

# Ubiquitous and Mobile Computing

## CS 525M: DroidCluster: Towards Smartphone Cluster Computing

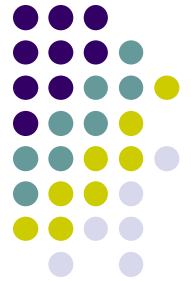
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# Introduction:



- Cloud computing are well-known and frequently investigated topics
- Plenty of research work during the past 30 years
- there is still recent and ongoing work in this area on big data like Hadoop



# Introduction/Motivation:

## Why is smartphone cluster computing important?



- In mobile computing, miniaturization and energy saving are obviously a trend
- Yesterday's clustered workstations could compute climate models or simulate nuclear explosions, clusters of today's smartphones could do so as well
- Volunteer computing is a viable alternative to buying or renting big compute clusters on many successful scientific projects like Seti@home , Einstein@home

# Introduction/Motivation:

## what will be learned?



- Some scenarios where it is reasonable to use the computational resources of mobile devices
- overview about the current state and development of technology for mobile computing
- a feasibility study, implementing and evaluating a small MPI cluster using ordinary Android mobile phones

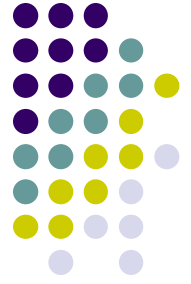
# Applications

- Rolling Clouds
- Corporate Environments
- Cooperative Cracking



# Rolling Clouds

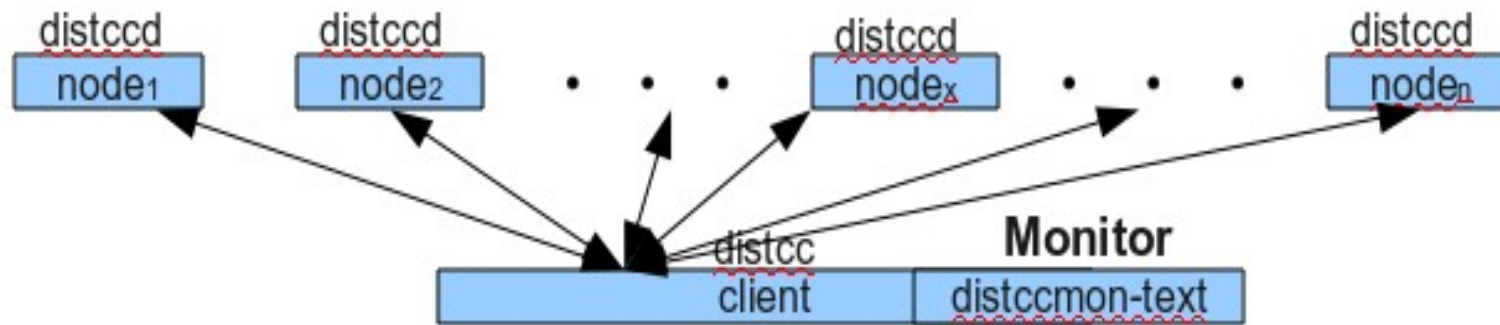
- Mobile devices can easily form a closely coupled computing cloud
- WiFi infrastructure already built into modern trains for providing with internet access
- Benefit: Fine grained local weather forecast and ozone concentration





# Corporate Environments

- Distcc is a distributed compiler framework for speeding up compilation of source code





# Cooperative Cracking

- Moxie Marlinspike's tool WPACracker uses a 400 CPU cluster running in the Amazon cloud
- At Black Hat DC 2011, Thomas Roth successfully demonstrated another Cloud Cracking Suite (CCS) that is able to crack WPA-encryption in a reasonable time
- Large number of smartphones share their resources and coordinate a distributed attack to lower the time



# Mobile computing hardware evolution



## Evolution of mobile processors

Technology	2007-8	2009-10	2011-12	Improvement
ARM® Processor	ARM11 470-700 DMIPS	Cortex-A8 1,200-2,000 DMIPS	Dual Cortex-A9 5,000+ DMIPS	10x + SMP
Ext. Display	VGA	XGA	WUXGA + HDMI	8x + HDMI
Video	VGA-30fps	720p-30fps	1080p-30fps	7x
3D Graphics	2 Mtri/s OpenGL ES 1.1	10+ Mtri/s OpenGL ES 2.0	20+ Mtri/s OpenGL ES 2.0	10x + Pgm. shaders
Imaging	3-5 MP	8-12 MP	16-20 MP	7x
Audio	15 hrs	40 hrs	140+ hrs	10x
DDR Memory	128-256 MB	256-512 MB	1-2GB	8x
Mass Storage	8-16 GB	16-32 GB	64-128 GB	8x
Process	90 nm	65/45 nm	45 nm / beyond	3+ nodes

# Mobile computing hardware evolution



LINPACK PERFORMANCE OF DIFFERENT ANDROID SYSTEMS

System	CPU	MHz	ARM Core	Android Version	MFLOPS $\Delta$
Huawei U8120	Qualcomm MSM7225	528	ARM11	2.3.7	3.7
LG P500	Qualcomm MSM7227	600	ARM11	2.2	4.0
HTC Legend	Qualcomm MSM7227	600	ARM11	2.3.7	7.5
Samsung Galaxy S	Samsung Exynos 3110	1000	Cortex A8	2.3.7	17.7
HTC Nexus One	Qualcomm QSD 8250	1000	Qualcomm Scorpion	4.0.3	31.0
Medion Lifetab P9514	Nvidia Tegra 2	2x1000	Cortex A9	3.2	54.4
Samsung Galaxy Nexus	Texas Instruments OMAP 4460	2x1200	Cortex A9	4.0.2	75.0

# Mobile computing hardware evolution



- Changes in performance reflect the rapid architectural innovations that we can currently witness in the mobile SoC market
- the computing power available in small mobile devices already surpassed the computing power of high-end workstations from a few years ago



## Feasibility study

- Build a small cluster with 6 Android nodes(LG P500)
- Each phone equipped with a 600MHz MSM7227 processor and 512MB RAM
- To distribute the calculation, using a LINPACK implementation based on a MPI library

MPI: Message Passing Interface is a standard describing the message exchange in parallel computations in distributed systems.

