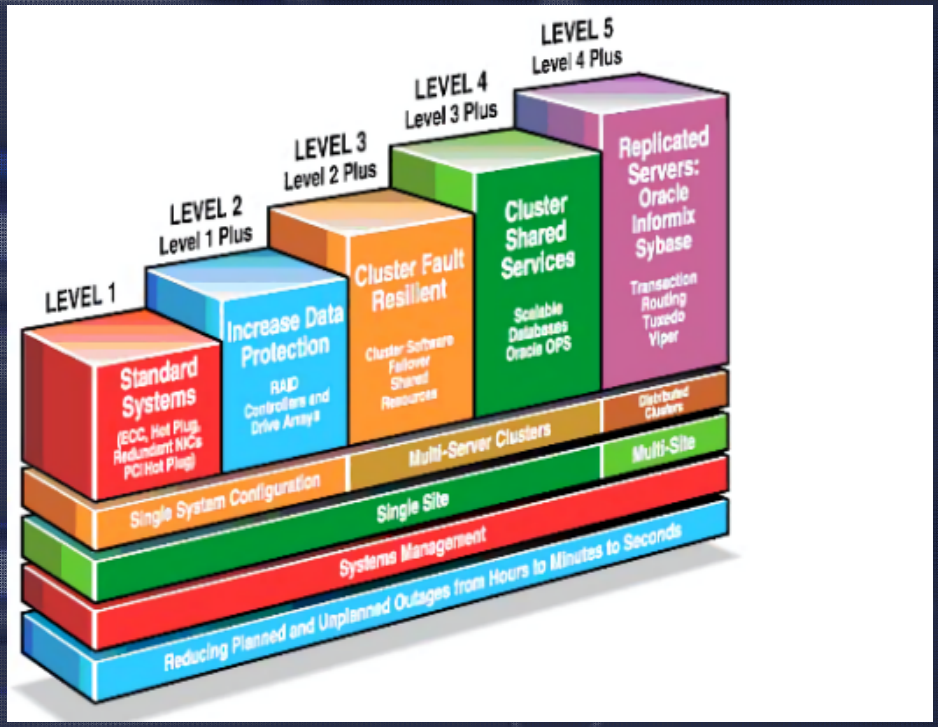
PODATKOVNI CENTAR
RIZICI, NAPAJANJE, KLIMA-

DUBRAVKO MILJKOVIĆ
HRVATSKA ELEKTROPRIVREDA
ZAGREB

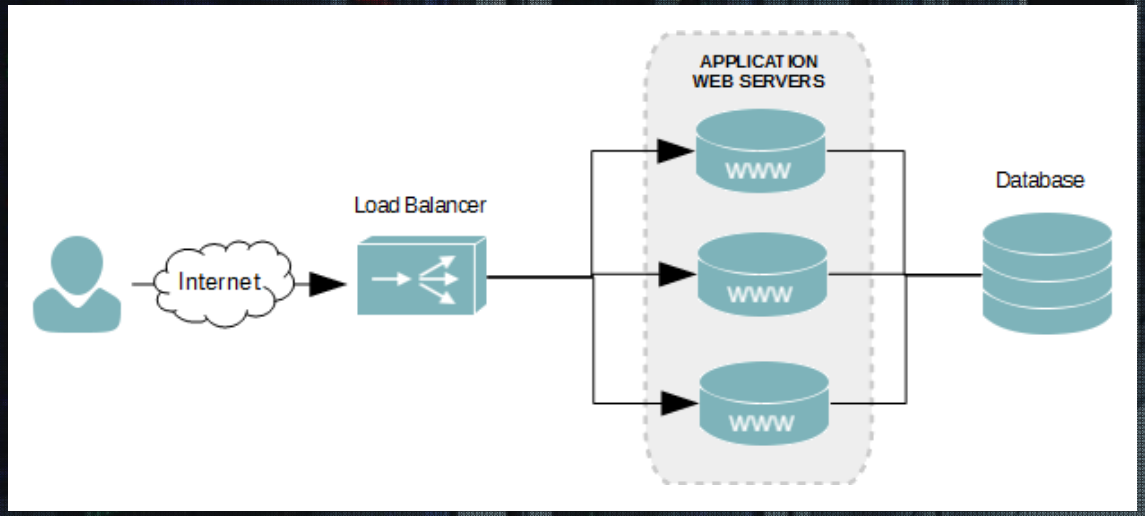
RASPOLOŽIVOST I DOWNTIME

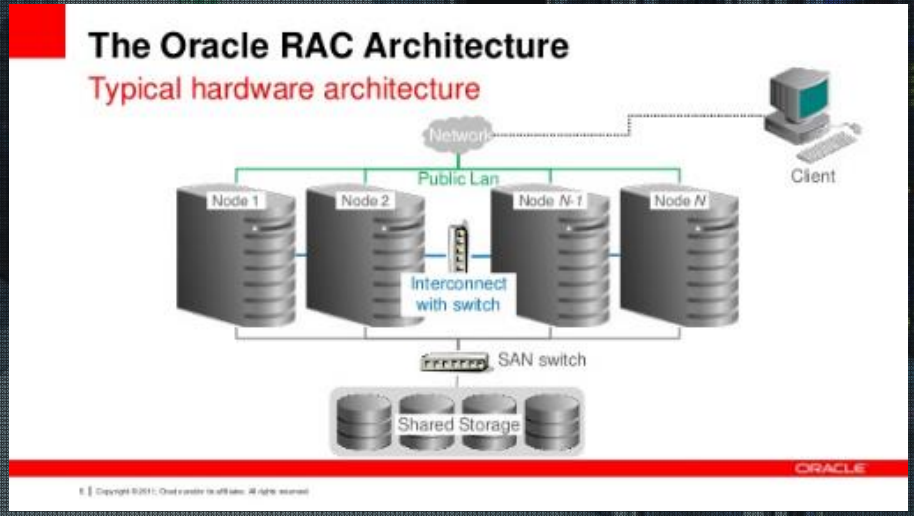
- Razina 1
  - Standardni poslužitelj
- Razina 2
  - RAID diskovi
- Razina 3
  - Failover cluster
- Razina 4
  - Skalabilni cluster
- Razina 5
  - Distribuirani cluster



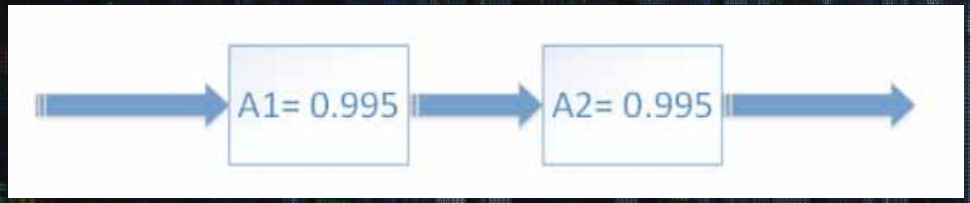
Availability	Annual downtime
99%	87.6 hours
99.9%	8.76 hours
99.99%	52.5 minutes
99.999%	5.25 minutes

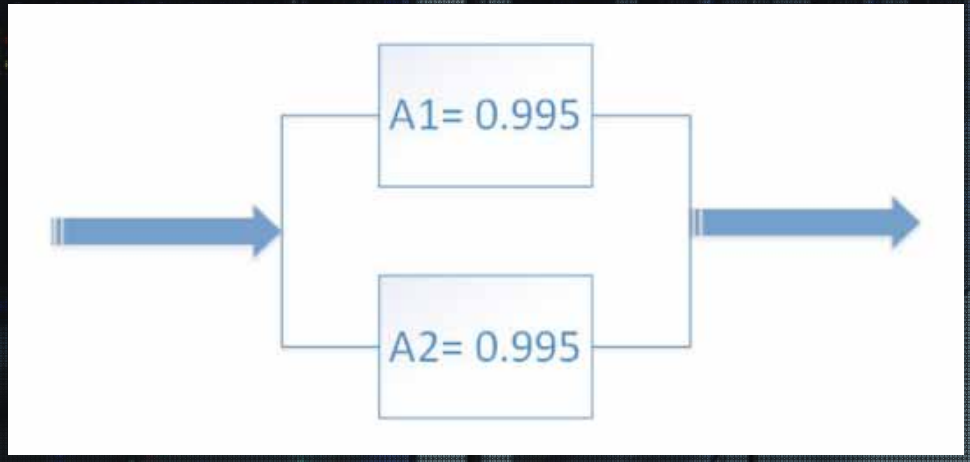
CLUSTER COMPUTING (RAČUNALNI GROZDOVI)





POUZDANOST I RASPOLOŽIVOST





KOMPONENTE PODATKOVNOG CENTRA

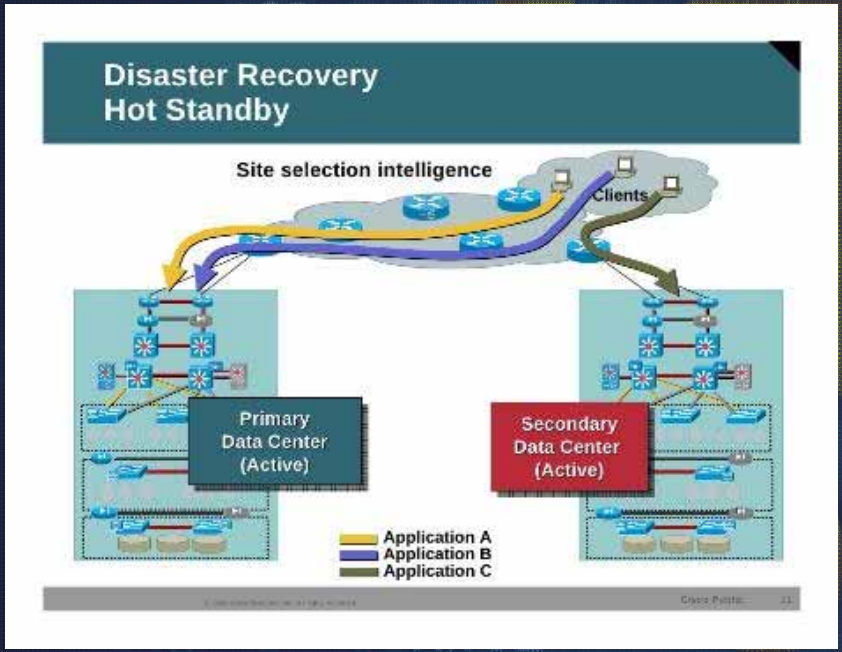
- Osnovni sustavi podatkovnog centra:
  - Fizički prostor
  - Podignuti pod
  - Unutarnje električne instalacije
  - Neprekidno napajanje
  - Kabliranje
  - Hlađenje
  - Sustav za detekciju i gašenje požara

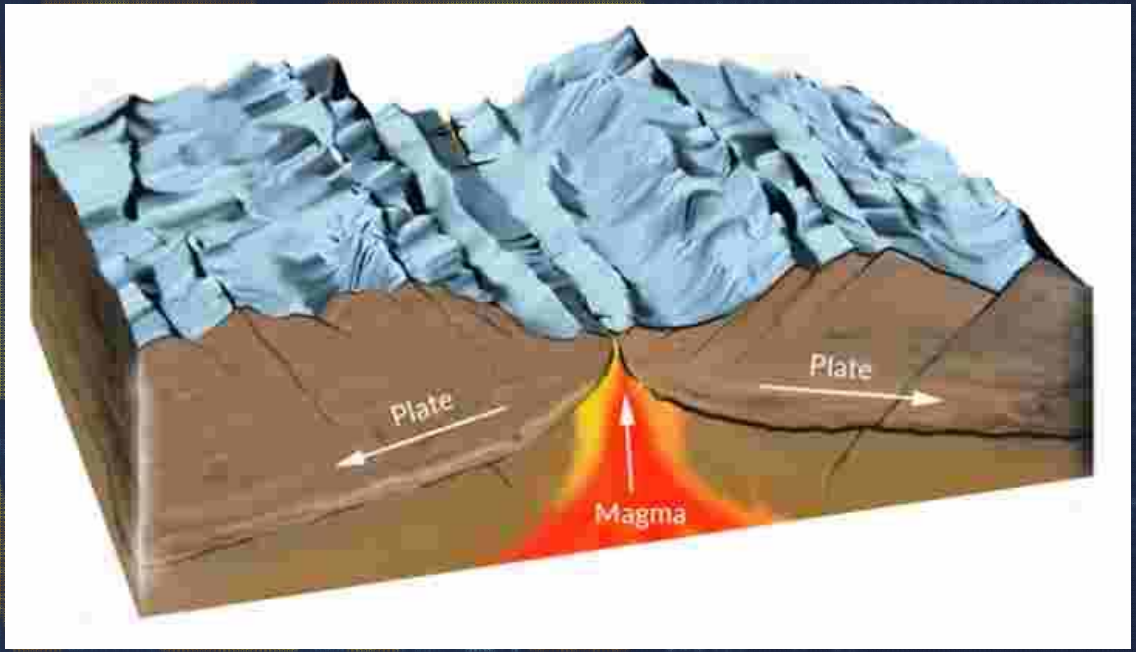
SUPREMA

PODATKOVNI CENTAR – KRITERIJ DIZAJNIRANJA

- **Jedan ili više prostora?**
- Jedan veliki podatkovni centar je jednostavniji za upravljanje nego više malih
- Jedan podatkovni centar stavlja sva jaja u jednu košaru
- Hot- hot site
- Hot – Cold site

PODATKOVNI CENTAR NA DVIJE LOKACIJE





Kod izbora druge lokacije voditi računa o tektonskim pločama i vanjskoj mreži za napajanje električnom energijom

SIGURNOST PRISTUPA

Proxy kartica

Biometrija - otisak prsta

Biometrija – raspoznavanje lica

Suprema

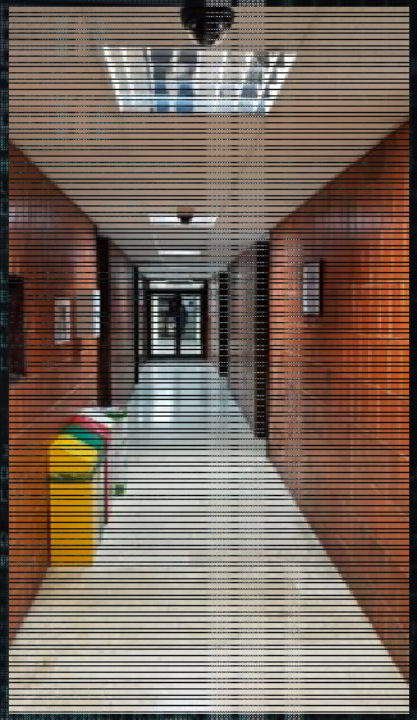
SIGURNOST PROSTORA

Govorne poruke putem telefonske mreže

Satel

VIDEONADZOR

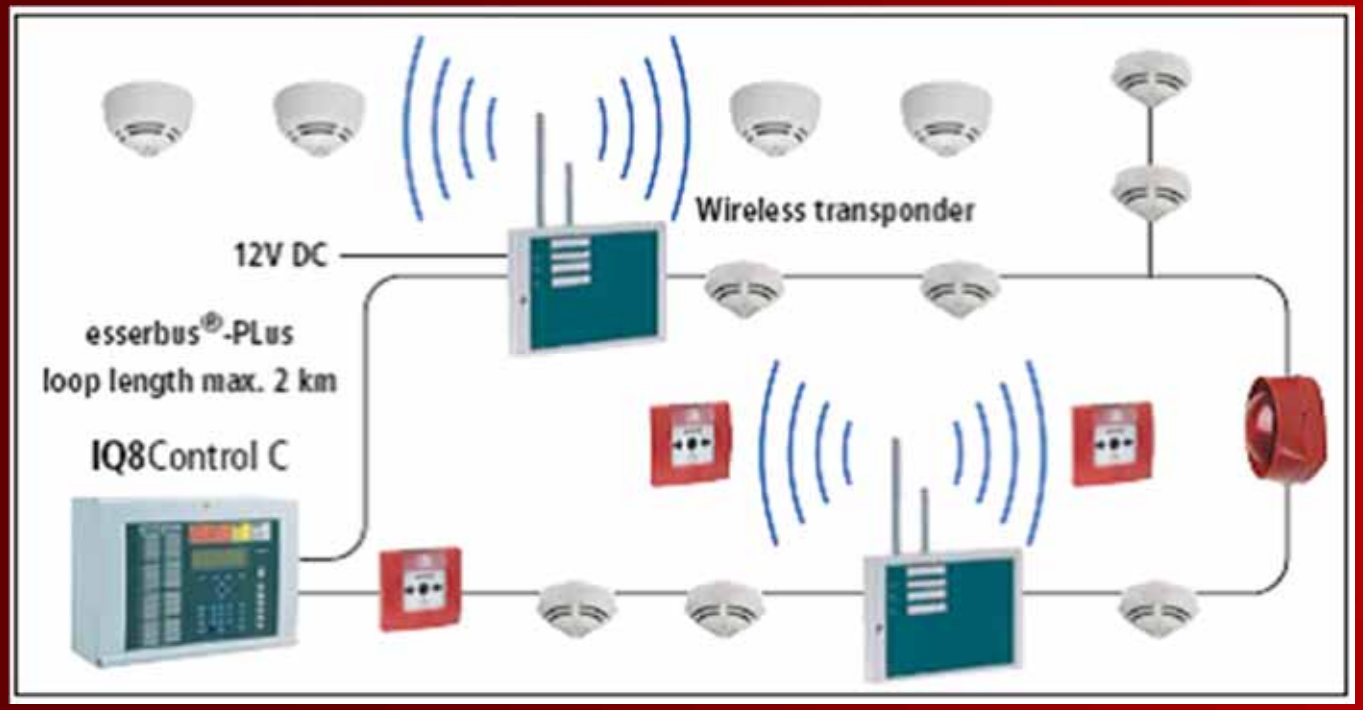
Motorizirane HD IP video kamere i pripadna mrežna oprema



