Art and Science of

Building

NUS Data Centres

National University of Singapore

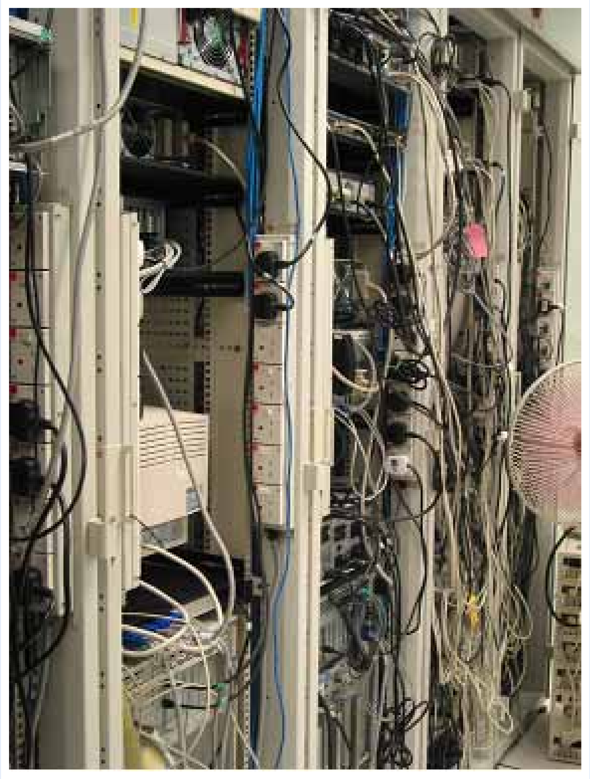
Contents

Part I

Nostalgia...

