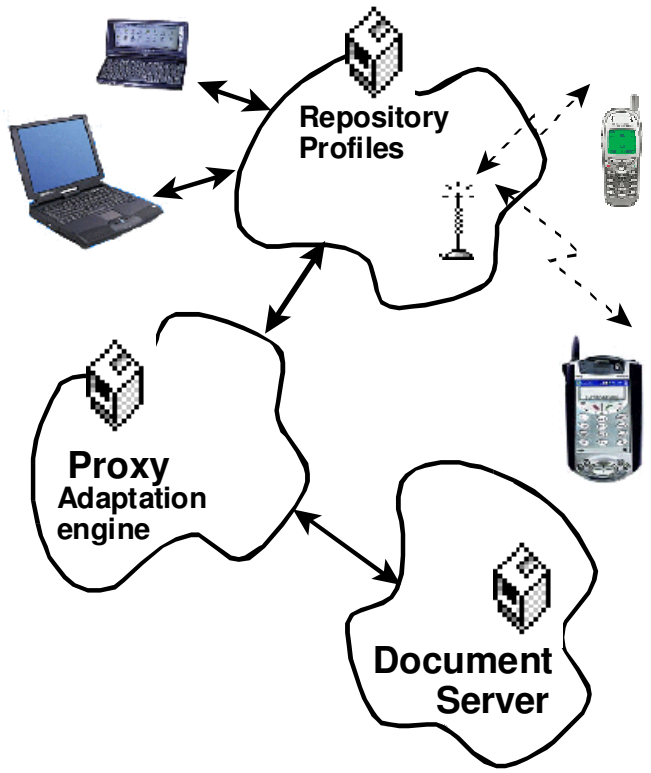
Context-aware information delivery across multiple networks

Delivery subject to
- **end user device properties**
- **network capabilities and status**
- **user preferences**

Adapt document contents for
- **bandwidth conservation**
- **friendly user interface**
- **single-source authored documents**

Profile collection and maintenance
- **repository and transport protocols**

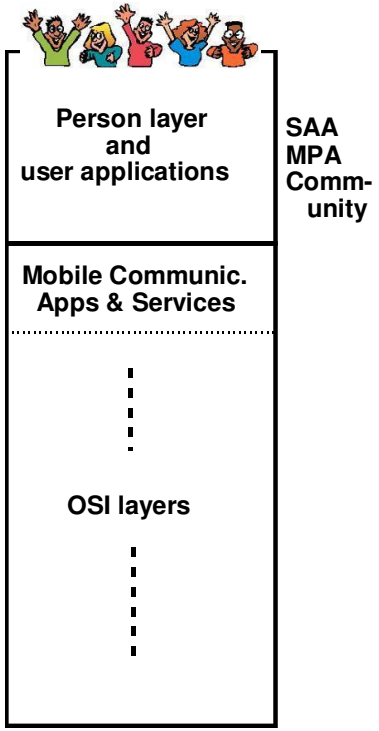
Where to adapt and how to adapt
- **server – proxy – end user device**
- **frames, graphics, menus, text**
- **deck of cards and navigation**



Current R&D Activities (16)

Selected existing Context-aware Projects (Popescu, Gallacher, You, Kurz)

MPA – Mobile People Architecture
Stanford University, piloting user-centric computing
SHAAD – Hypermedia Adaptable Adaptive and Dynamic System
Univ. de Girona, comprehensive adaptation model
WSCA – Web Stream Customizer Architecture, Penn State Univ.
dynamic customization of web content
BARWAN - Bay Area Research Wireless Access Network
U of Calif. Berkely, scaleable mobile apps in heterog. networks
LBS - Location Based Web Service
Keio University, NTT DoCoMo, localized service
Community-Driven Content Adaptation – BUL at U of Toronto
Cooltown – citizens in a connected world, by HP Labs
Websphere – proprietary content adaptation servers, by IBM
Thunderhawk – font scaling and client adaptation



Combine the positive aspects, add more and discard negative aspects

Source: cartoonworks.gospelcom.net

Current R&D Activities (17)