ZAŠTITA OD POŽARA

VATRODOJAVNI SUSTAV

Detektori požara i upravljačka stanica



VATRODOJAVNI SUSTAV

Detektor dima i mlaznica za gašenje

VATRODOJAVNI SUSTAV

Akustički i svjetlosni alarm

VATRODOJAVNI SUSTAV

Upravljačka stanica

VATRODOJAVNI SUSTAV

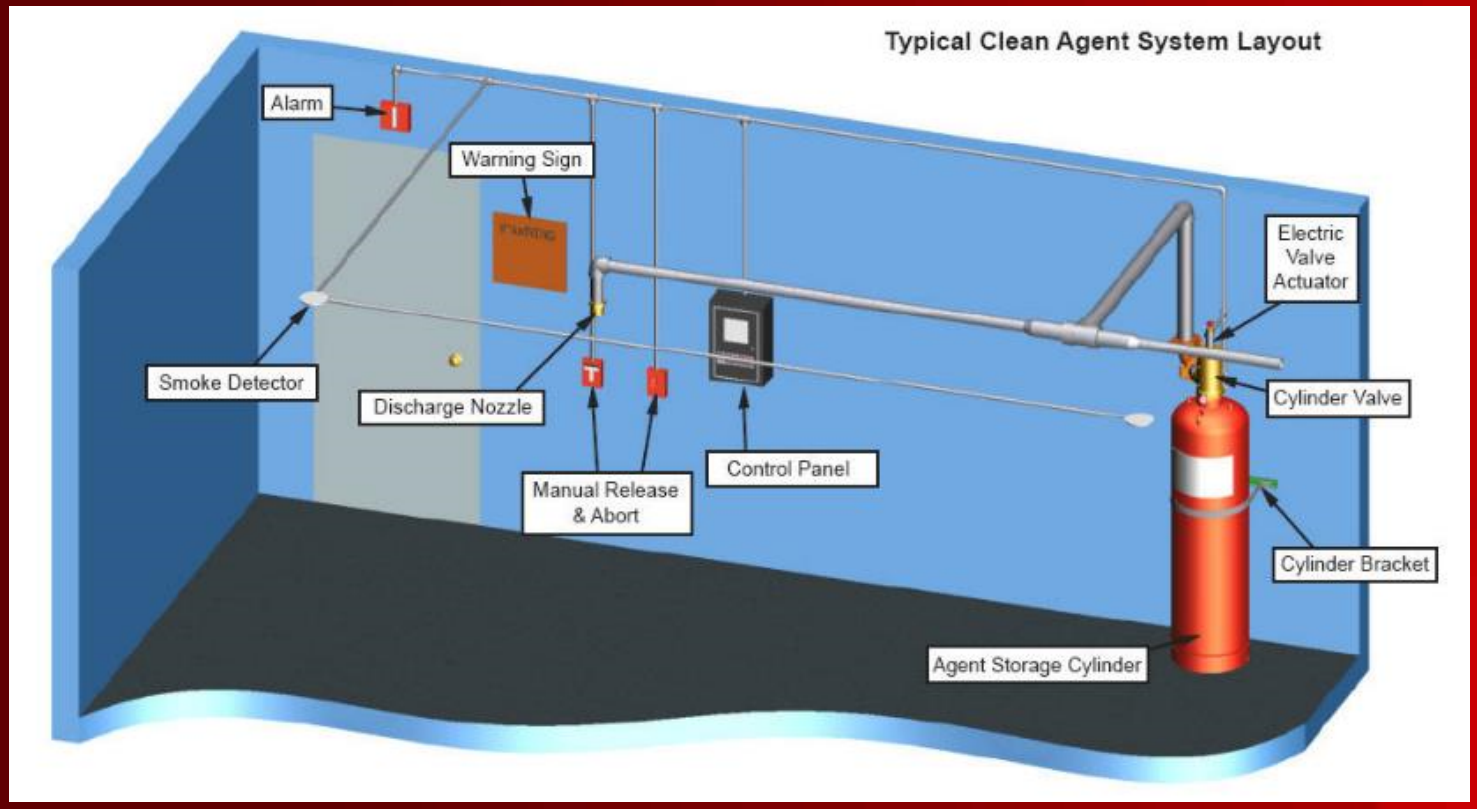
Upravljačka stanica

EKOLOŠKI PLIN ZA GAŠENJE

Plin za gašenje u bocama – FM 200

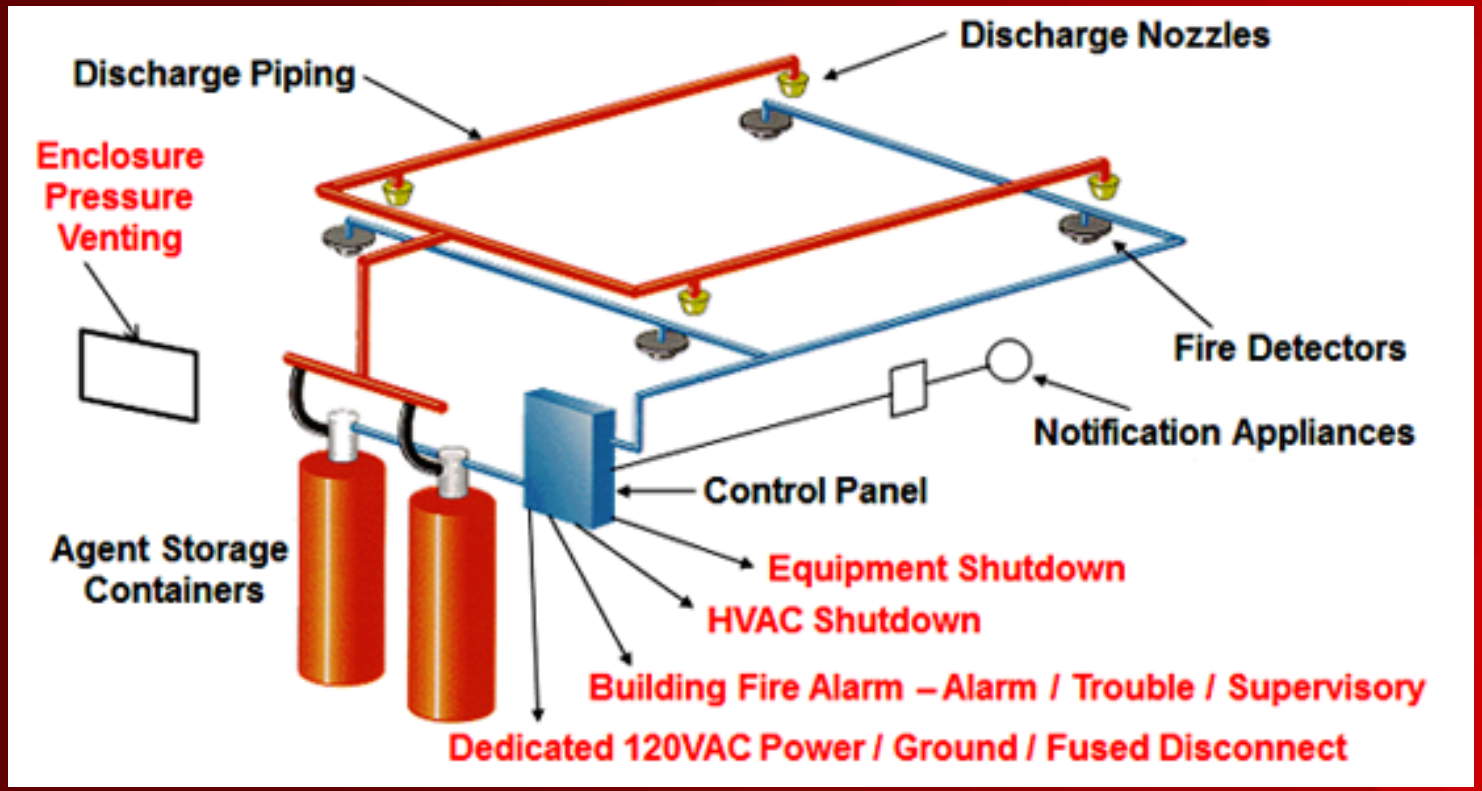
VATRODOJAVNI SUSTAV

Tipični sustav za detekciju, dojavu i gašenje



VATRODOJAVNI SUSTAV

Tipični sustav za gašenje

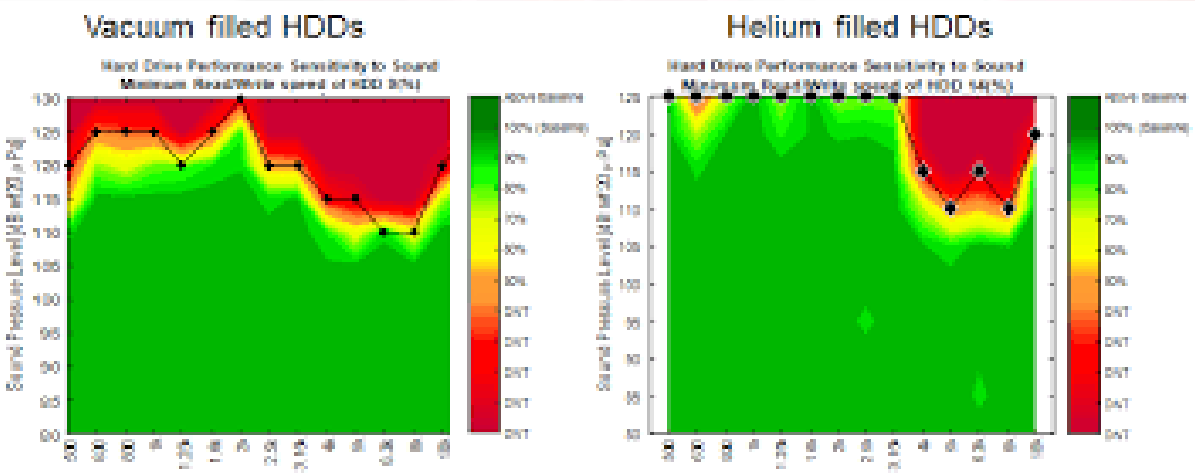


VATRODOJAVNI SUSTAV

- Pražnjenje FM-200® kratkotrajno smanjuje vidljivost u prostoriji (mogućnost dizorijenatcije)
- Izrazito velika (zaglušna) buka tijekom pražnjenja sustava (110 – 130 dB)
- Prilikom pražnjenja treba izbjegnuti dodir sa kožom (mogućnost smrzotina)

HDD OSJETLJIVOST NA BUKU I VIBRACIJE

- Sustav za gašenje proizvodi veliku buku (110 – 130 dB) koja će barem uzrokovati kratkotrajnu degradaciju performansi nekih HDD-ova
- U najgorem slučaju može doći do kvara HDD-a



Melissa A. Loureiro, A. Elder and A. Ahmadzadegan Johnson Controls

HDD OSJETLJIVOST NA BUKU I VIBRACIJE

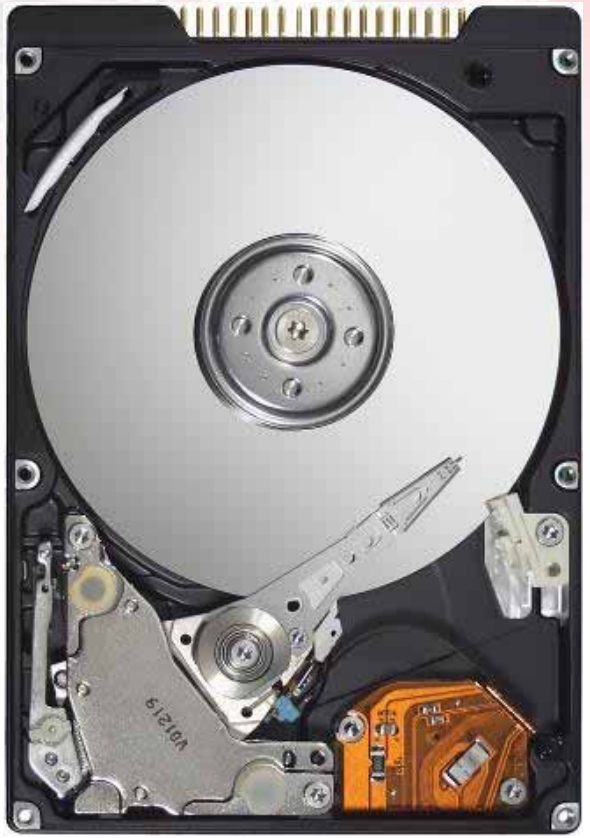
- Kvarovi zbog vibracija

- Uzroci:
- Protupožarni alarm
- Sustavi za gašenje požara plinom

- Pojedine frekvencije zvuka naročito utječu na rad HDD-a
- Visoke amplitude zvuka utječu na rad HDD-a
- Osjetljivost ovisi o konstrukciji HDD-a
- Gašenje servera prije pražnjenja plina za gašenje

- Prevencija

- Poboljšana konstrukcija HDD-a
- Gašenje diskova
- Smanjenje buke na izvoru
- Pozicija mlaznica za gašenje u odnosu na pozicije HDD-ova
- Umoraba alata za matematičko modeliranje pri određivanju načina za smanjivanje utjecaja buke na HDD (pozicije diskova)
- Akustička izolacija HDD-ova
- Uporaba robusnih HDD-ova
- Uporaba solid-state data (SSD) uređaja za pohranu

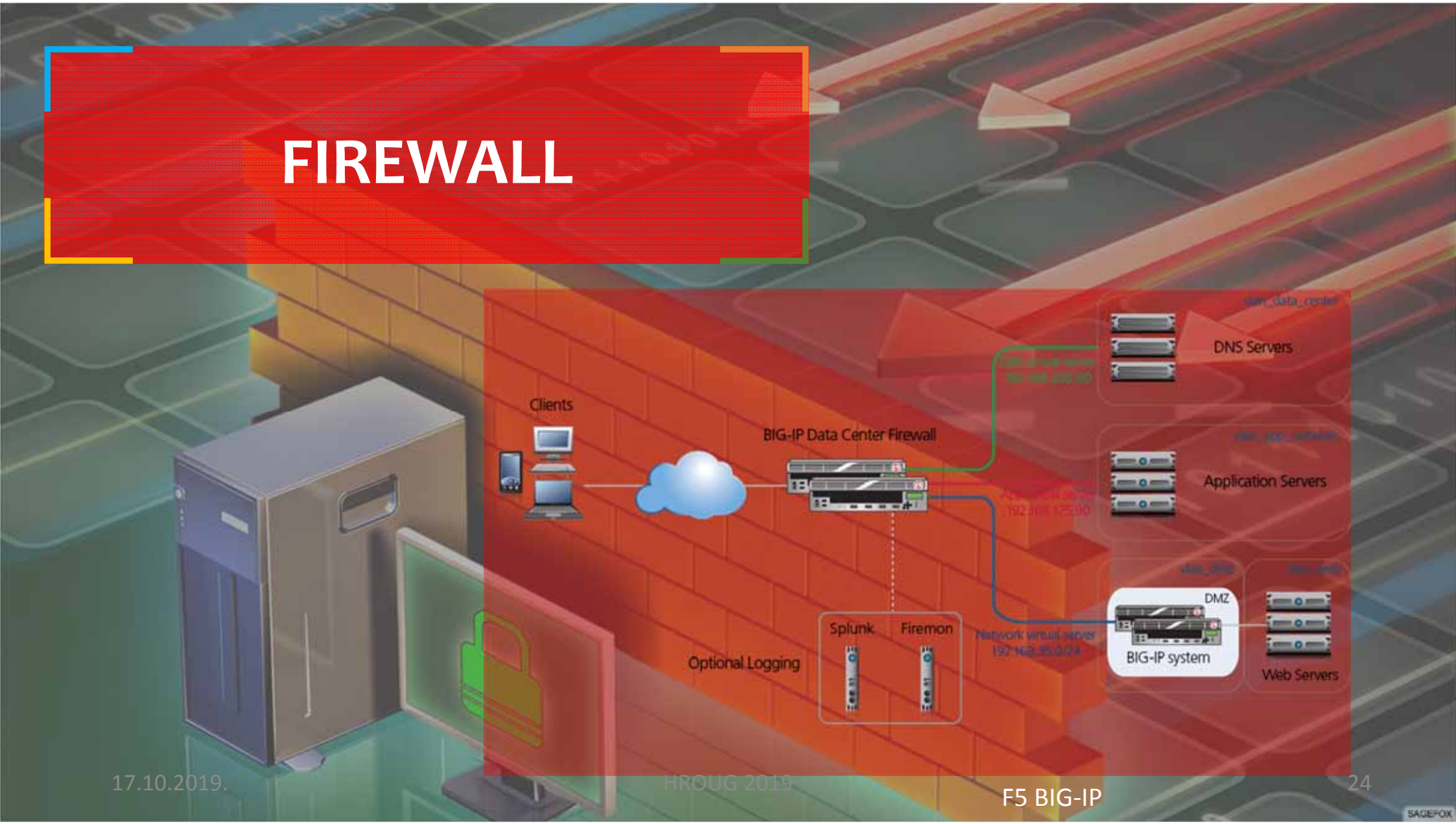


VIRUSNA ZAŠTITA

Zaštita na razini fizičkih i virtualnih poslužitelja

Adrián Otayza

FIREWALL


Clients
BIG-IP Data Center Firewall
DNS Servers
Application Servers
DMZ
BIG-IP system
Web Servers
Splunk
Firemon
Optional Logging

VATROOTPORNO PODATKOVNO SPREMIŠTE (FIREPROOF DATA STORE)

HDDFire

POPLAVA – KIŠA I SLIVNE VODE

KONTROLA LETA ZAGREB

Nacional

Crocontrol

KONTROLA LETA ZAGREB

AIN

KONTROLA LETA ZAGREB

AIN

ZRAČNI PROSTOR HRVATSKE

TCAS

Normalna situacija

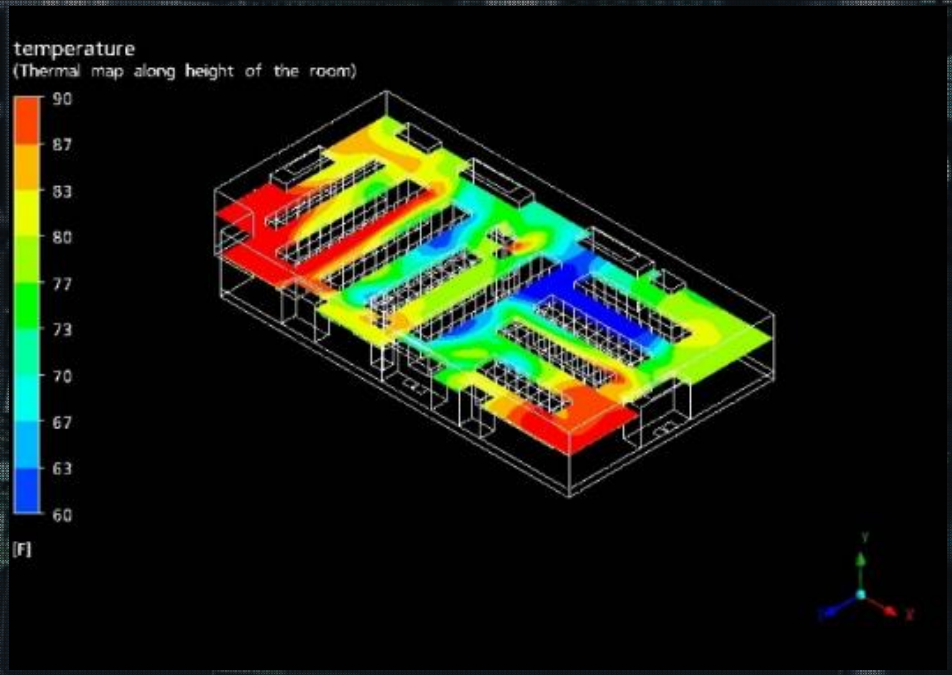
Pad računalnog sustava

Flightradar24

KLIMATIZACIJA (HVAC)