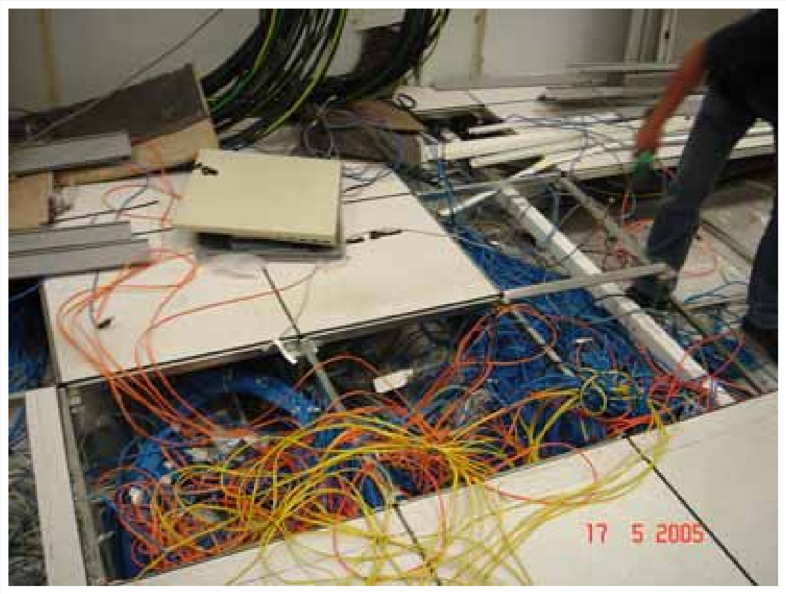
DATA CENTRE @ NUS

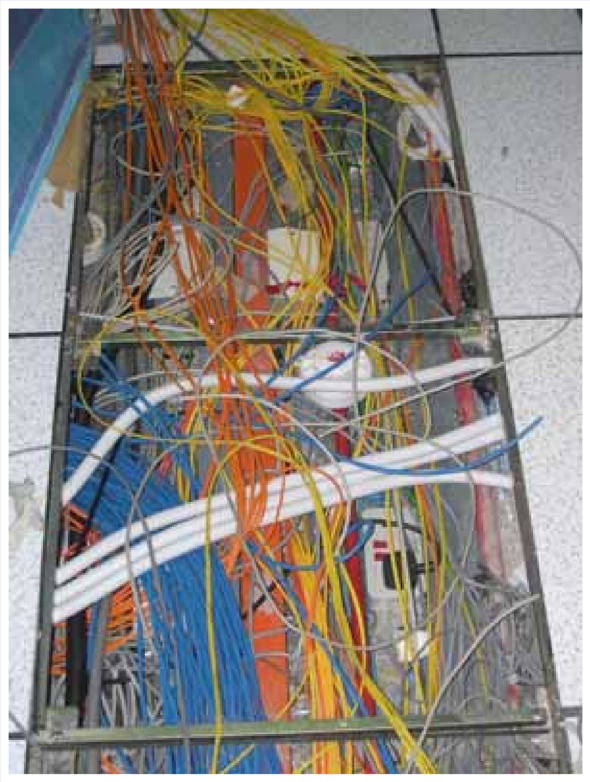
- Electrical System



DATA CENTRE @ NUS

- Raised Floor Cablings





DATA CENTRE @ NUS

- Air Conditioning System

DATA CENTRE @ NUS

- UPS System

DATA CENTRE @ NUS

- Layout and Space Utilization


DATA CENTRE @ NUS

- Tape Library

DATA CENTRE @ NUS

- Secure Printing of SmartCards

DATA CENTRE @ NUS

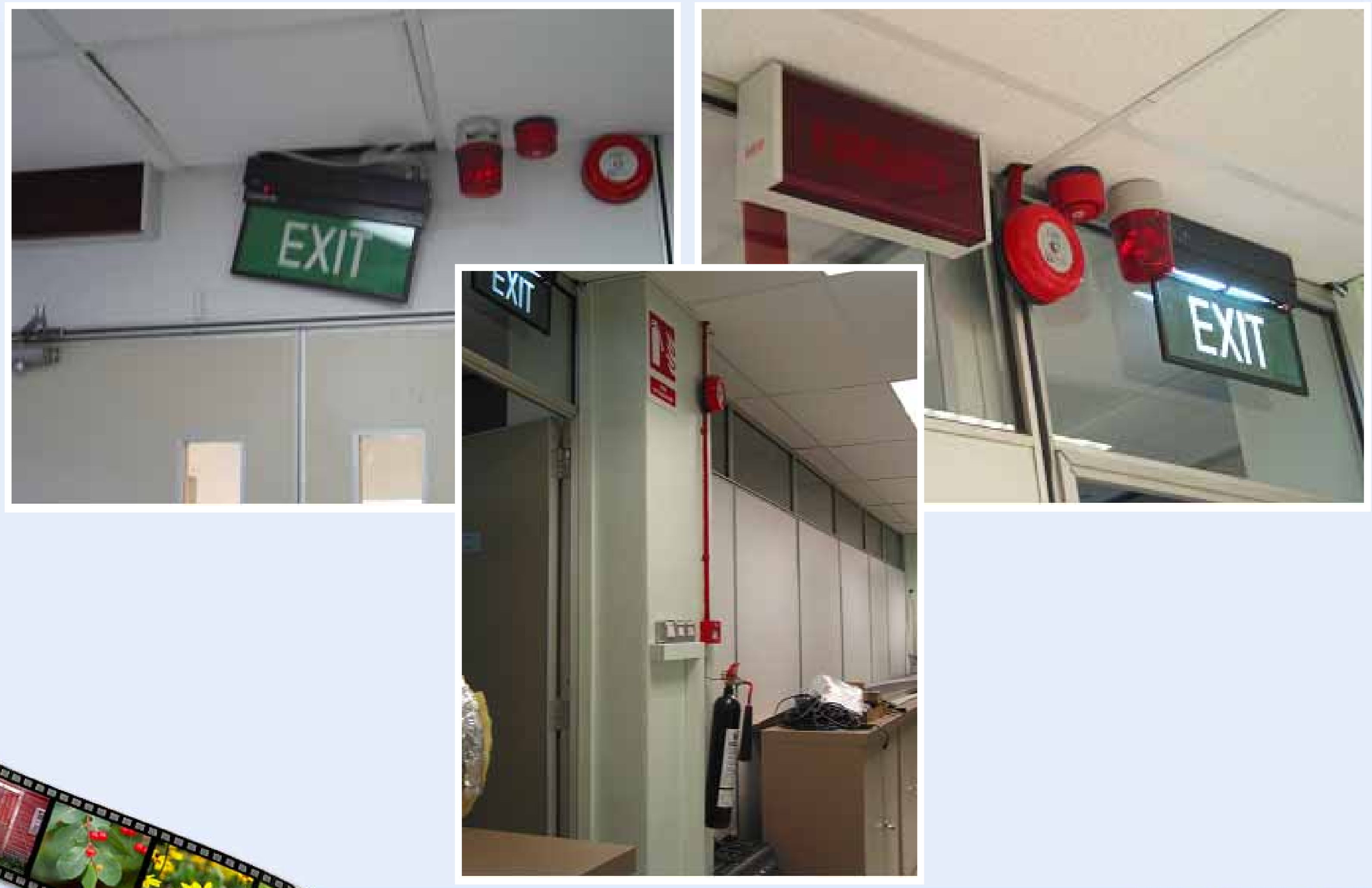
- Emergency Exits

DATA CENTRE @ NUS

- Surveillence Cameras

Data Centre @ NUS

- Signages



Part II

Science of Elements in a Data Centre

Critical Elements in a DataCentre

- **Tiering of Data Centre**
- **IT Area Versus Non-IT area**
- **Ceiling Height and Raised Floor System**
- **Power Design (Supply + cabling)**
- **HVAC units (Temperature and Humidity)**
- **Fire Detection and Suppression**
- **Environmental Monitoring System**
- **Structural Loading**
- **Physical Security**
- **Structured Cabling**
- **Network Considerations**

Tiering of Data Centre