FAÇADE – FrAmework for Context-Aware content DElivery

A shell through which the user interacts with the application

Comprehensive context representation
- **CC/PP and UAProf, CCPPex over HTTP**

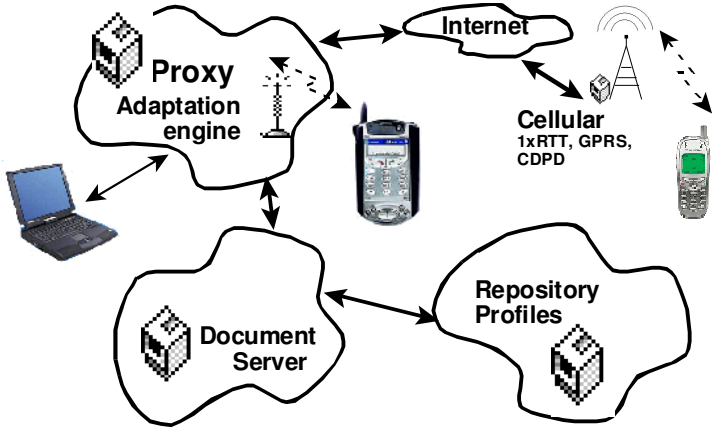
Content representation by XHTML
- **extra set of tags for layout**
- **single-source applications/documents**

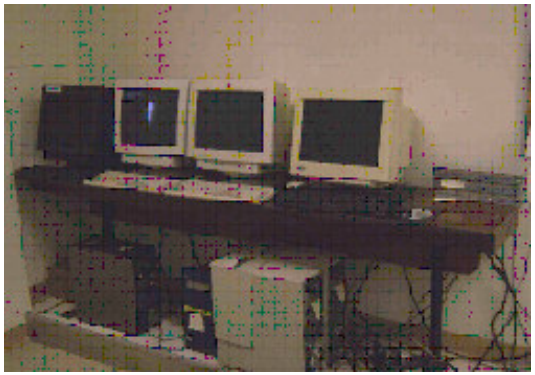
Adaptation by proxy and adaptation engine
- **trade-off client vs. server-side**

Easy migration
- **use of standard-track protocols**
- **add-on, no changes to Internet structure**

Pre-production multi-network testbed is in
- **operation with limited functionality**
- **'UNB Campus Tour' as MM application**

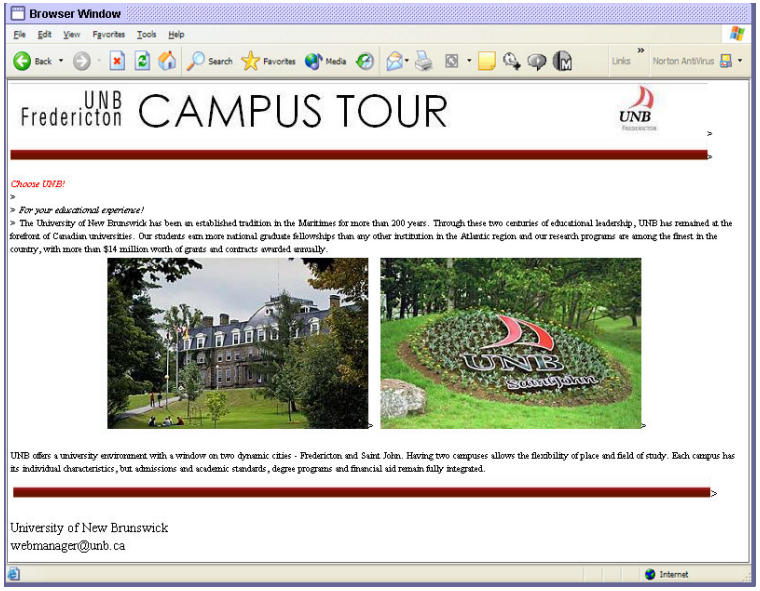
Promotional web site
- ***http://131.202.240.141:8080/campus_tour/Demo/***

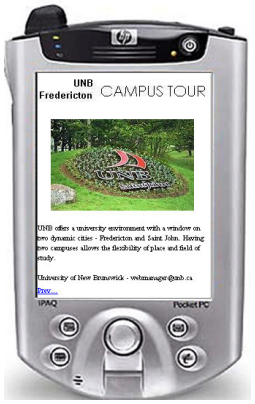


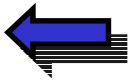


Current R&D Activities (18)

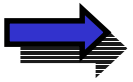
Live FAÇADE context-aware content delivery







HTML Document



Source: Iuli Popescu

Current R&D Activities (19)