- Kritična za rad podatkovnog centra
- Održava potrebnu temperaturu i vlažnost
- Bez klimatizacije muguć je rad oko pola sata (nakon toga se termička zaštita gasi servere)
- Potreban redundantni dizajn

  (npr. dva ili više klima uređaja)
- Termalno modeliranje za predviđanje potreba

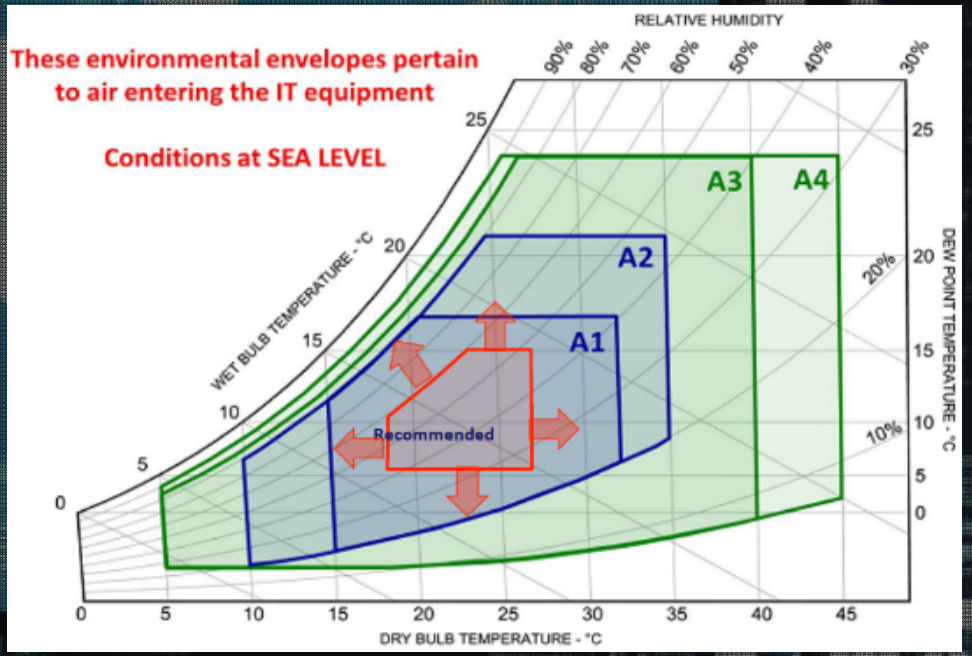


KLIMATIZACIJA (HVAC)

Summary of vendor datacenter temperature recommendations

Vendor	Low (C°/F°)	High (C°/F°)	Optimal
ASHRAE[5]	18/64.4	27/80.6	-
Enviromon[6]	18/64.4	27/80.6	-
Avtech[7]	20/68	24/75	-
Cisco[8]	18/64.4	27/80.6	-
Google[9]	-	-	26.7/80
Dell[10]	24+/Upper 70 F°	26+/Lower 80 F°	
HP[11]	18/64.4	27/80.6	
IBM[12]	18/64.4	27/80.6	
ServersCheck[4]	18/64	27/80	-
Oracle[13]	21/70	23/74	22/72

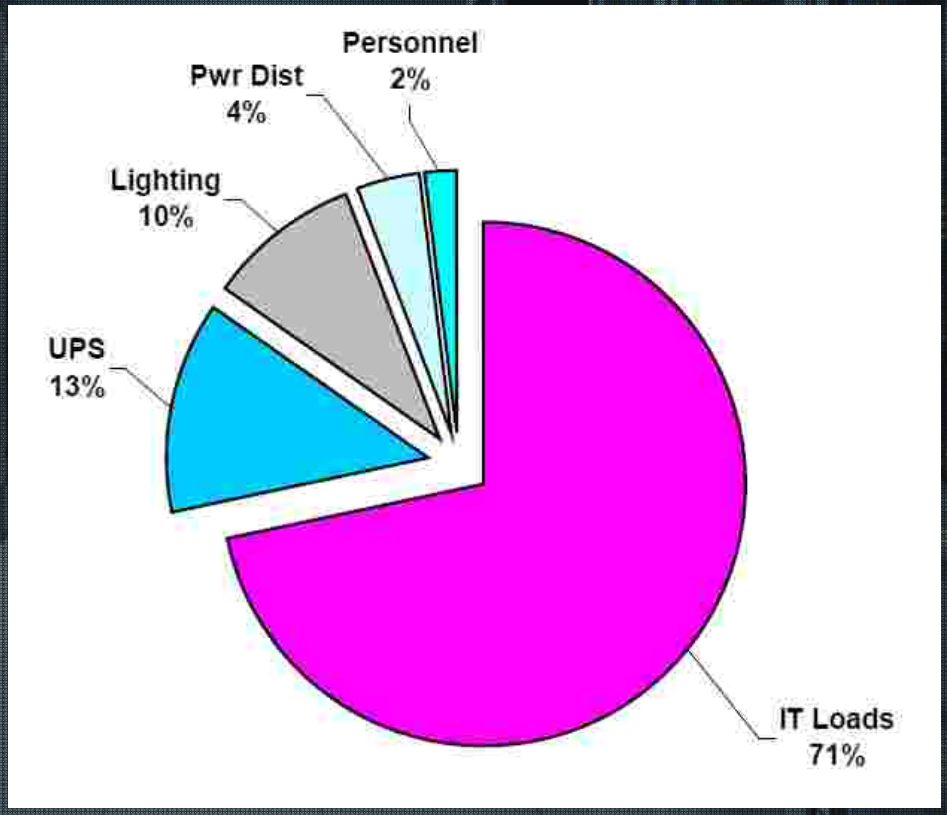
Većina opreme u centru spada u klasu A1 i A2



ASHRAE

DOPRINOSTI TERMALNOM OPTEREĆENJU

- Ukupan toplinski izlaz je suma toplinskih izlaza svih komponenti
  - IT oprema
  - UPS
  - Rasvjeta
  - Distribucija energije
  - Osoblje



IZRAČUN ZAHTJEVA ZA HLAĐENJE

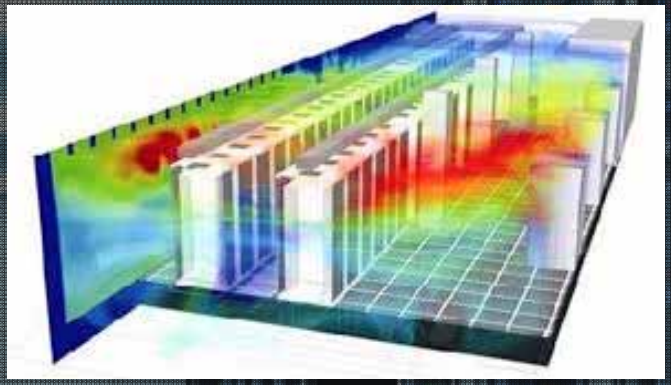
Item	Data required	Heat output calculation	Heat output subtotal
IT Equipment	Total IT load power in Watts	Same as total IT load power in watts	_____ Watts
UPS with Battery	Power system rated power in Watts	(0.04 x Power system rating) + (0.05 x Total IT load power)	_____ Watts
Power Distribution	Power system rated power in Watts	(0.01 x Power system rating) + (0.02 x Total IT load power)	_____ Watts
Lighting	Floor area in square feet, or Floor area in square meters	2.0 x floor area (sq ft), or 21.53 x floor area (sq m)	_____ Watts
People	Max # of personnel in data center	100 x Max # of personnel	_____ Watts
Total	Subtotals from above	Sum of heat output subtotals	_____ Watts

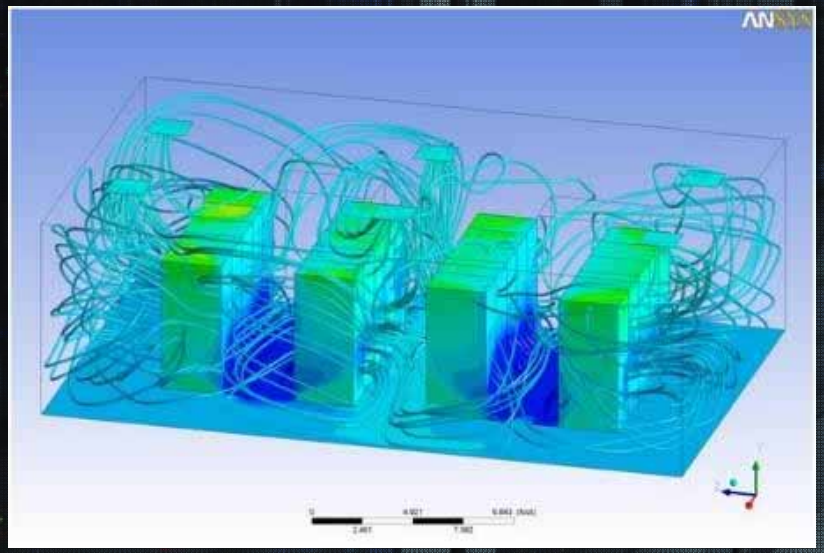
Kod većih podatkovnih centara uzeti u obzir i ulaz topline izvana preko zidova
Ukupnu dobivenu sumu povećati za 30% i dodati potrebnu redundanciju

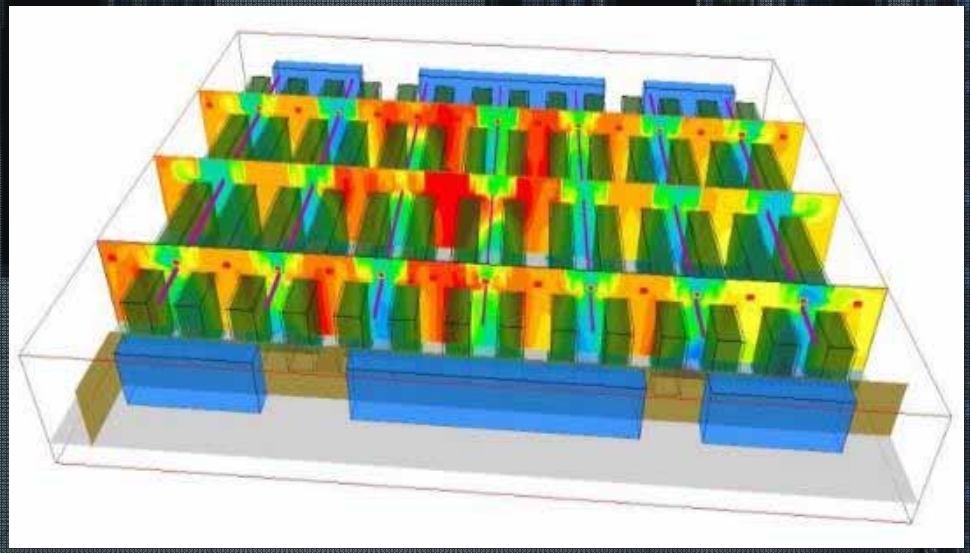
APC

KLIMATIZACIJA – THERMAL MODELING

CFD – Computational Fluid Dynamics
Digitalni klon podatkovnog centra

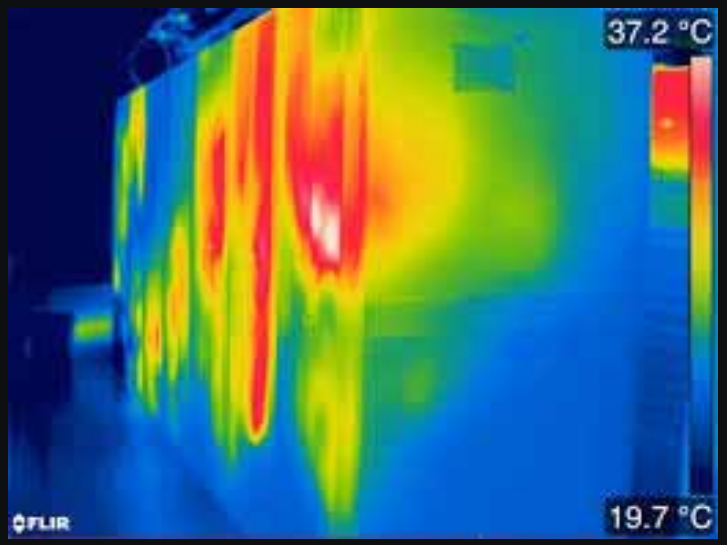




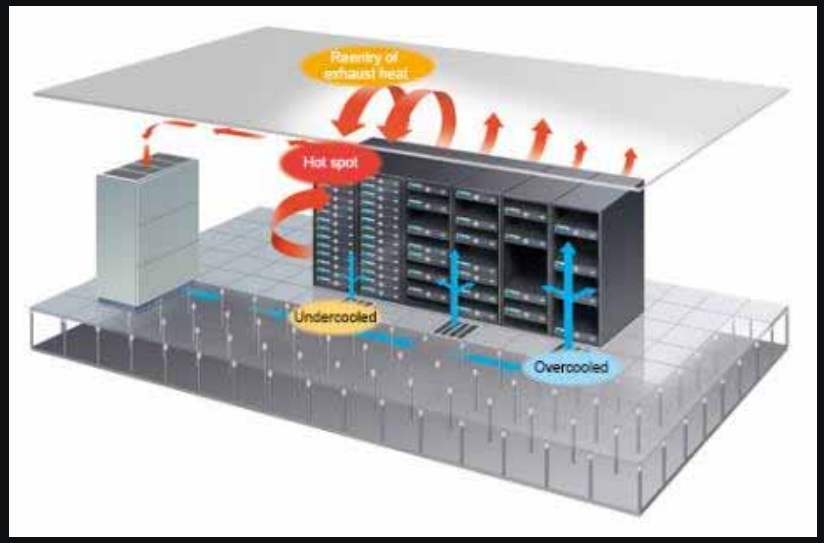


TERMOVIZIJSKA FLIR KAMERA

Infracrveno termičko mapiranje je odličan alat za upravljanjem topline unutar podatkovnog centra /detekcija vrućih točaka – hot spots)