LINPACK: software used to measure a system's floating point computing power. Now, it is the standard benchmark for the TOP500 list.

# Feasibility study

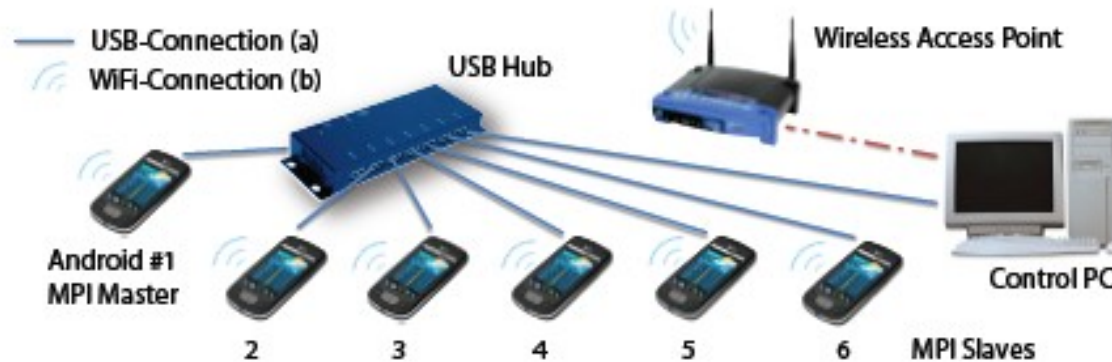


Figure 1. System Overview

# Feasibility study

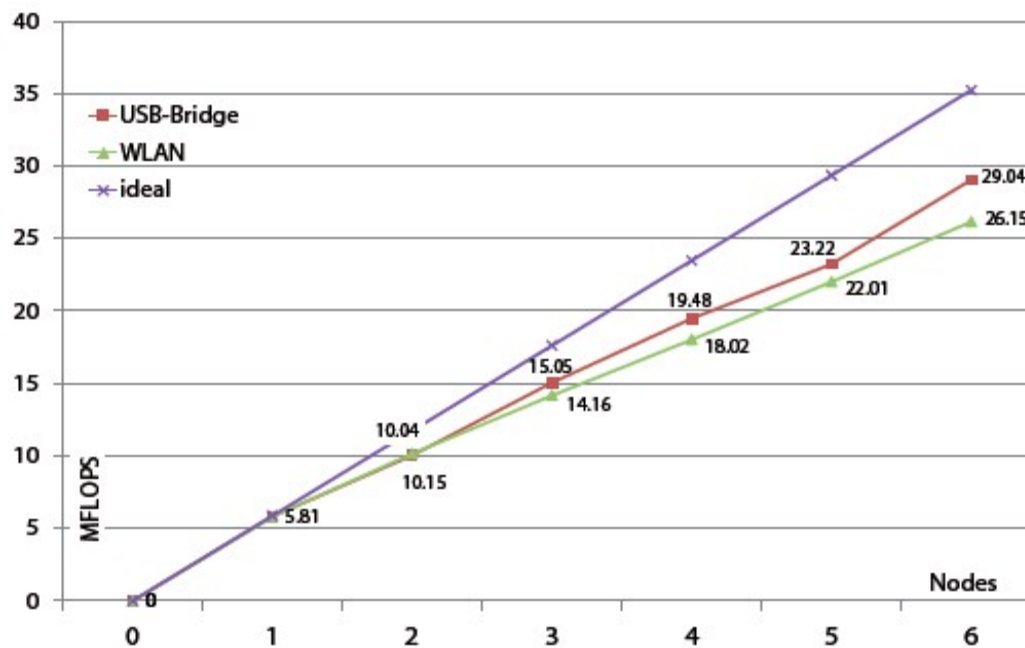


Figure 2. Combined computation power (Mega-FLOPS) of clustered smartphones (1 to 6 phones) running Linpack and MPI.



## Conclusions/Future Work

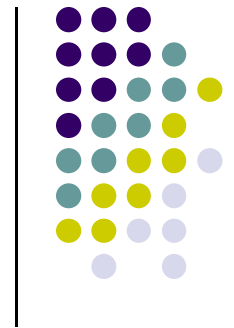
- The current evolution in mobile computing platforms is at a faster pace and follows the developments in the desktop world.
- In order to pursue the highest performance, mobile computing platform are formed between mobile and desktop.
- This combination leads to conclude that we should find ways to fully utilize these computational capacities



## Conclusions/Future Work

- It is possible to integrate Android devices into a distributed cluster in a way does not interfere with the running Android system and apps.
- Distributed computing frameworks better adapted to the special challenges in the mobile computing world will be developed
- A bunch of mobile devices replace a stationary server will be a real benefit in an environmental as well as in a cost sense





- Thanks.
- Questions?