Multi-Context Visual Web Page Authoring Tool

FAÇADE requires embedded layout cues
- **XHTML tags**

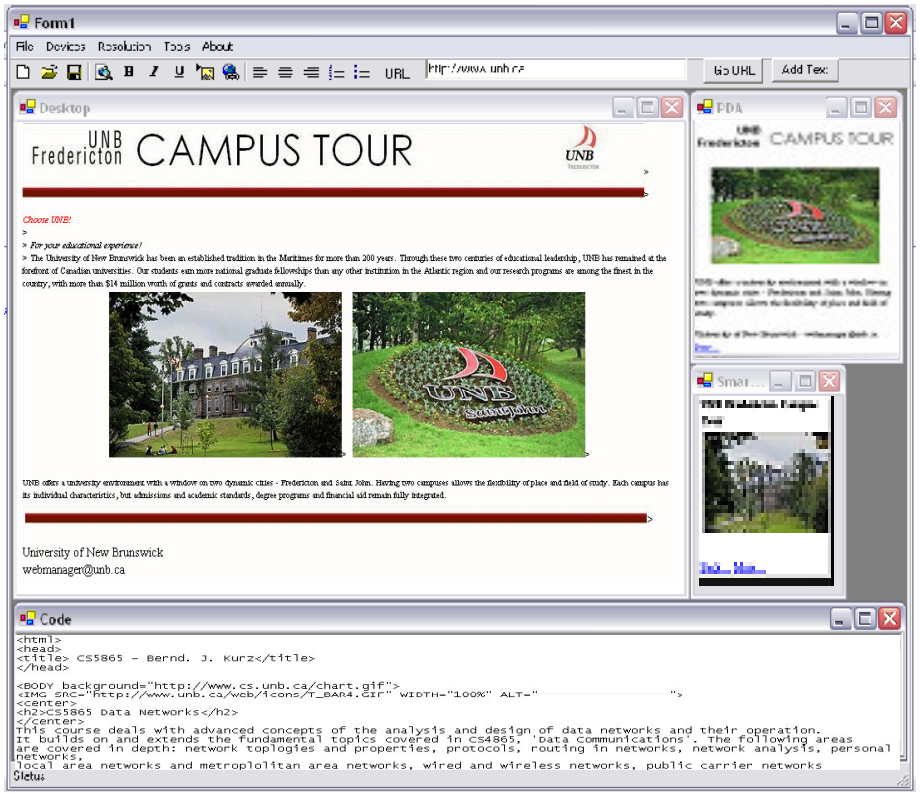
complicates authoring
- **steep learning curve**
- **deterrent for adoption**

need to automate the authoring process
- **simultaneously for multiple contexts**
- **graphical UI – WYSIWYG**
- **drag and drop objects**
- **automatic XHTML code generation**

author is in full control of semantics
- **help overcome legal issues**
  - **copyright and intended meaning**

Design and implementation with
- **selected functionality complete.**

Provisional patent filed in US and Canada



Source: Zhan, Kurz

Current R&D Activities (20)

Mobile Application Design

Most mobile applications are poorly developed
- often ported from fixed desktop equivalents

Need specific design paradigms for mobile context
- frequent location changes, nomadic or mobile
- end user device limitations
- wireless network limitations
- reduced reliability (wireless, battery power)
- limited user interaction methods
- preferred thin vs legacy thick clients

Research and development of user guidelines for mobile application design
- pursued along 4 cornerstones
  - user and usage related
  - device and network related
  - OS and programming language related
  - human computer interaction related

Sources: compaq.com, ericsson.com

Current R&D Activities (21)

Mobile Application Design – continued …

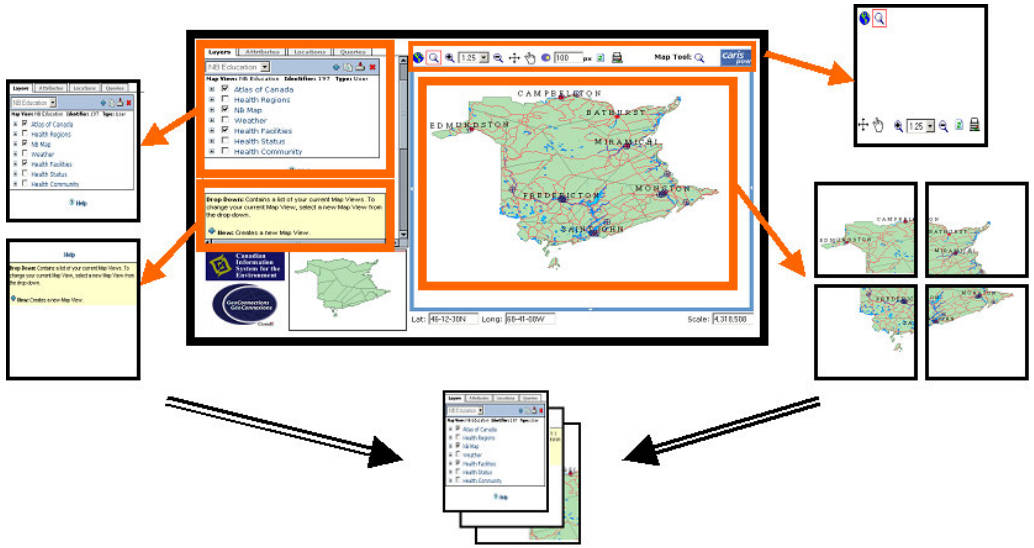
Demonstration of design rules by sample applications