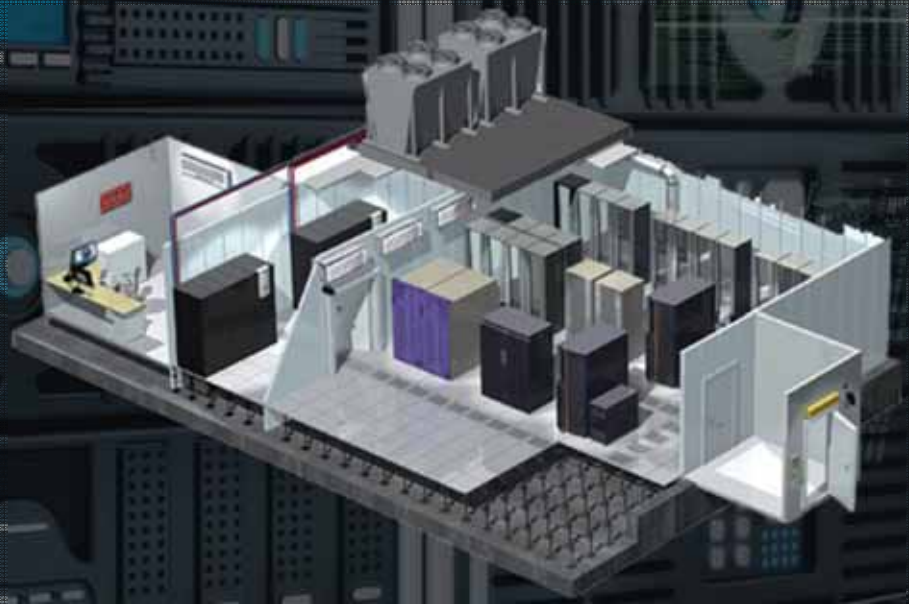
FLIR Systems

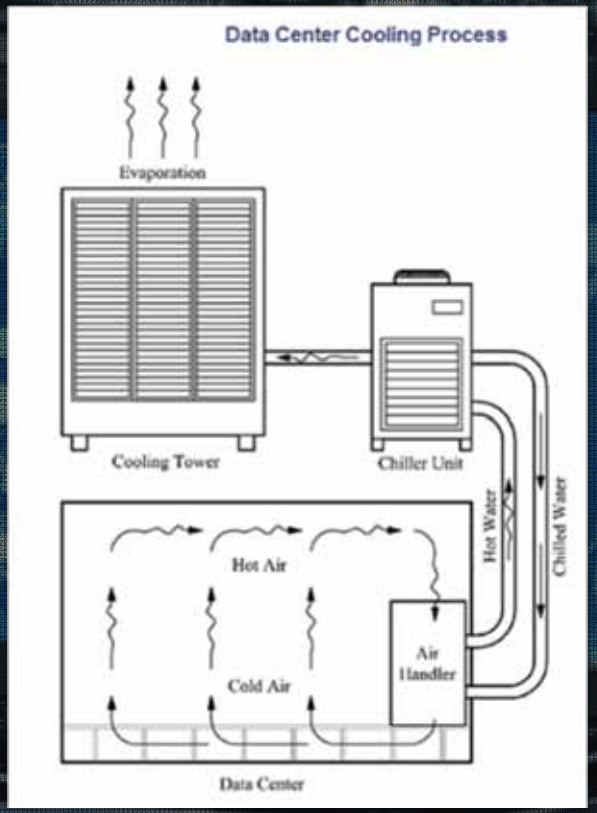


Azbil

KLIMATIZACIJA PODATKOVNOG CENTRA

Cjelokupni sustav





N. Khasawneh and R. A. Dasan

KLIMATIZACIJA PODATKOVNOG CENTRA

Chiller

Cooling tower

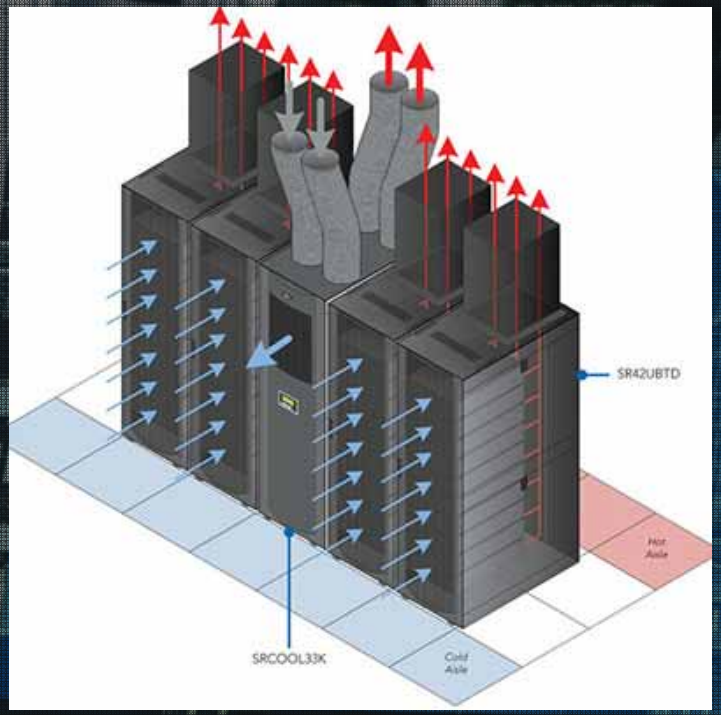
CRAC/CRAH Unit

KLIMATIZACIJA PODATKOVNOG CENTRA

Pumpe za fluid

Elektronika za nadzor pumpi

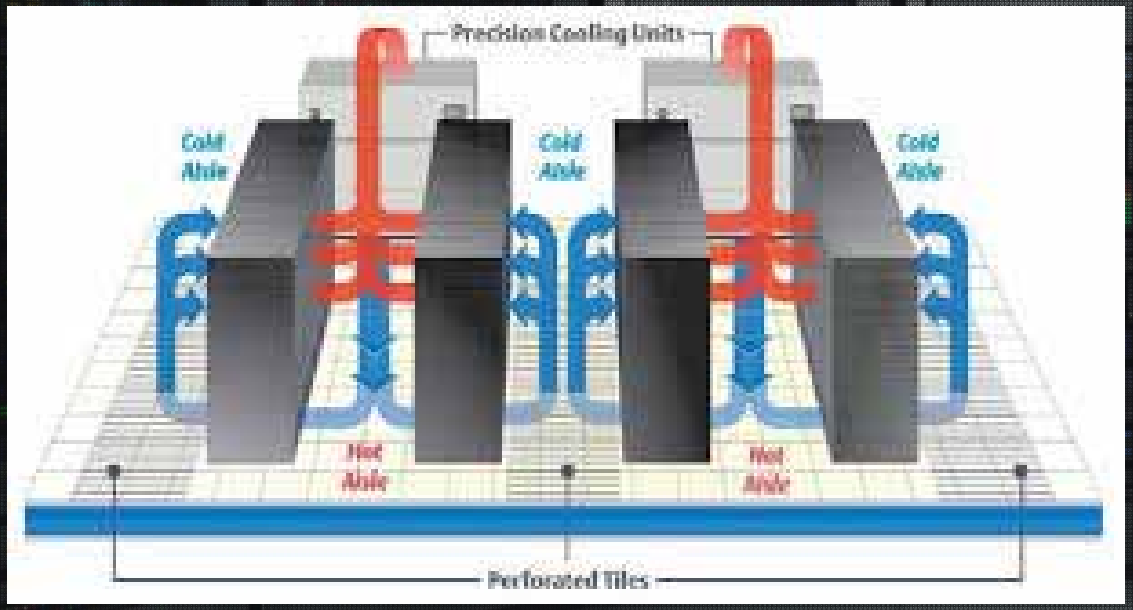
KLIMATIZACIJA PODATKOVNOG CENTRA

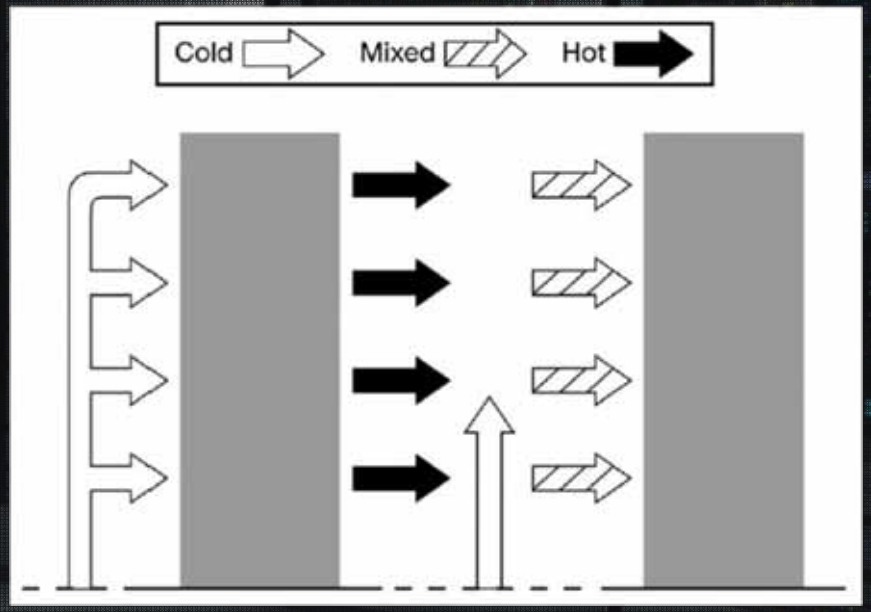


Hladan zrak dolazi kroz perforirani uzdignuti pod (ili posebne otvore)

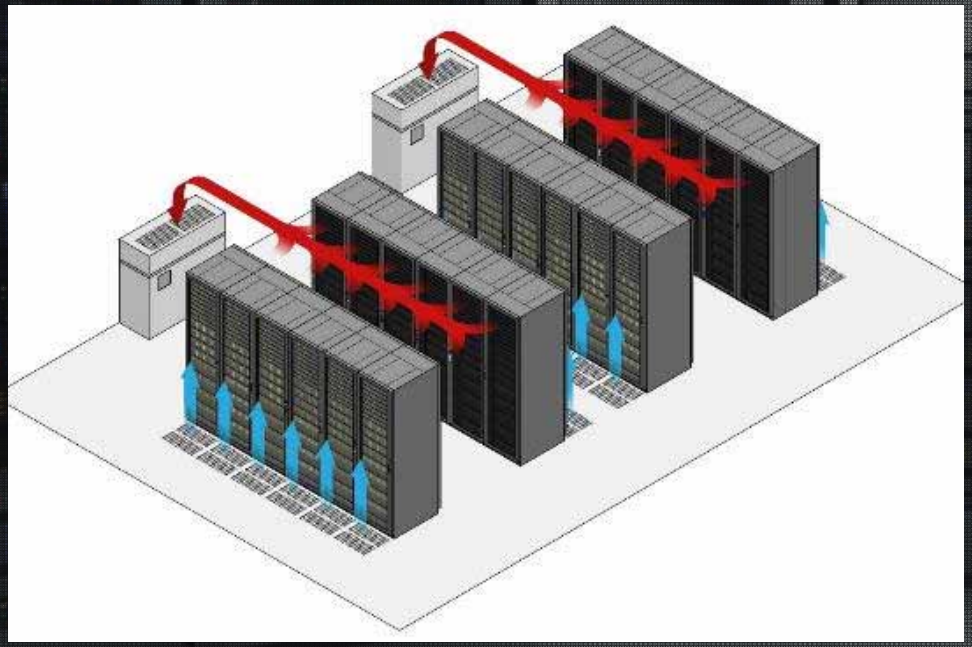
Odvojiti tokove hladnog i toplog zraka

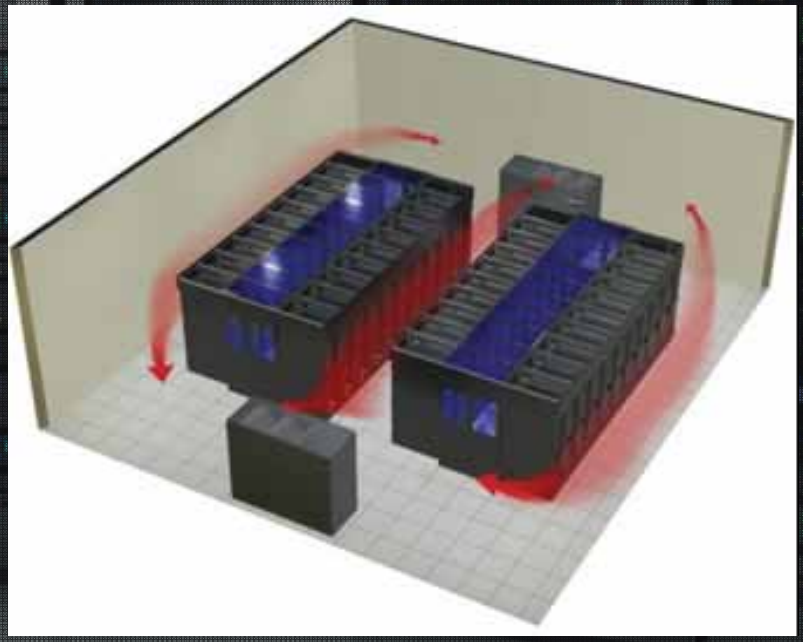
KLIMATIZACIJA PODATKOVNOG CENTRA



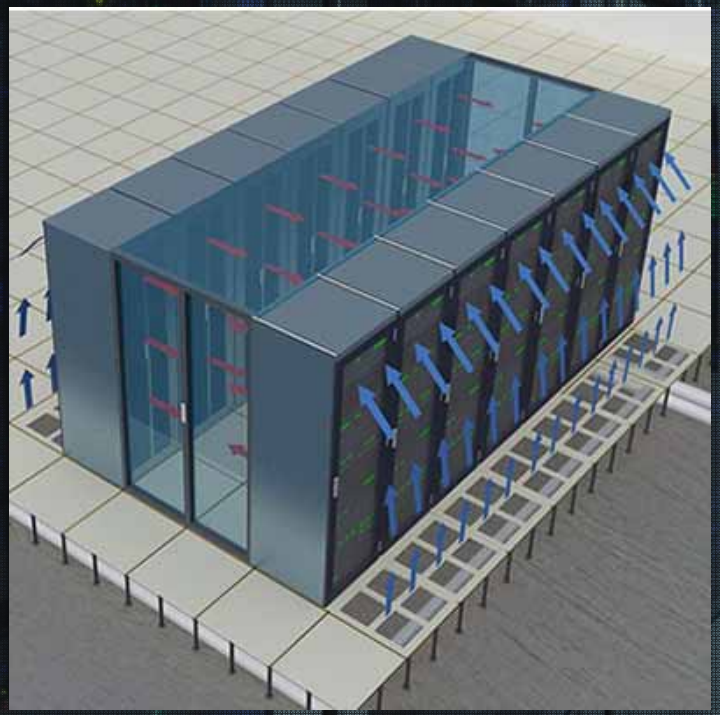


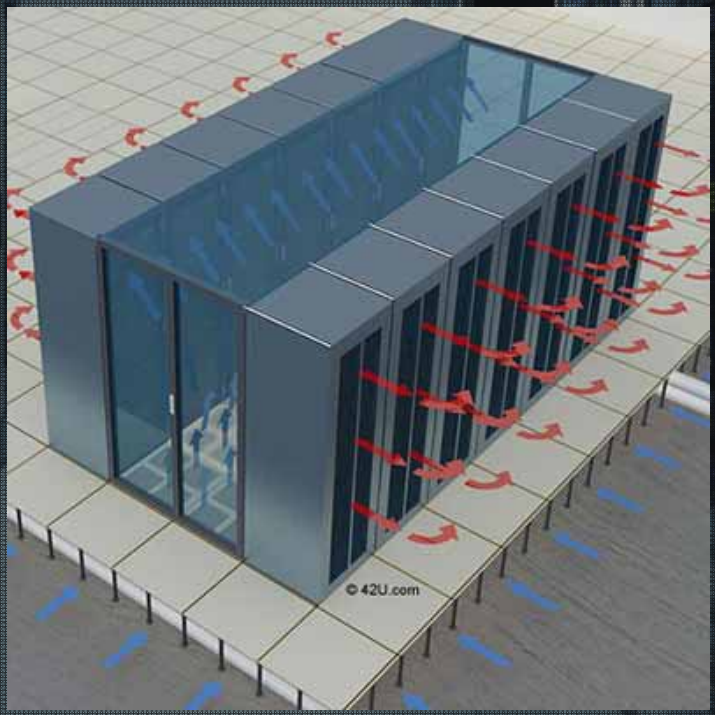
VRUĆ PROLAZ – HLADAN PROLAZ (HOT AISLE - COLD AISLE) Zadržavanje protoka zraka (Air Flow Containment)





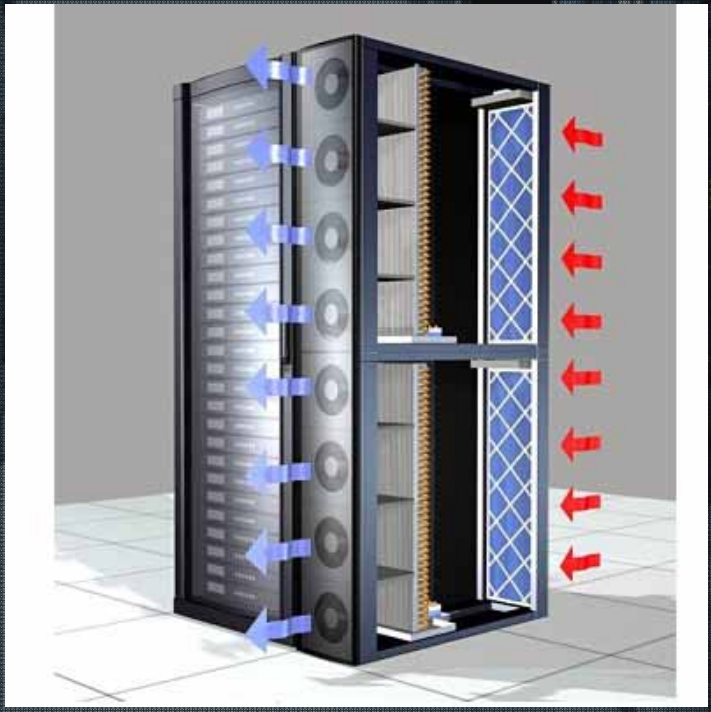
VRUĆ PROLAZ – HLADAN PROLAZ (HOT AISLE - COLD AISLE)
Zadržavanje protoka zraka (Air Flow Containment)





InRow HLAĐENJE

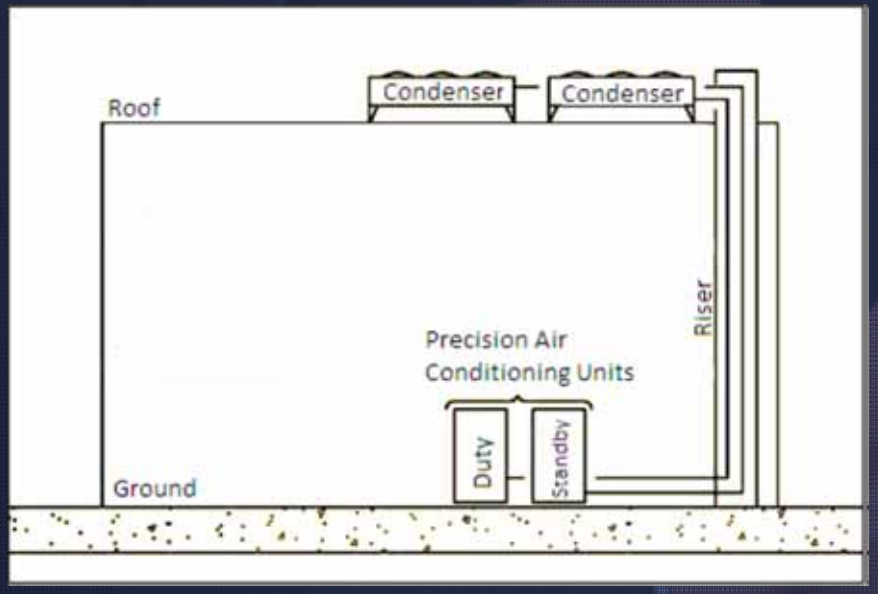
- Dodatne jedinice za hlađenje uz postojeću klimatizaciju
- Primarno hlađenje na podu bez perforacije