- Defining the Tiers.

Tier I

Tier I is composed of a single path for power and cooling distribution, without redundant components, providing 99.671% availability.

Tier II

Tier II is composed of a single path for power and cooling distribution, with redundant components, providing 99.741% availability.

Tier III

Tier III is composed of multiple active power and cooling distribution paths, but only one path active, has redundant components, and is concurrently maintainable, providing 99.982% availability.

Tier IV

Tier IV is composed of multiple active power and cooling distribution paths, has redundant components, and is fault tolerant, providing 99.995% availability

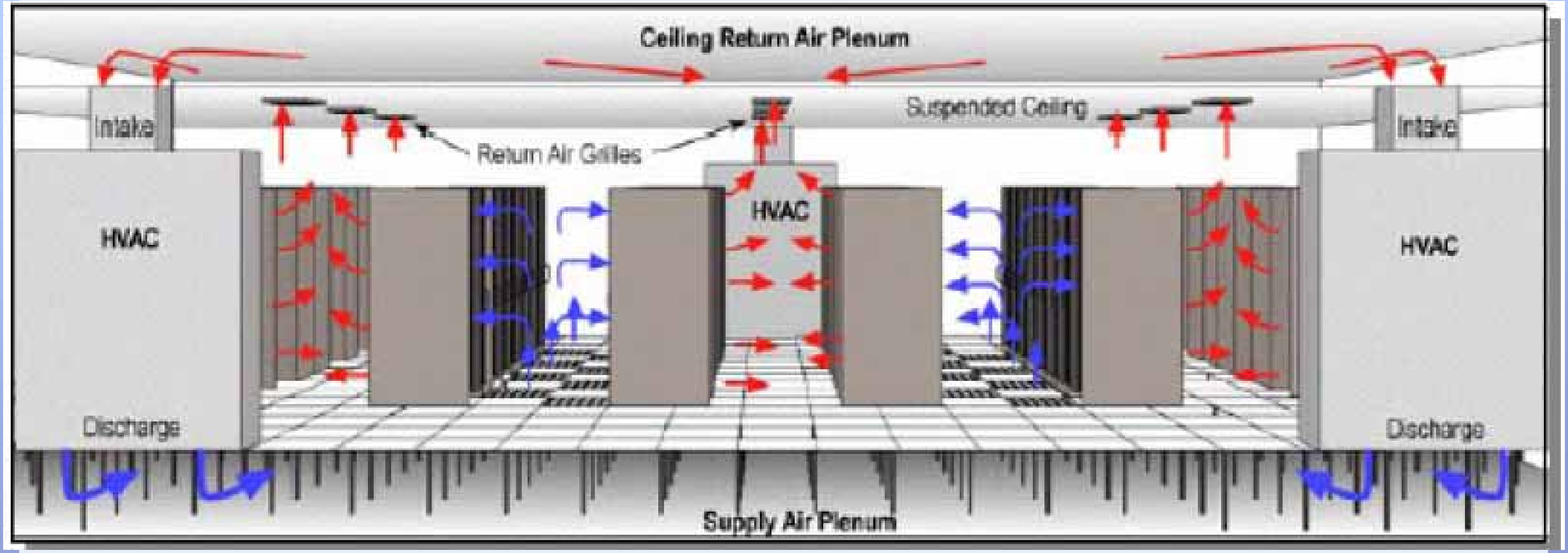
This chart illustrates tier requirements:

	Tier I	Tier II	Tier III	Tier IV
Number of Delivery Paths	Only 1	Only 1	1 Active 1 Passive	2 Active
Redundancy	N	N + 1	N + 1	S + S or 2 (N + 1)
Compartmentalization	No	No	No	Yes
Concurrently Maintainable	No	No	Yes	Yes
Fault tolerance to Worst Event	None	None	None	Yes