- **Visitor Information Center Aid for Fredericton Tourism Department**
- **Re-rendering gateway for desktop-GIS to handheld devices for web mapping**

show effectiveness and increased usability

Training guides produced

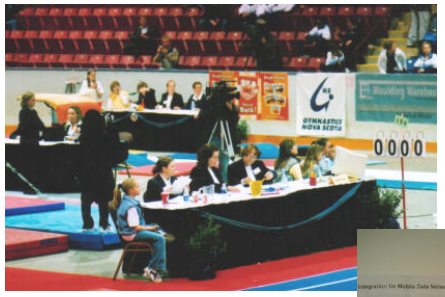
- **Mobile Application Design Guide (110 pages)**
- **PowerPoint presentation**

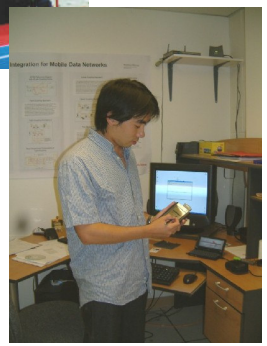


Latest Products of R&D (1)

Combining wireless and applications for handheld devices client/server structure with 'thin clients'

downloading application environment as needed just-in-time
uploading end user responses
supporting a variety of connectivities





Selected examples

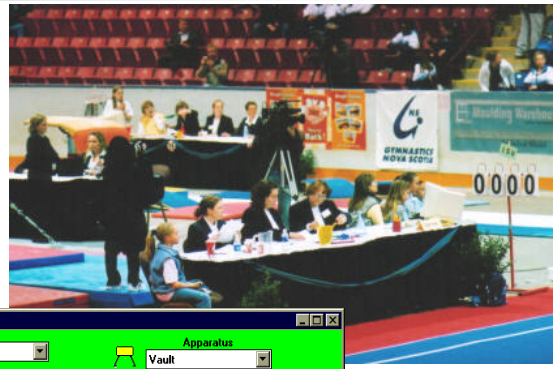
- **Gym Scoring Assistant Suite**
- **Restaurant Assistant**
- **Tourism Information Push Application**
- **Web-based Integrated Health GIS Initiative**
- **Facilitated Access to access-controlled public Hotspots**

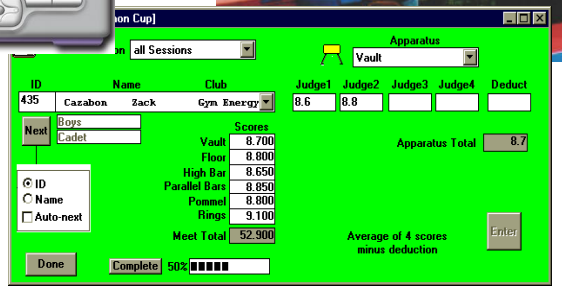
Source: Bernd Kurz and Beika Zhan

Latest Products of R&D (2)

Gym Scoring Assistant (BJK)

suite of programs for gymnastics scoring
Master, Slaves (incl. PPCs), displays
Bar code assisted score entry
wired or wireless
many report and management functions
used at Eastern Canadian Championships
in Halifax (2006) and Saint John (2007)
across North America and worldwide