INROW COOLERI IZMEĐU RACKOVA

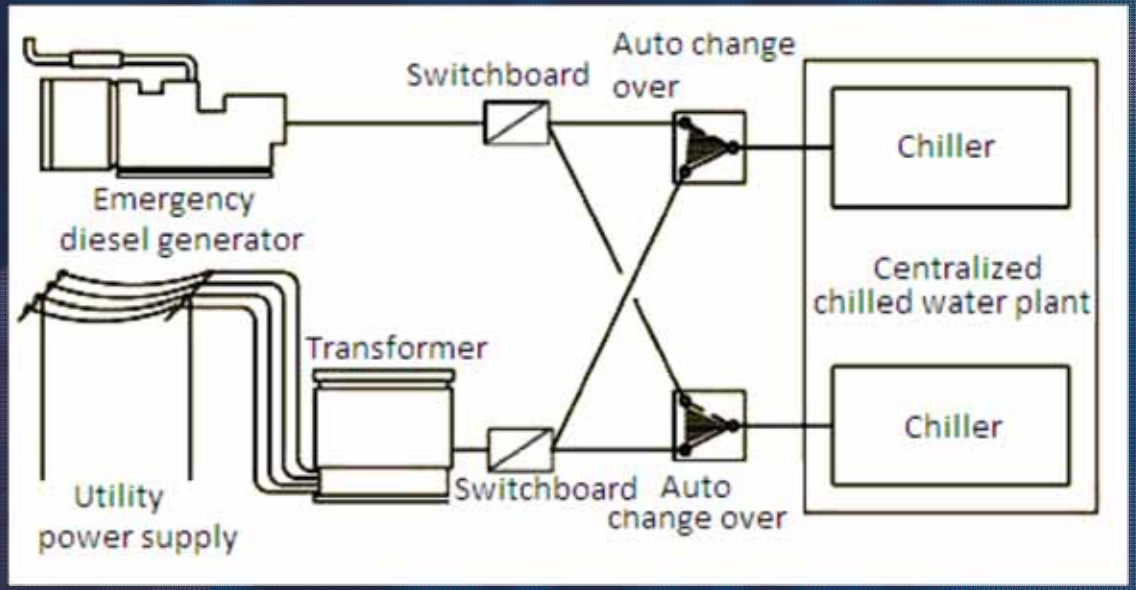
REDUNDANCIJA KLIMATIZACIJE

Redundancija na razini opreme za hlađenje



Električna redundancija (redundantno napajanje)

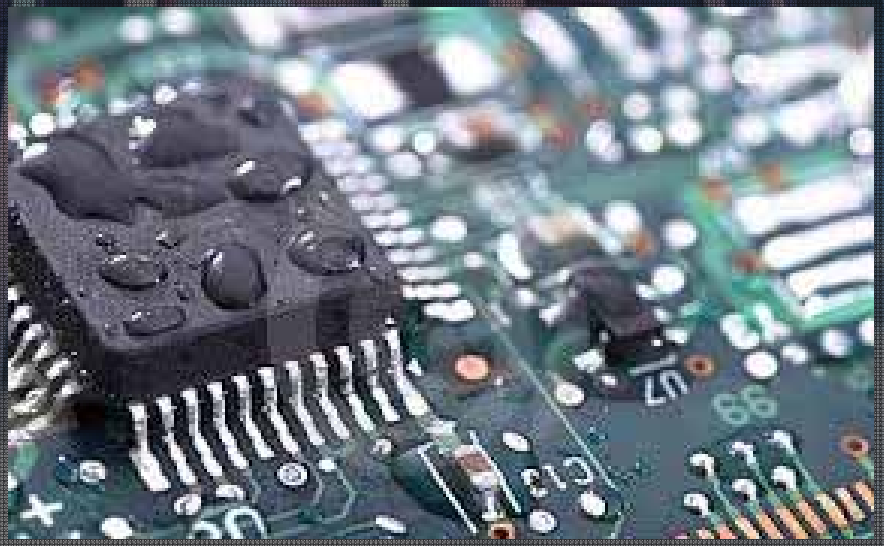
napajanje uz pomoć agregata



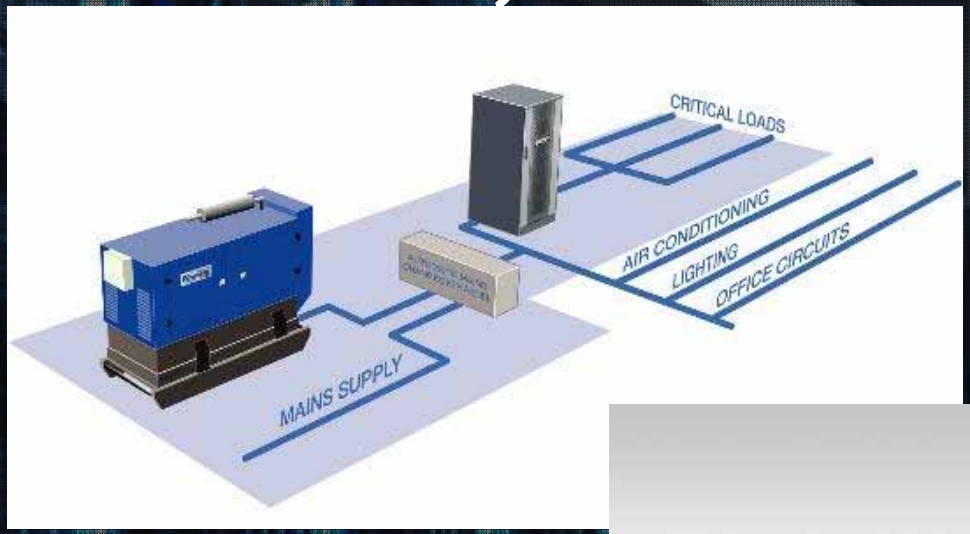
A. Bhatia

KONDENZACIJA VLAGE

Važnost nadzora vlažnosti zraka
Ne koristiti otvorene vanjske prozore za hlađenje podatkovnog centra (kondenzacija)
Mogući trajni kvarovi na računalnoj opremi (štampane ploče)



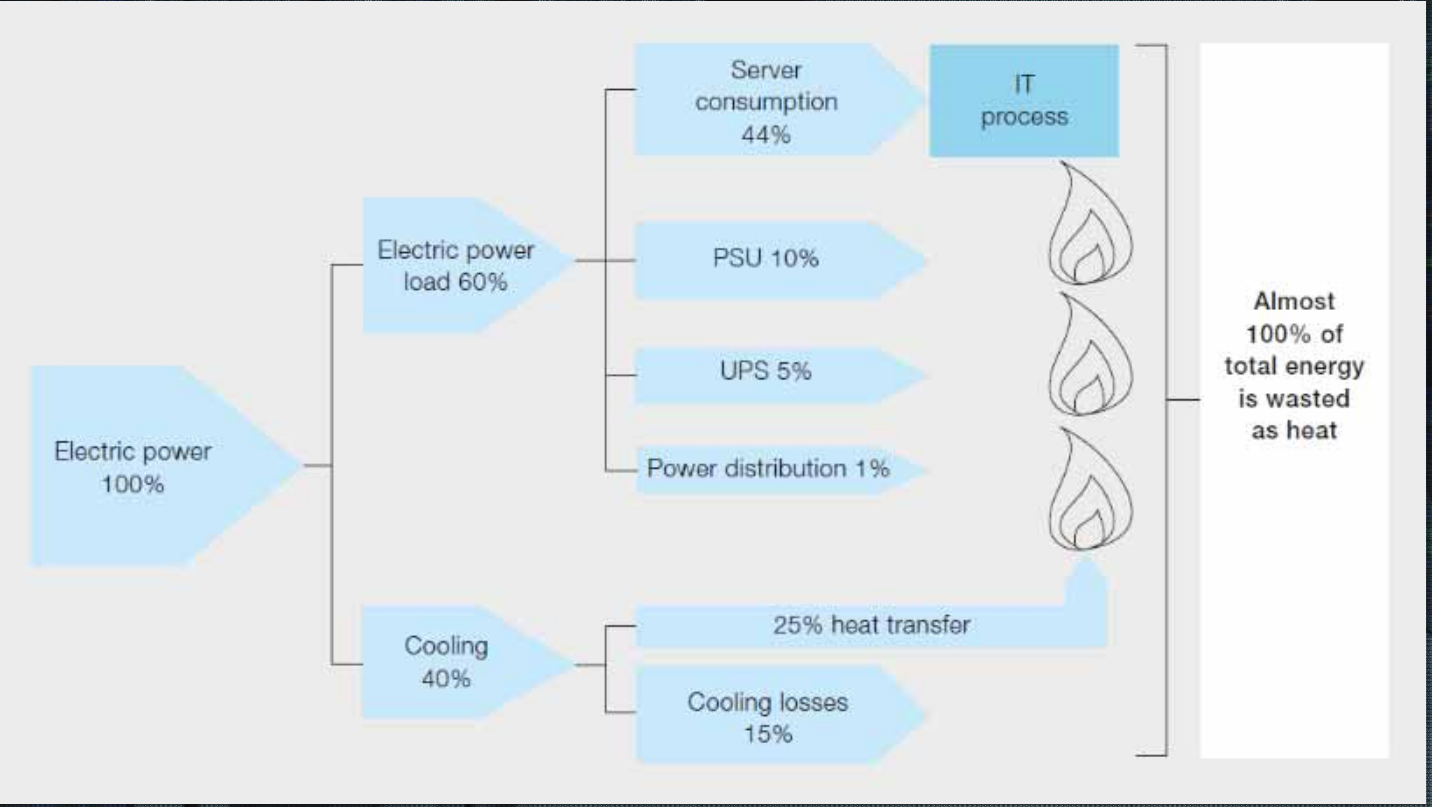
DIESEL GENERATOR I UPS (NEPREKIDNO NAPAJANE)



Agregat treba biti sposoban snabdjeti energijom uz IT opremu, rasvjetu i klimatizaciju

NAPAJANJE ELEKTRIČNOM ENERGIJOM

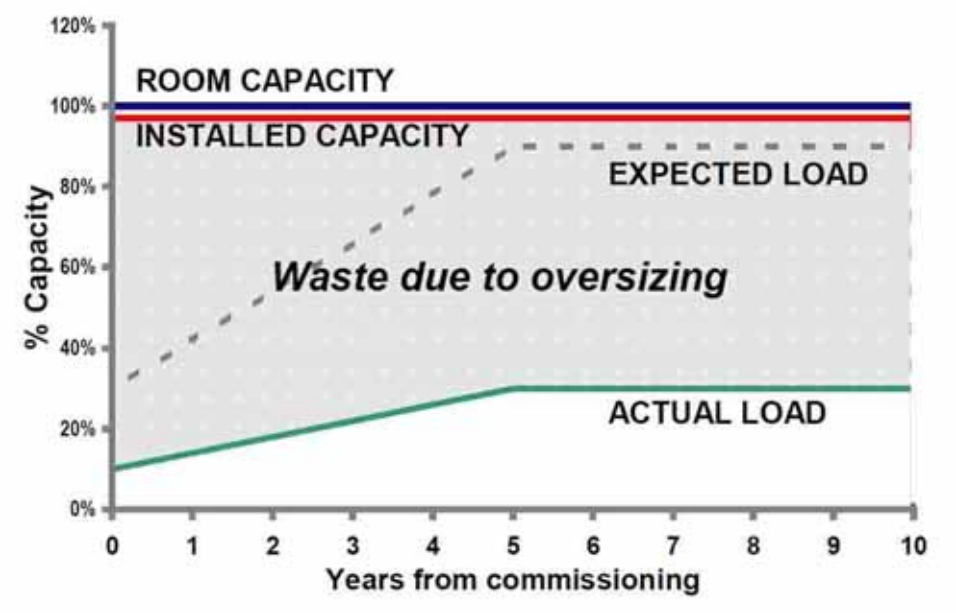
NAPAJANJE ELEKTRIČNOM ENERGIJOM

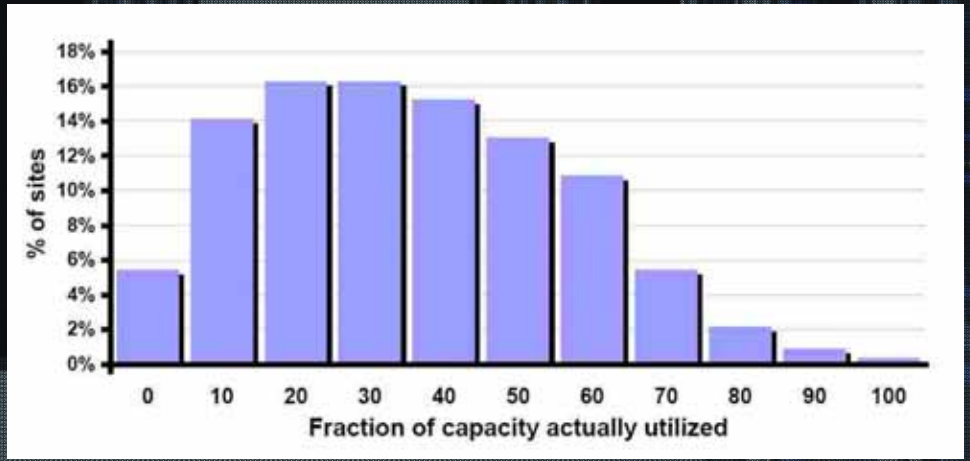


ABB

(PRE)DIMENZIONIRANJE NAPAJANJA

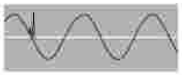
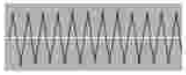
Kapitalni troškovi za napajanje i hlađenje iznose oko 5 USD / W





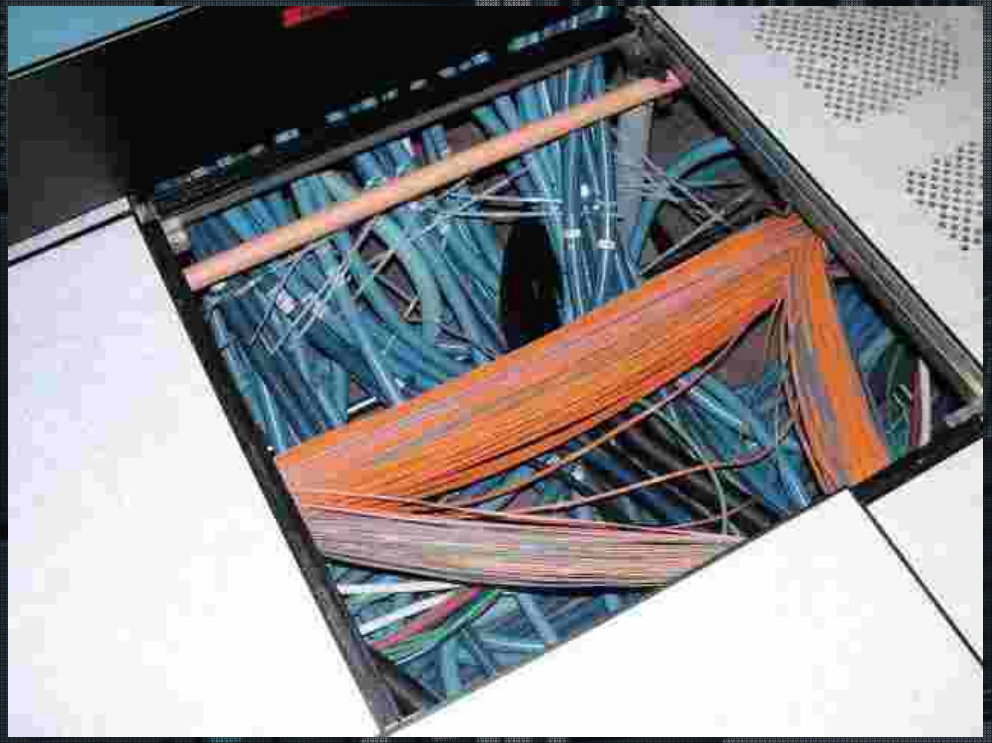
APC

KVALITETA NAPAJANJA (POWER QUALITY)

Power line malfucntion phenemona	Example of cause and influence	Example of waveform	Notes
Voltage Swell	Lightnings or heavy load switching on power line may cause momentary swell on voltage.		
Voltage Dip	Generating moments on motor load may cause an inrush current and cause dips on voltage.		
Voltage interruption	Momentary or long interruption to power distribution by lightning or open breakers		Occurred time and waveform is recorded. Digital output is set on during the occurred period.
Transient overvoltage (impulse)	Lightning or heavy load switching on power line may cause momentary change on voltage.		
Inrush current	Generating moments on motor load may cause an inrush current.		
Flicker	Increase and decrease on certain phases could cause flickering distortion on voltage and currents.		Pst (1 min), Pst or Plt is measured.
Harmonics	Inverter and Thyristor circuits (phase control cirtuits) which are used for the control circuit of general devices could affect currents and cause harmonic distortion.		Up to 50th harmonic contents are measured.
Unbalance rate	Heavy loading on a specific phase, could influence motor operation and could cause harmonic distortion.		Voltage and Current unbalance rate measured on vector screen for 3 phase