This chart illlustrates the tier attributes of the sites from which the actual availability numbers were drawn:

	Tier I	Tier II	Tier III	Tier IV
Building Type	Tenant	Tenant	Stand-alone	Stand-alone
Staffing	None	1 Shift	1 + Shifts	"24 by Forever"
Useable for Critical Load	100% N	100% N	90% N	90% N
Initial Gross Watts per Square Foot (W/ft²) (typical)	20-30	40-50	40-60	50-80
Ultimate Gross W/ft² (typical)	20-30	40-50	100-150[1,2,3]	150+[1,2]
Uninterruptible Cooling	None	None	Maybe	Yes
Support Space to Raised-Floor Ratio	20%	30%	80-90%[2]	100+%
Raised-Floor Height (typical)	12"	18"	30-36"[2]	30-36"[2]
Floor Loading lbs/ft² (typical)	85	100	150	150
Utility Voltage (typical)	208, 480	208, 480	12-15 kV[2]	12-15 kV[2]
Single Points-of Failure	Many + human error	Many + human error	Some + human error	None + human error
Annual Site-Caused IT Downtime (actuals)	28.8 hours	22.0 hours	1.6 hours	0.4 hours
Site Availability	99.671%	99.749%	99.982%	99.995%
Months to Implement	3	3-6	15-20	15-20
Year First Deployed	1965	1970	1985	1995
Construction Cost (±30%)[1,2,3]				
Raised Floor	$220/ft²	$220/ft²	$220/ft²	$220/ft²
Useable UPS Output	$10,000/kW	$11,000/kW	$20,000/kW	$22,000/kW

[1] 100 W/ft² maximum for air-cooling over large areas, water or alternate cooling methods greater than 100 W/ft² (added cost excluded).
[2] Greater W/ft² densities require greater support space (100% at 100 W/ft² and up to 2 or more times at greater densities), higher raised floor, and, if required over large areas, medium voltage service entrance.
[3] Excludes land; architectural, engineering, and commissioning fees; permits and other fees; interest; and abnormal civil costs. These can be several million dollars. Assumes minimum of 15,000 ft² of raised floor, architecturally plain, one-story building, with power backbone sized to achieve ultimate capacity with installation of additional components or systems. Make adjustments for NYC, Chicago, and other high cost areas.


Ceiling Return Air Plenum
Intake
Suspended Ceiling
Intake
Return Air Grilles
HVAC
HVAC
HVAC
Discharge
Discharge
Supply Air Plenum

[HP]

Part III

NUS DC Live Migration – the Art and Challenges

Key Considerations and Difficulties Encountered

- **The datacentre must have minimal downtime as it is running live.**
- **Renovated DC must be able to cater for DC operation till year 2010.**
- **Deciding DC tier level.**
- **Maximising IT Area.**
- **Identifying possible/planned hot spot/area.**
- **Non-standard air flow racks/equipments.**
- **Inter-racks dependencies.**
- **Control/minimising dust in operating IT area during the renovation.**
- **Racks with weight overloading floor structural design.**
- **Air flow issues within a rack.**
- **Standardising racks design.**
- **Linkage of M&E vendors and IT vendors during renovation and IT migration in this live DC.**

DATA CENTRE @ NUS

OLD DC

- **Single** incoming power source (electrical to IT)
- **Standalone** UPSes; not all equipment on UPS
- Equipments mostly on **single** UPS supply
- Insufficient cooling with **no humidity control**
- **Generator** does not meet existing IT load requirement
- **No** environmental monitoring system
- Building smoke detectors and **Inergen** gas system at selected areas
- **Un-structured** cablings

New DC

- **Two** different incoming power source to DC (electrical for IT)
- **Centralized** 2N UPS with individual isolation transformer supplying power to all IT equipments in DC
- **Dual** power source for all IT racks
- **400mm** Raised Floor System
- Fire detection and protection systems - **FM200** and building smoke detectors
- **Structured** Cabling
- **Hot & Cold aisles** with ducted return
- **Fire rated** perimeters
- Stand alone **earthing system**
- **CCTV** Monitoring
- **Contactless** Door Access System
- Dedicated N+1 Crac units with **humidity control**, backup by a dedicated generator
- **New generator** for IT electrical supply
- **EMS** (temperature, humidity, water detection, PDU incoming and outgoing, crac units, FM200, etc)

Interesting Facts...