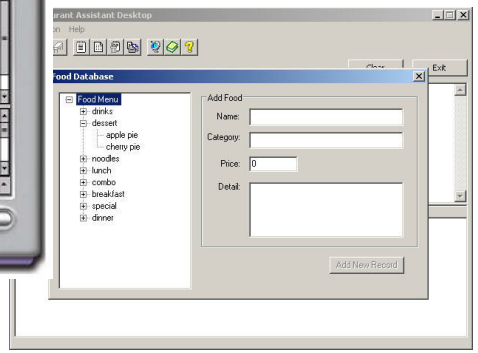




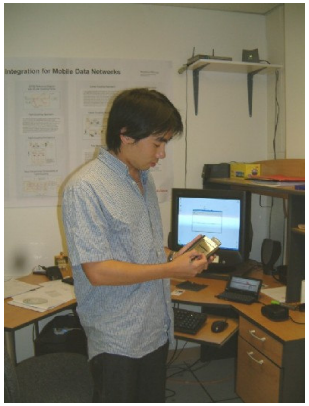
Source:
Bernd Kurz

Restaurant Assistant (BJK, Zhan)

Restaurant order processing system
from the waiter to the kitchen
automated order routing
and billing
prototype, student project



Sources: microsoft.com and
Beika Zhan



Latest Products of R&D (3)

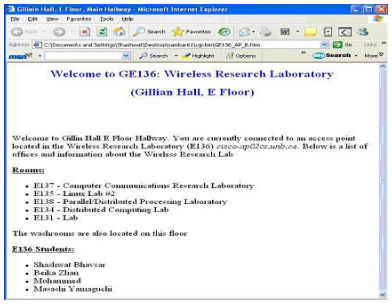
Tourism Information Push Application (BJK)

Fred-eZone Community net
- **Fredericton, N.B.**
- **free high-speed Internet**
- **WiFi roaming**

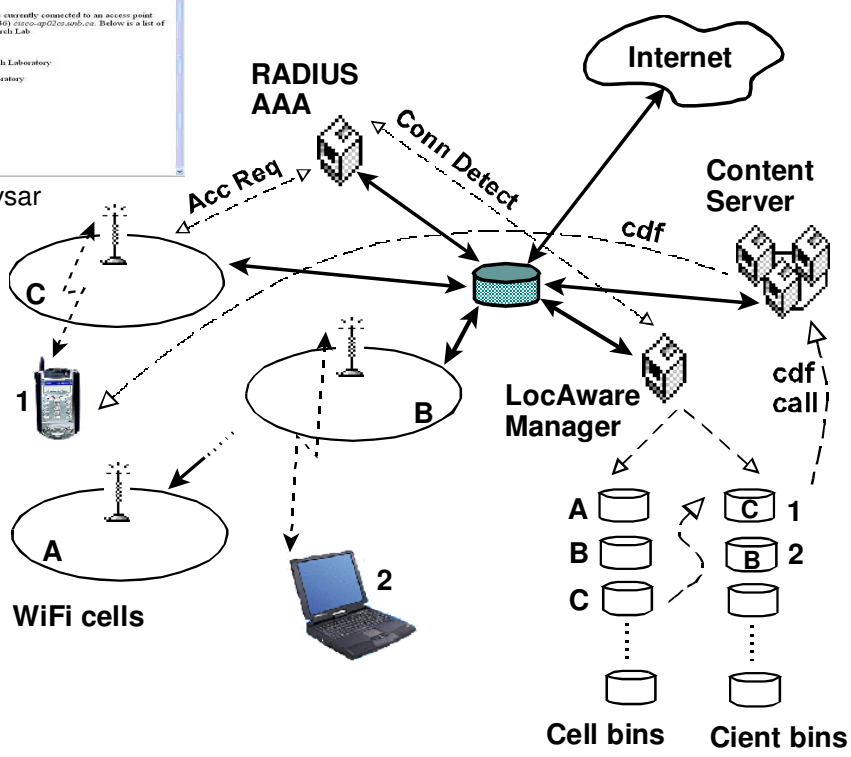
for mobile guest devices location-sensitive push of
- **attractions, history**
- **advertisement**

RADIUS based location awareness
Web-based smart push to browser
MS Active Channel technology

Prototype installed in CS production network and tested



Source: S.Bhavsar



Latest Products of R&D (4)