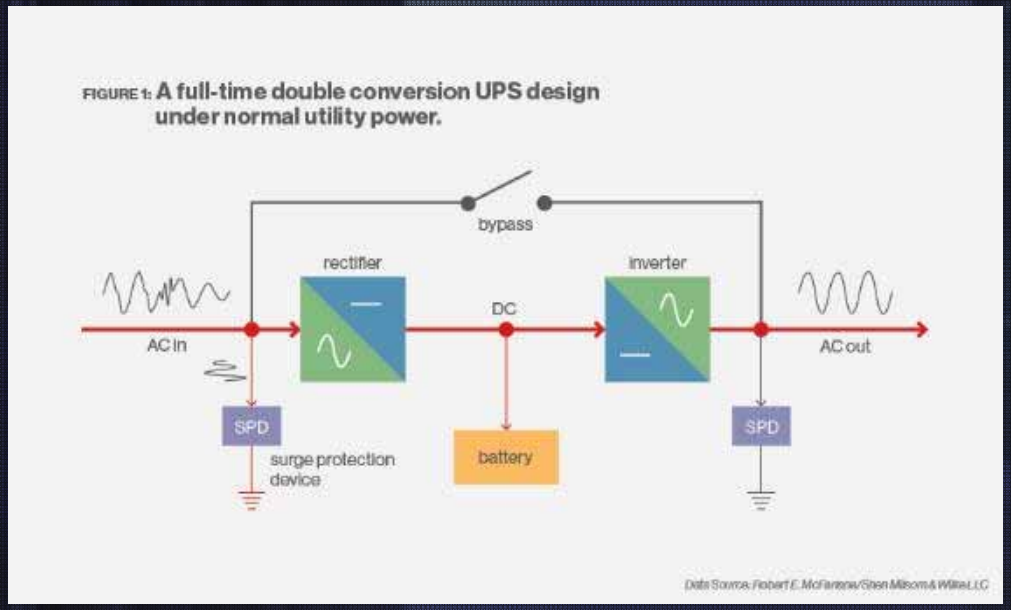
YOKOGAWA

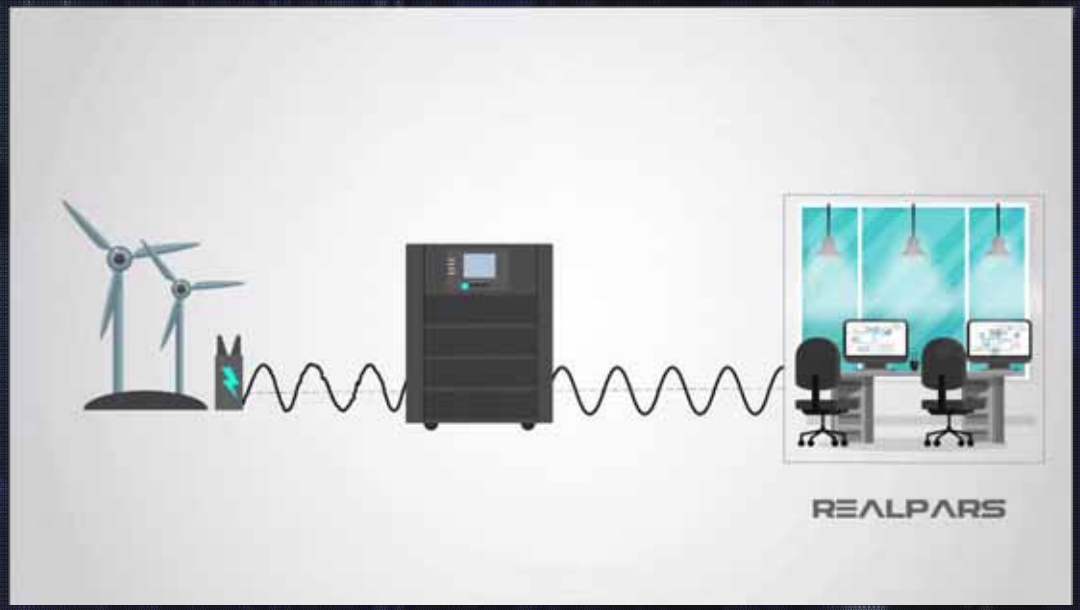
POWER DISTRIBUTION



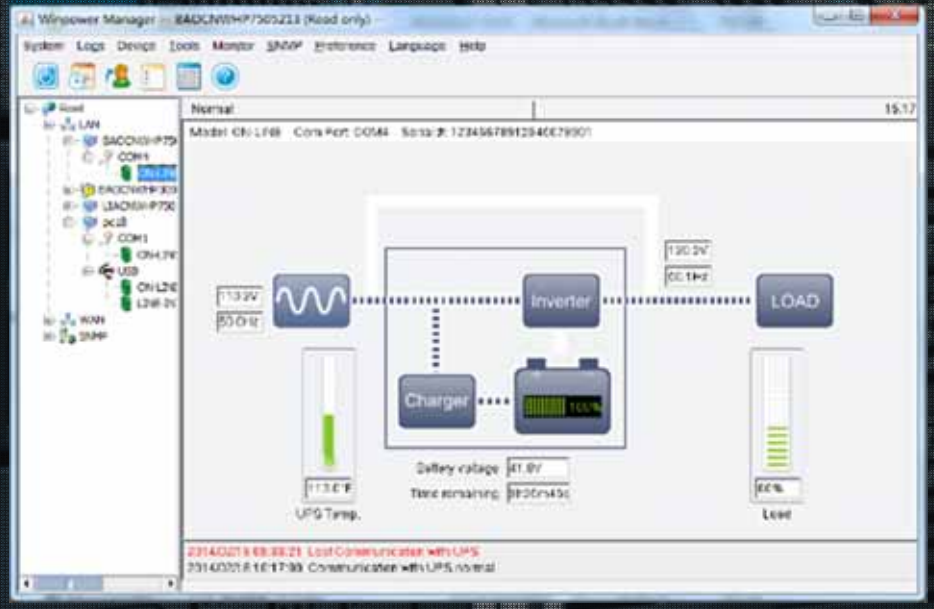
Raritan

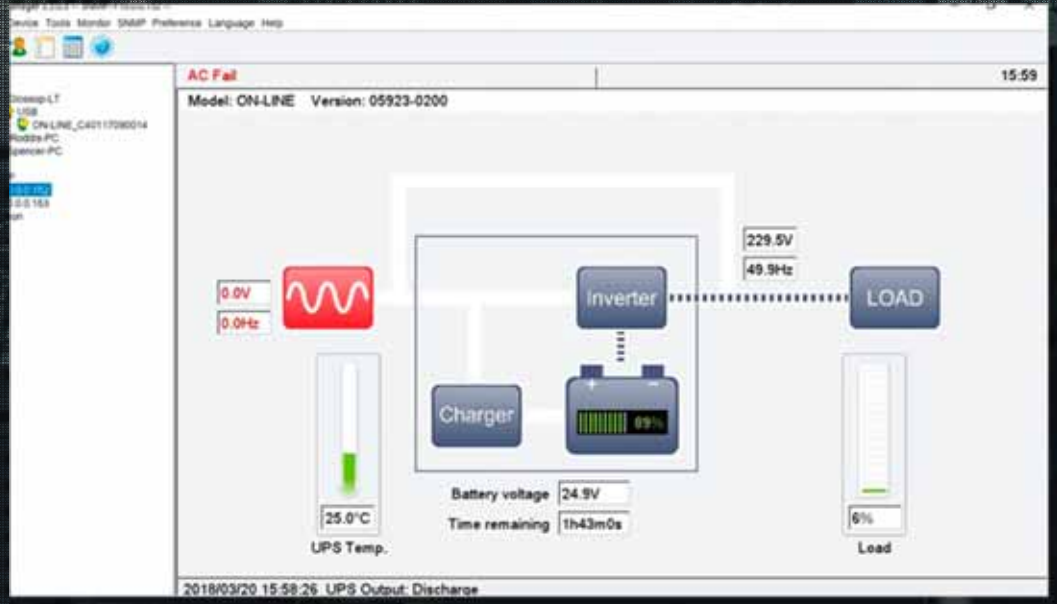
UPS - UNINTERRUPTIBLE POWER SUPPLY (NEPREKIDNO NAPAJANJE)





UPS - UNINTERRUPTIBLE POWER SUPPLY (NEPREKIDNO NAPAJANJE)





Pri normalnom radu UPS puni akumulatore i kondicionira vanjsko napajanje

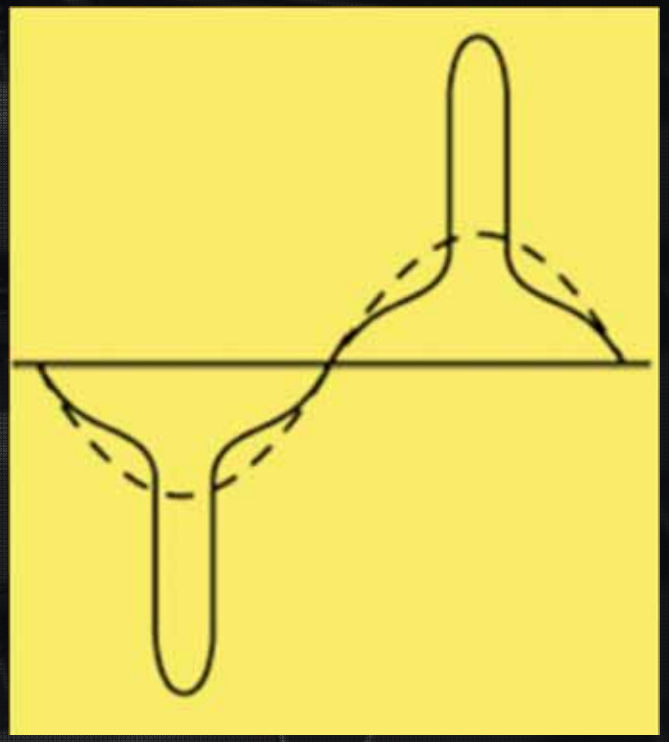
Kod prekida vanjskog napajanja UPS koristi energiju pohranjenu u akumulatorima

Premoštava period do pokretanja diesel generatora (agregata)

WinPower

UPS - WATI VS. VA.

- UPS imaju dva ratinga:
  - maximum kW (kilo watt) rating
  - maximum kVA (kilo volt-amper) rating
  - kW rating < kVA rating
  - PF – Power Factor (Faktor snage)
  - Konstruirani za PF 0,9 (većina UPS-ova)
- Standard EN 62040-3
  - UPS ne smije biti derated za standardizirana ne-linearna opterećenja s vršnim faktorom (crest factor) manjim od tri (3:1)
- cold inrush current
  - 6 – 8 x nominal current



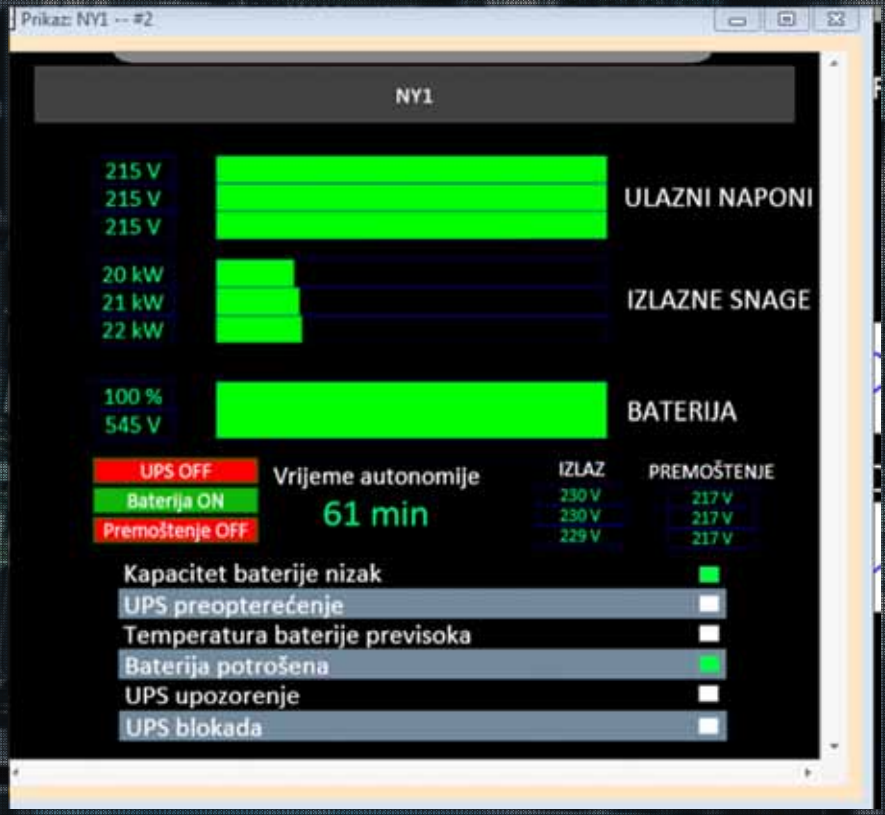
E. Csanyi

UPS - BATERIJE

- Radna temperatura za olovne akumulatore: 20-25 °C
- Svako povećanje temperature za 8 °C skraćuje vijek trajanja baterija za pola:
  - 4 godine na 25 °C
  - 2 godine na 33 °C
- Baterije ne treba pohranjivati na dulji rok, čuvati na hladnom (-15°C to + 30°C) i puniti svakih 6 mjeseci

UPS WEB KONZOLA

- Omogućava nadzor ulaznog napona, izlazne snage i stanje napunjenosti baterija
- Autonomija (30 – 60 min)
- Opterećenje ne treba biti iznad 80% kapaciteta UPS-a

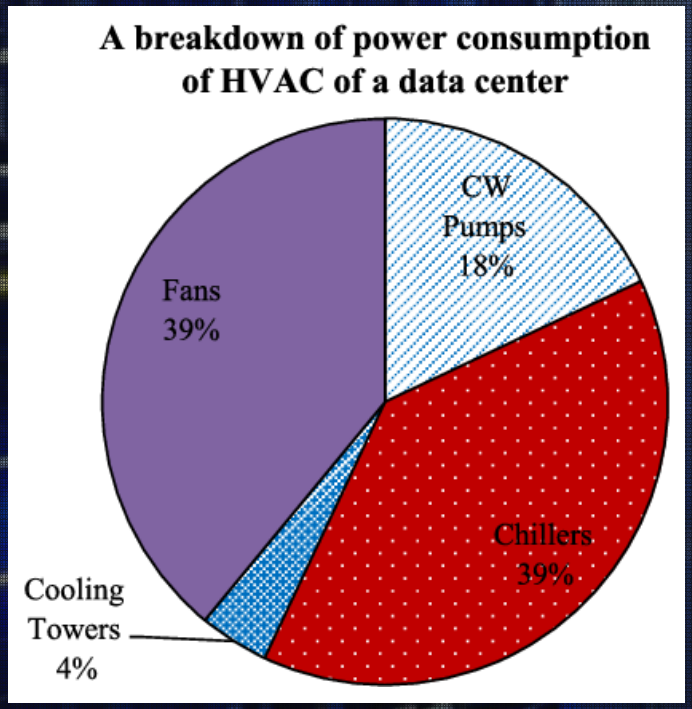


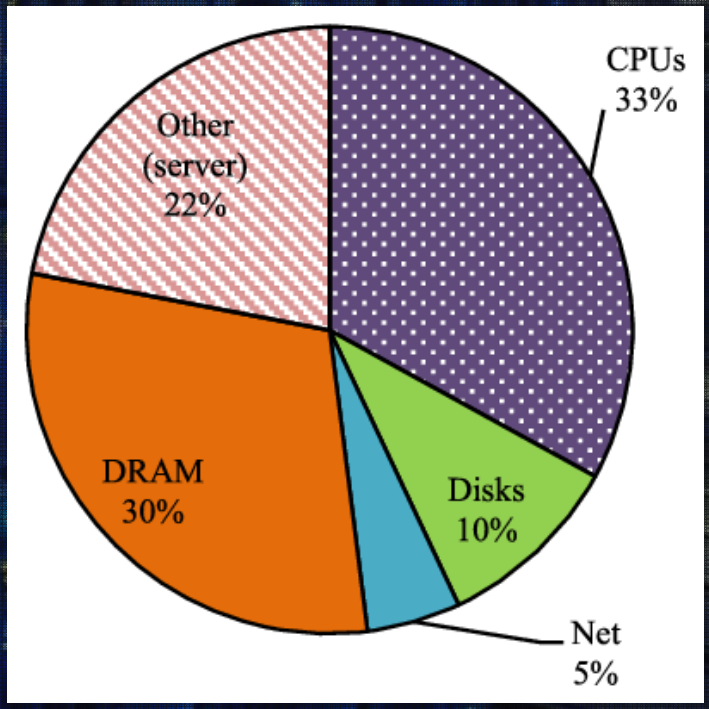
Trofazni ups sustav

NAPAJANJE PODATKOVNOG CENTRA

- Crvene i utičnice
  - podržane s UPS-om
- Crne utičnice
  - bez UPS-a
  - na agregatu
  - kratkotrajni prekidi napajanja

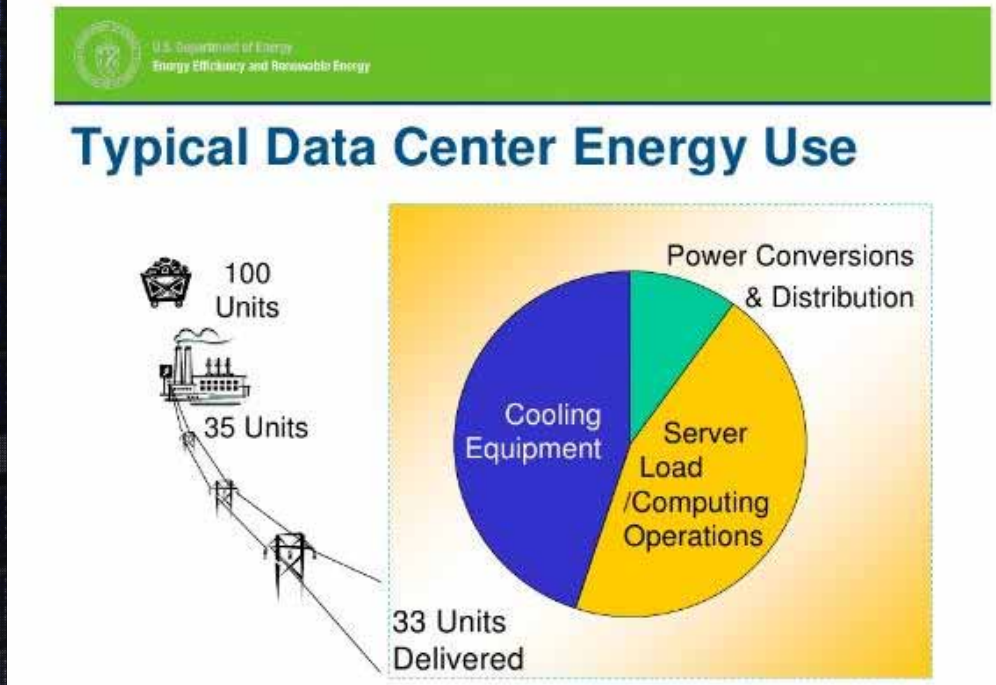
ENERGETSKA UČINKOVITOST PODATKOVNOG CENTRA