- Renovation Duration
  : 1 Year
- DC NFA
  : 720 sqm
- 60% attained IT Area

Part III

Data Centre Highlights…

Security Contactless Card Access

Security Cameras

Two different incoming power source to DC

Centralized UPS for all IT equipment in DC

Dual power source for all IT racks

Dedicated A/C with humidity control (backup by generator)

New generator for project IT electrical requirement

EMS (temperature, humidity, liquid detection, etc)

FM200 Gas Cylinders

FM200 Pipings above Ceiling Boards

FM200 System

>> 0 >> 1 >> 2 >> 3 >> 4 >>

FM200 Release Nozzle on Ceiling Board

Water Detection Cable

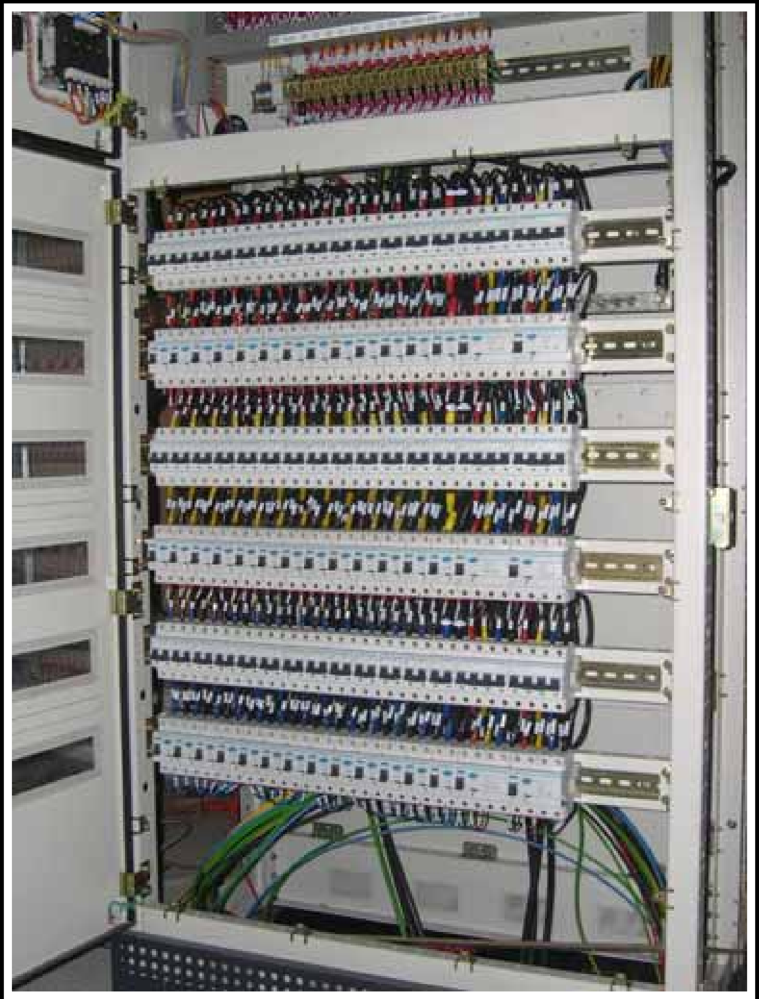
Structured cabling below raised floor

Network Cablings

Earth Cablings

Return Air Duct for CRAC

Internal View of a Typical PDU



Part IV

Milestones in Pictures…

Installation of compressors for CRAC units

>> 0 >> 1 >> 2 >> 3 >> 4 >>

Installation of compressors for CRAC units

>> 0 >> 1 >> 2 >> 3 >> 4 >>

Installation of compressors for CRAC units

Installation of compressors for CRAC units

Delivery of CRAC units

Phase-3

Phase-4

Media Room Entrance

Media Room

Network Room Entrance

>> 0 >> 1 >> 2 >> 3 >> 4 >>

Network Room

UPS Room

Part V

What’s next...

- **DC @ NUS High School (NUSHS)**
  - ✓ Disaster Recovery Site outside Kent Ridge Campus
  - ✓ Construction Duration: Jun – Oct’ 05 (4 mth)
  - ✓ NFA = 800 sqm
  - ✓ Operational in Nov / Dec 2005

- **Primary Data Centre**
  - ✓ Able to cater to Computer Centre’s 10-year IT plans
  - ✓ Proposed NFA = 2,000 sqm
  - ✓ Coming soon...

Thank You