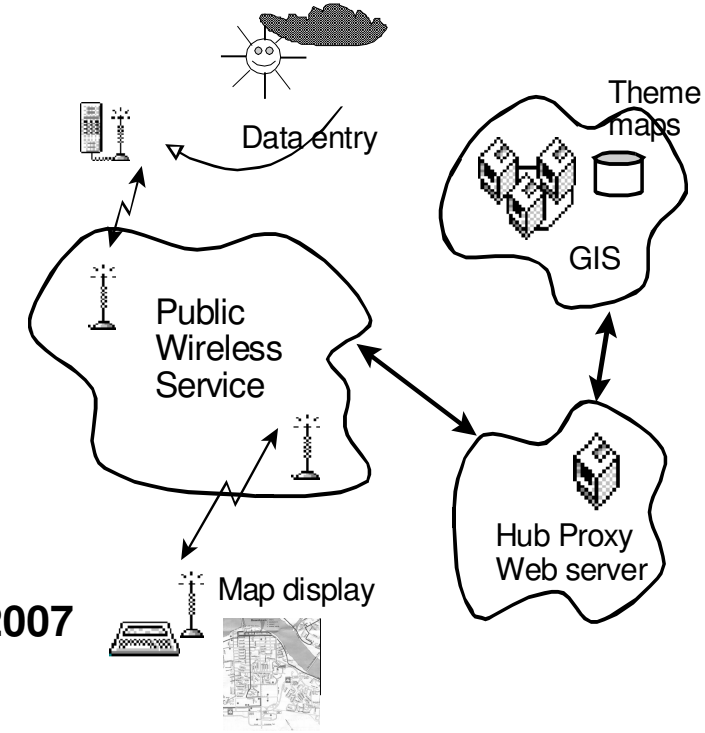
Web-based Integrated Health GIS Initiative

Source:
Mei Jiang

Public information system supporting research and information dissemination on air quality, climate change and health
NB Climate Change Hub/NB Lung Association

Wireless mobile Client (BJK)
- **low-cost thin web-enabled client**
- **collection of environmental and health data**
  - **downloadable questionnaire**
- **data query for GIS theme data**
- **map query and local display**
- **using wireless public services (e.g. 1xRTT, EDGE) and WiFi hotspots**
- **initially NB, later country-wide**

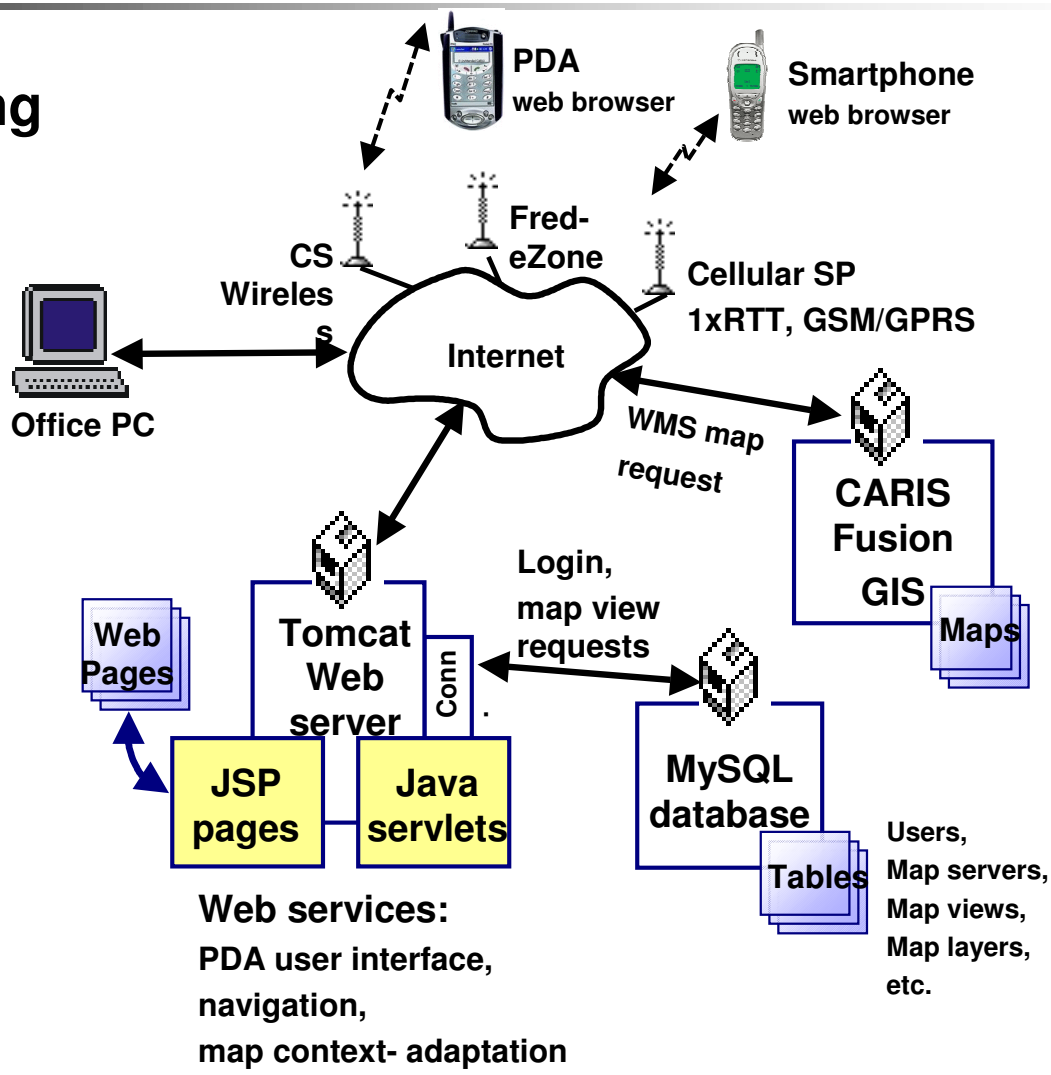
Prototype completed. Field-tested in NBLA/EMO NB/Maine health pandemic birdflu exercise, March 2007