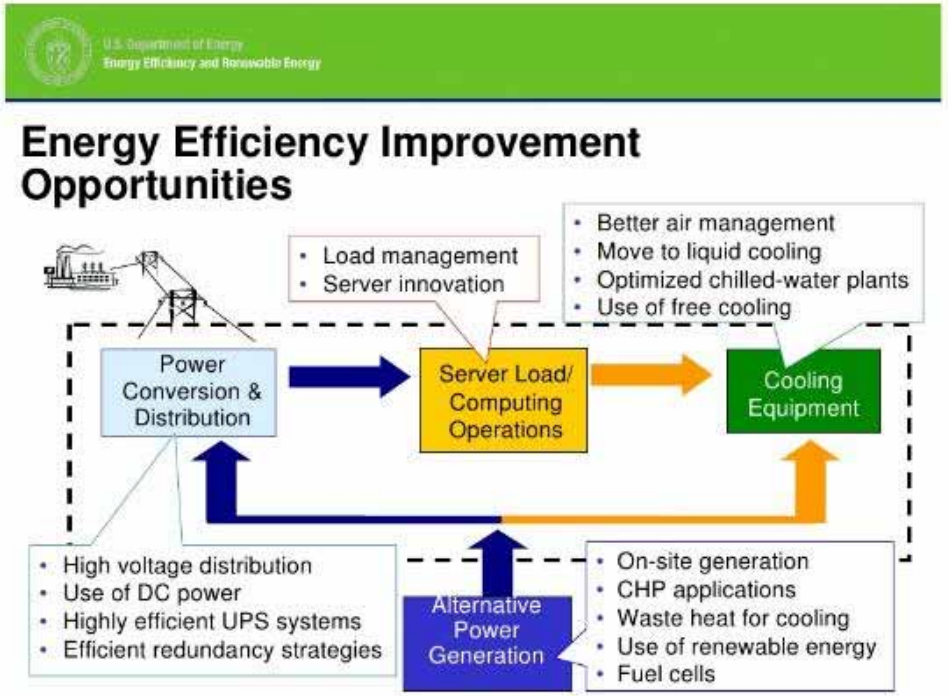




U.S. Department of Energy

ENERGETSKA UČINKOVITOST PODATKOVNOG CENTRA





U.S. Department of Energy

ENERGETSKA UČINKOVITOST PODATKOVNOG CENTRA

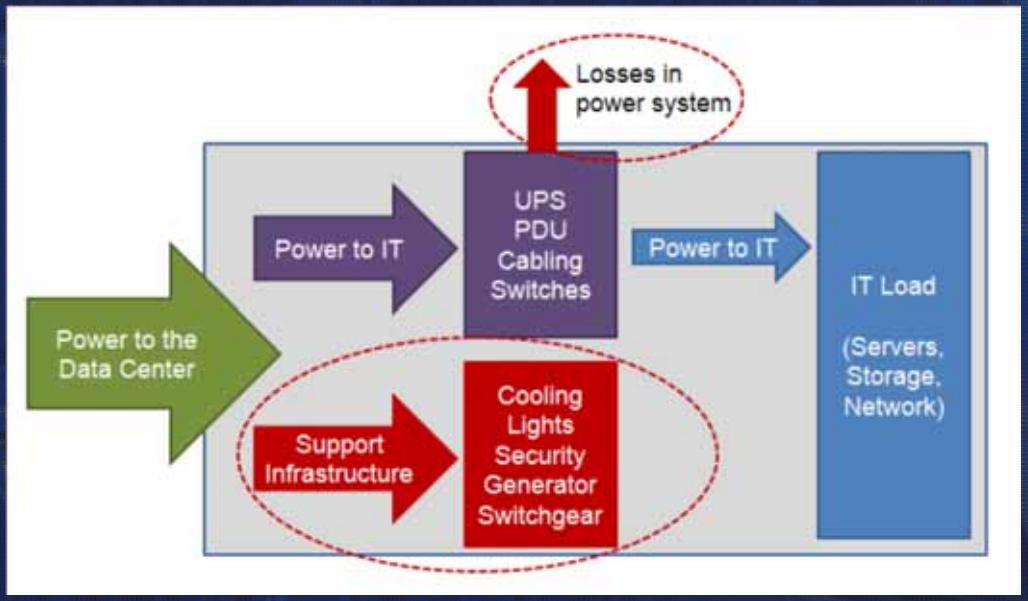
- Power Usage Effectiveness (PUE)
- DCE (Data Center Efficiency)
- DCiE (Data Center Infrastructure Efficiency)

$$PUE = \frac{Total\ Power\ into\ Data\ Center}{IT\ Equipment\ Power}$$

$$DCiE = \frac{IT\ Equipment\ Power}{Total\ Power\ into\ Data\ Center}$$

PUE	DCiE	Level of Efficieny
3.0	33%	Very Inefficient
2.5	40%	Inefficient
2.0	50%	Average
1.5	67%	Efficient
1.2	83%	Very Efficient

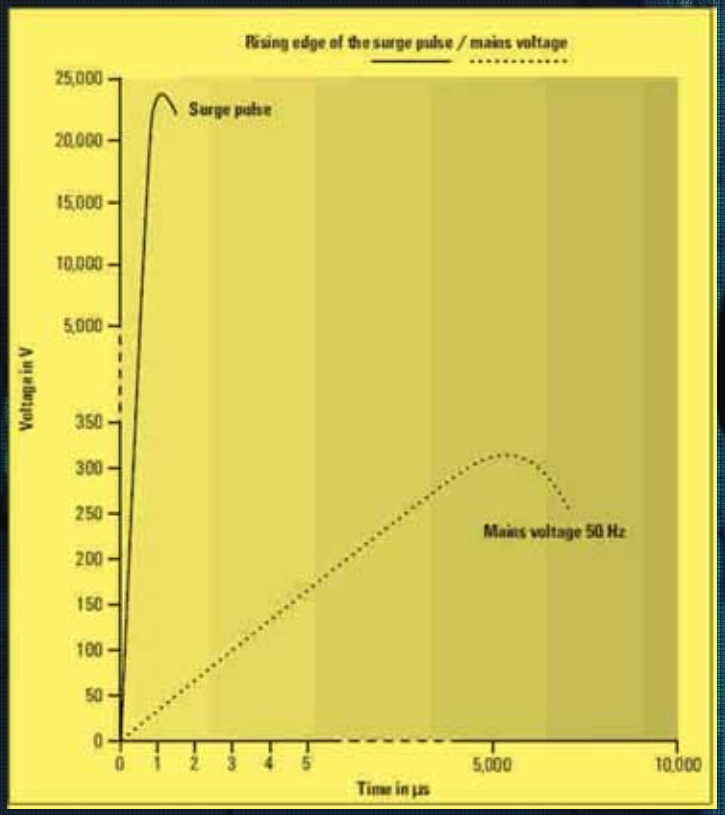
- Idealno PUE = 1
- U stvarnosti PUE > 1 (1.2 je jako dobro)



D. Cole

PODATKOVNI CENTAR – ZAŠTITA OD PRENAPONA (NAPONSKIH VRHOVA)

- „Loš” napon u mreži (“dirty” power off the grid)
- Direktni i indirektni udarci munja
- Naponski tranzijenti generirani unutar podatkovnog centera od motora, generatora i ostale električne opreme



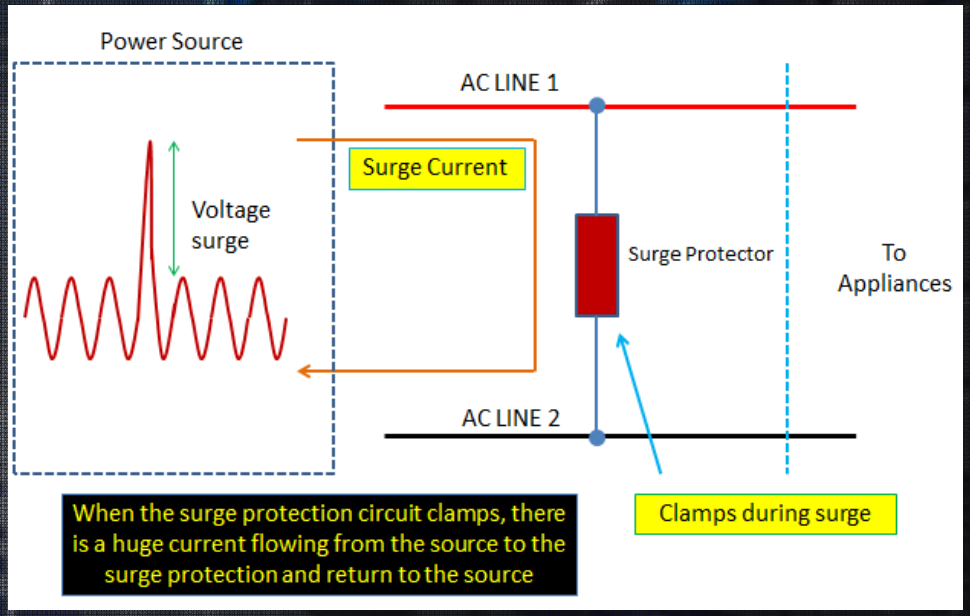
Weidmüller

PODATKOVNI CENTAR – ZAŠTITA OD PRENAPONA (NAPONSKIH VRHOVA)

- Cijena zaštitnih uređaja je mali dio cijene ugrađene računalne opreme

- Naponske linije
- Signalne linije (mreža)

- Na ulazu u podatkovni centar
- Na ulazu u ormare (lokalno)



ElectronicsBeliever

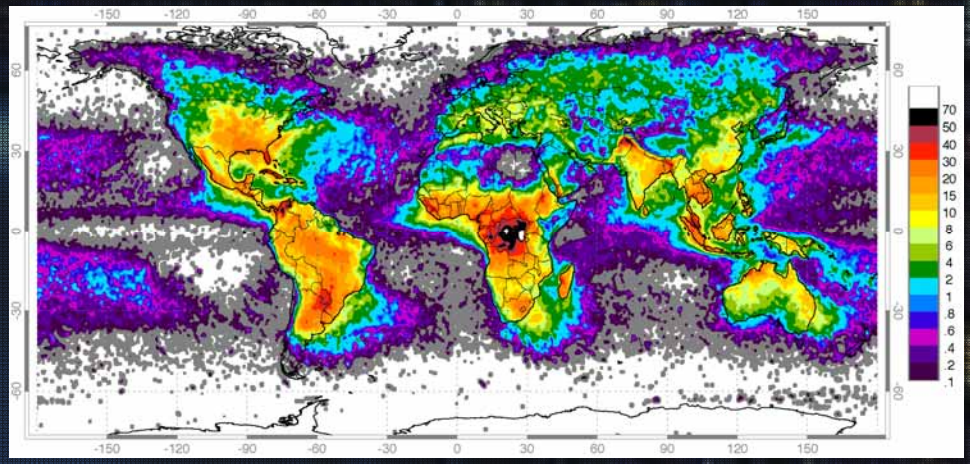
PODATKOVNI CENTAR – ZAŠTITA OD PRENAPONA (NAPONSKIH VRHOVA)

Zaustavljač munja (lightning arrester)

Zaustavljač prenapona (overvoltage arrester)

Zaštita opreme (equipment protection)

MUNJE


-150 -120 -90 -60 -30 0 30 60 90 120 150
60
30
0
-30
-60
70
50
40
30
20
15
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8
6
4
2
1
.8
.6
.4
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.1

MUNJE – ŠTETE I STRUJNE AMPLITUDE

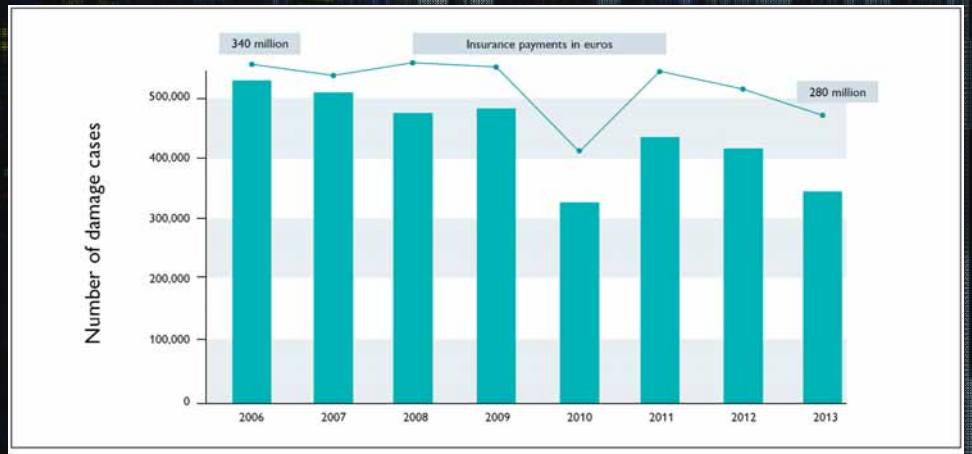


Fig. 6: Number of damage cases caused by lightning strikes and surge voltages and cost of insurance payments

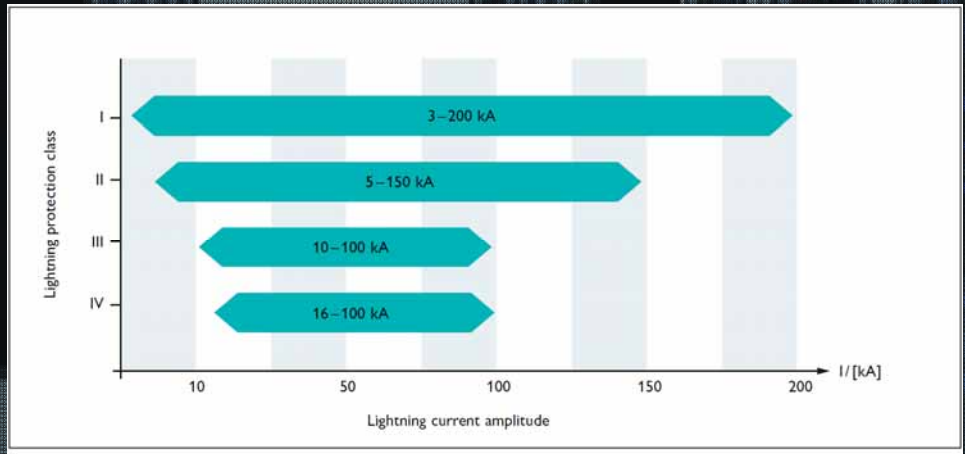
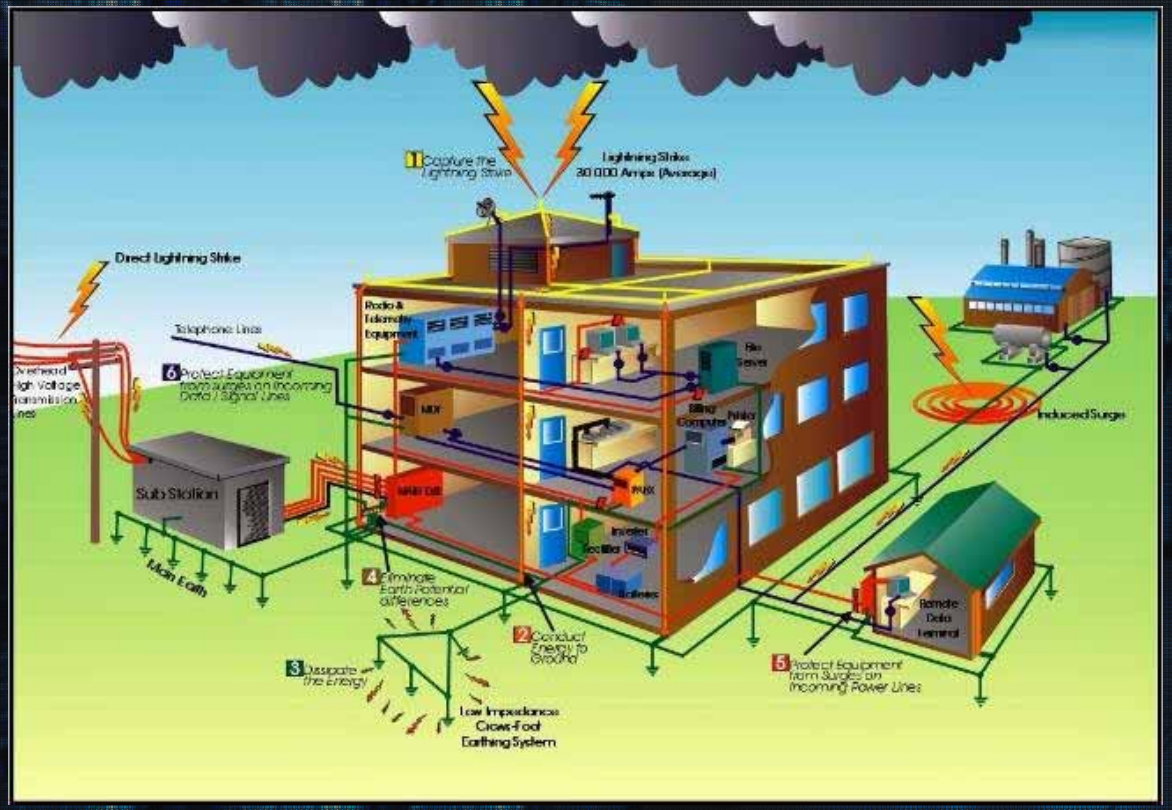


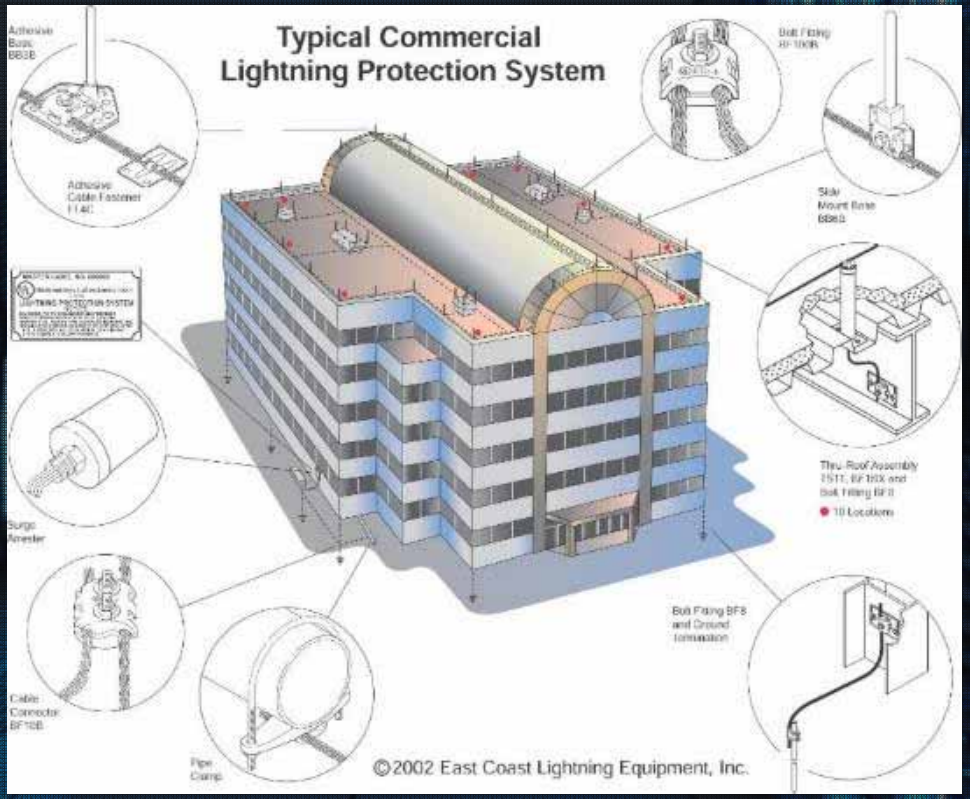
Fig. 14: Lightning protection classes in accordance with IEC 62305-1 [1] with corresponding minimum and maximum values of lightning current amplitude