Latest Products of R&D (5)

GIS Web Mapping Map View

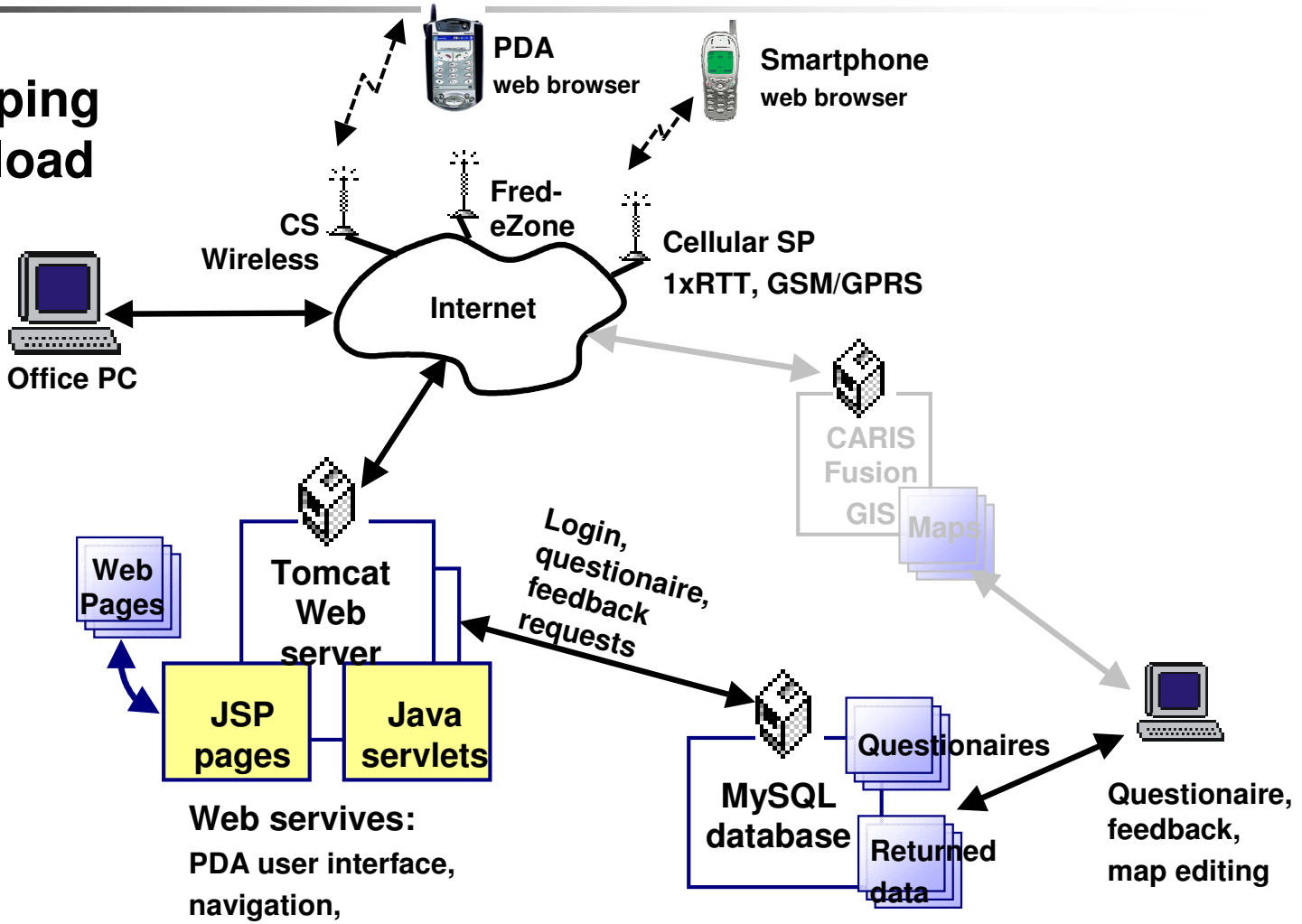
Web server and database server currently at UNB in GW-E136



Latest Products of R&D (6)

GIS Web Mapping Feedback Upload

Web server and database server currently at UNB in GW-E136



Web servives:

PDA user interface,
navigation,
form context-adaptation

Latest Products of R&D (5)

Facilitated Access to access-controlled public Hotspots

Wide-spread deployment of WiFi hotspots/zones
- Fred-Ezone, Hotel intranets, etc.
- trend from open to access-control for legal reasons

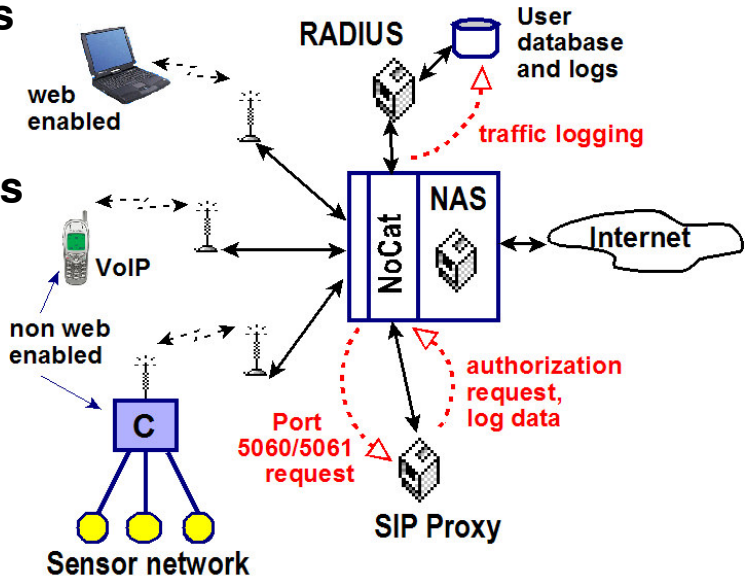
Access control mostly web based, captive portal
- suitable for web-enabled devices
- incompatible with emerging non web-based devices
  - VoIP phones, game boxes, sensor networks

Research into approaches to facilitate access
- subject to retaining some security measures

Consider Session Initiation Protocol (SIP) protocol
- for common connection management
  - capture and re-route port 5060/5061 requests
  - log user data, MAC address, IP address
  - negotiate access with existing NAS via RADIUS

Use of specialized SIP proxy

Facilitated access testbed completed and tested



Laboratories and Facilities (1)

CS- Data Communications laboratory, ITC B214

- general data communications
- IP network integration and mobility
- QoS and multimedia
- focus on user and terminal mobility
  - multi-network mobility testbed
  - MobileIP, SIP, Radius AAA
  - VHE and Smartcard

CS- CTI Studio, Head Hall H213

- UG and teaching lab
  - CTI and IVR applications
  - Nortel Meridian Option 11 switch
  - Genesys T-Server CTI suite
  - IVR development environments
    - Artisoft VisualVoice

Laboratories and Facilities (2)

CS - Wireless Networking laboratory, Gillin Hall E136

SOHO office testbed & city hotspot

mobile application development environments
- **Code Warrior, JavaME, eVB/VC++, .Net, Symbian for Palm, PPC, HHPC, Smartphones**

misc. wireless networks and connectivities
- **CDPD, 1xRTT (Aliant), GPRS, EDGE (Rogers)**
- **802.11a,b,g, Bluetooth 802.15.1, ZigBee 802.15.4**

misc. hand held PDAs
- **Palm, iPaq, Jornada PC, HPC, Treo-600**

HCI development environments
- **mobile application design**
- **usability studies**
- **multi-network test bed for context-awareness, content-adaptation, FAÇADE**

Research in Next Generation Telecommunications

Questions and Tour

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