MUNJE – DIREKTAN I INDIREKTAN UTJECAJ

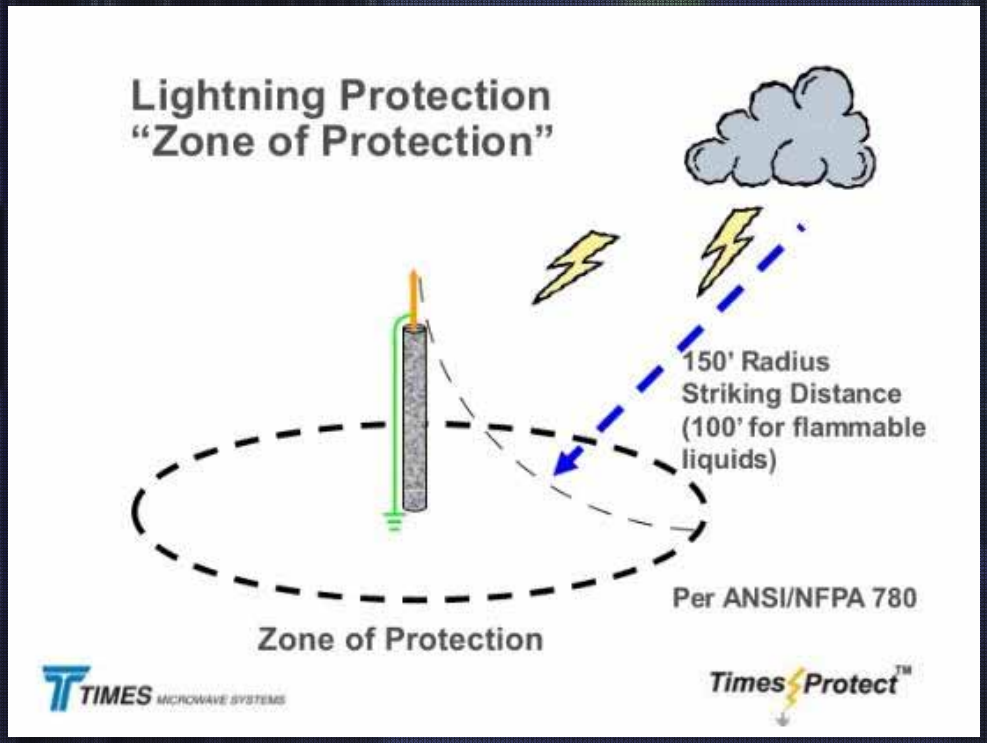


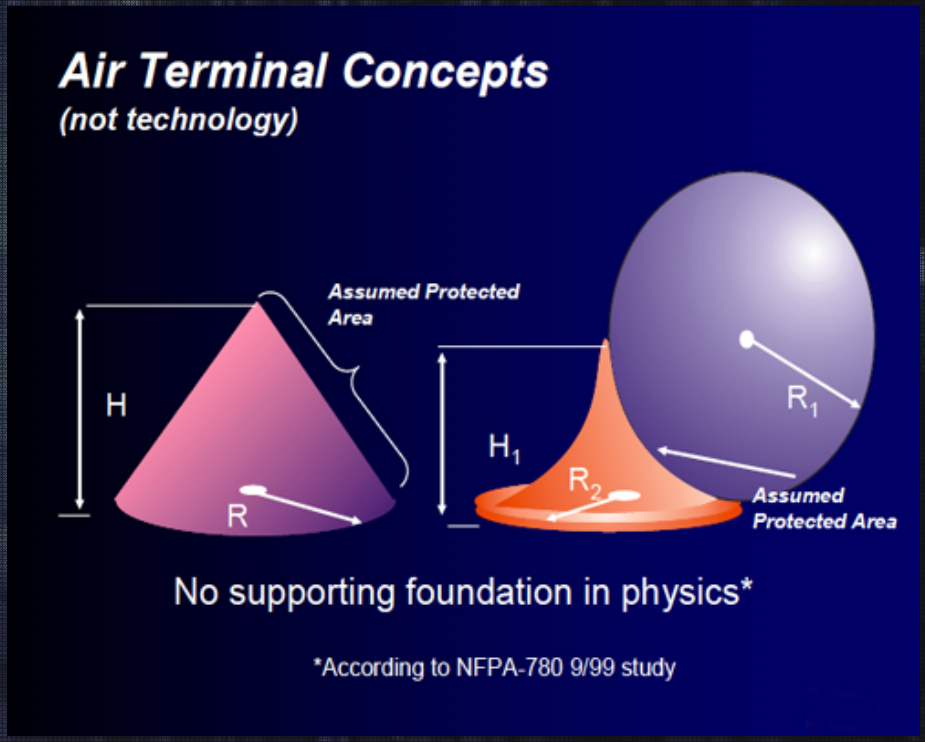
MUNJE– PLANIRANJE POZICIJA GROMOBRANA

- Empirijske metode projektiranja (klasične) - 69kV i manje
- Metoda fiksnog kuta (32.5%)
- Empirisjka metoda krivulje (12.6%)
- Elektogeometrijske metode (EGM) - 345kV & above
- Metoda kotrljajuće sfere (16.3%)
- Mousa's Software Subshield (21.1%)



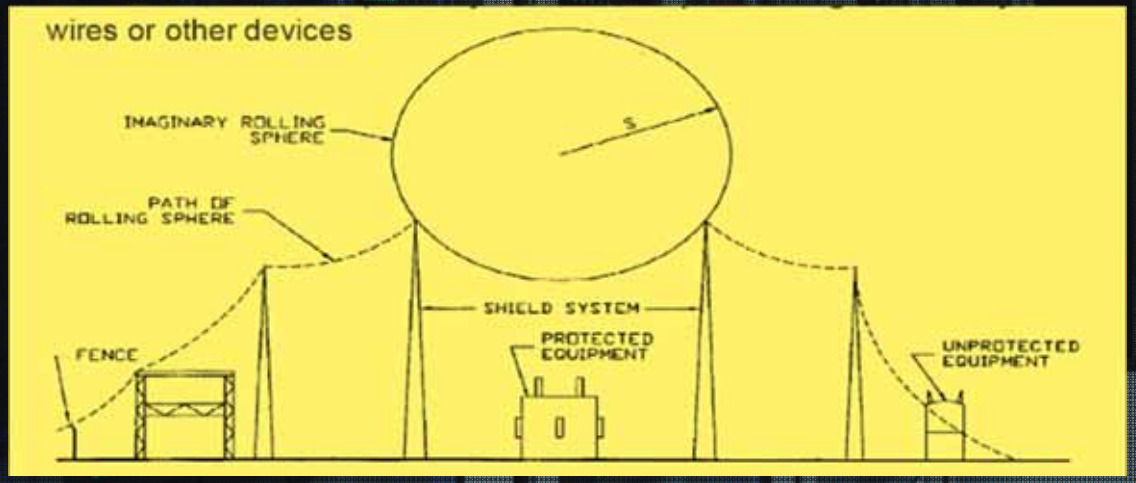
MUNJE – PLANIRANJE POZICIJA GROMOBRANA



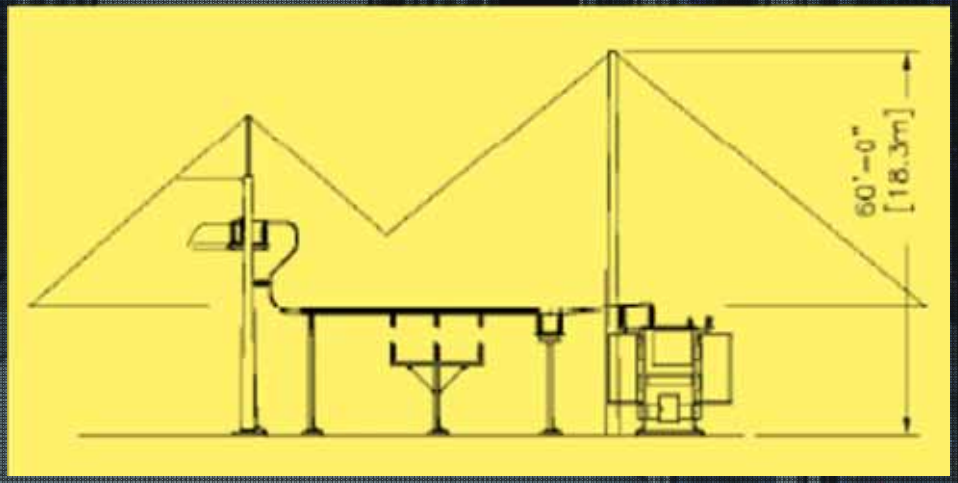


MUNJE– PLANIRANJE POZICIJA GROMOBRANA

Metoda kotrljajuće sfere



Metoda fiksnog kuta



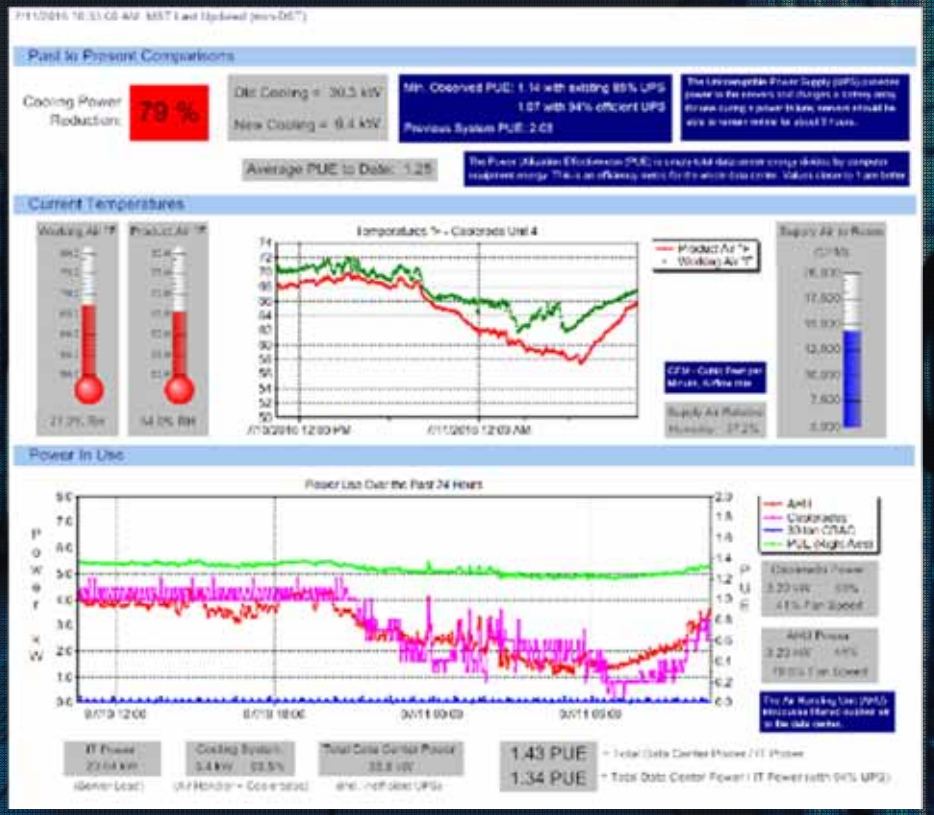
SUSTAV ZA NADZOR I UPOZORAVANJE

SUSTAV ZA NADZOR I UPOZORAVANJE

- Senzori za sve uvjete:
- Temperatura
- Vlaga
- Indeks topline (subjektivni osjećaj)
- Točka rošenja
- Main / UPS Power
- Potrošnja struje (Amperi)
- Aktivna snaga i temperatura
- Poplava / kabel
- Poplava / točka
- Zaštita od poplave (kit)
- Dim / vatra
- Kretnje
- Ulazna vrata
- Protok zraka
- Analogni senzori
- Releji
- Mrežne kamere
- Osvjeljenje

SUSTAV ZA NADZOR I UPOZORAVANJE

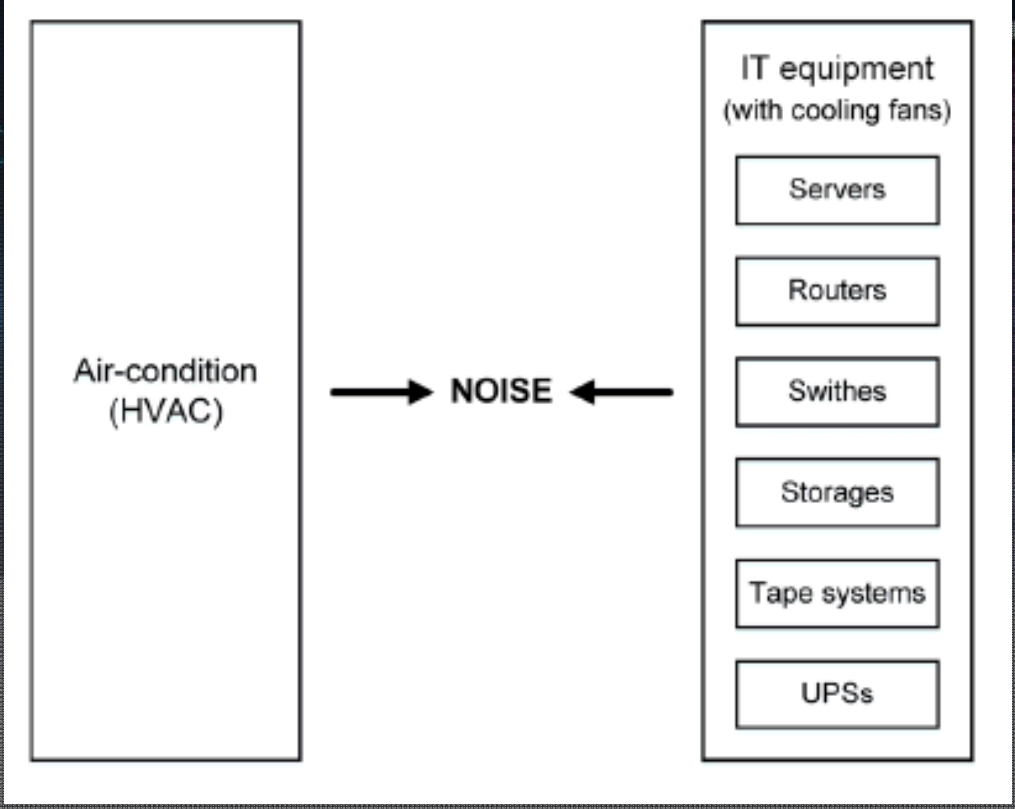
Sunbird



NSIDC

ERGONOMIJA U PODATKOVNOM CENTRU

BUKA



Vrijednosti izmjerene buke

Position	Description, contributing sources in aisle	dBA
1	Servers, storage, cabinet cooling system	76,2
2	Servers, storage, cabinet cooling system	76,1
3	Servers, storage, cabinet cooling system	79,2
4	Servers, storage, cabinet cooling system	76,9
5	Servers, storage, cabinet cooling system	78,1
6	Servers, cabinet cooling system	79,1
7	Servers, storage, cabinet cooling system	74,2
8	Servers, cabinet cooling system	75,0
9	Servers, cabinet cooling system	74,7
10	Servers, cabinet cooling system	73,9
11	Servers, cabinet cooling system	70,9
12	Servers, cabinet cooling system	70,9
13	Routers	75,2
14	Routers	80,3
15	Fire central (alarm and dischargers)	70,7
16	Console room	57,8
17	Archive	55,6
18	Operators room	58,5
19	Entrance hall	58,3

ERGONOMIJA U PODATKOVNOM CENTRU TEMPERATURA, VLAGA I STRUJANJE ZRAKA

- Temperatura 18 – 27 °C
  - preporučeno 20 – 22 °C
- Vlaga 40 % i točka rošenja 5.5 °C do 60 % i točka rošenja 15 °C
- Nošenje adekvatne odjeće prilikom duljeg boravka

ZAKLJUČAK

- Infrastruktura podatkovnog centra je okosnica pouzdane računalne usluge
- Ranjivost obično mnogo veća od same računalne opreme i programa
- Razmišljati još u fazi planiranje izgradnje
- Redundantni sustavi za klimatizaciju i napajanje
- Zaštita pristupa, prevencija i detekcija požara i polava

LITERATURA

- Five Levels of High Availability, Compaq, 1998
- H. Rohani, Azad Kamali Roosta, Calculating Total System Availability
- H. Geng, Data Center Handbook, Willey ,2015
- Data Centar Solutions, Suprema, https://www.supremainc.com/en/solutions/solution-for-data-center.asp
- N. Srinarayana, B. Fakhim and S. W. Armfield, A comparative study of raised-floor and hard-floor configurations in an air-cooled data centre, in 3th IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems (ITherm), 2012 : May 30, 2012 - June 1, 2012, San Francisco
- ASHRAE, Data Center Power Equipment Thermal Guidelines and Best Practices, 2016, https://tc0909.ashraetcs.org/documents/ASHRAE_TC0909_Power_White_Paper_22_June_2016_REVISED.pdf
- DataSpan, How to Calculate Cooling Requirements for a Data Center, 2019, https://www.dataspan.com/blog/how-to-calculate-cooling-requirements-for-a-data-center/
- N. Rasmussen, Calculating Total Cooling Requirements for Data Centers, 2007, https://www.apcdistributors.com/white-papers/Cooling/WP-25%20Calculating%20Total%20Cooling%20Requirements%20for%20Data%20Centers.pdf
- R. Miller, CFD Thermal Modeling: Who's Using It, and How?, Oct 07, 2008, https://www.datacenterknowledge.com/archives/2008/10/07/cfd-thermal-modeling-whos-using-it-and-how
- Abraxas - Face Recognition Access Control Solution, from https://www.youtube.com/watch?v=gctfBFY7q30
- The basics of lightning and surge protection, Weidmüller, 2013
- A Clear Path to Electrical Power Excellence! CW500 Power Quality Analyzer, YOKOGAWA
- Raadbeco, Uninterruptible Power Supply, http://www.raadbeco.com/en/ups-2/
- E. Csanyi, Sizing a Static UPS System In Data Center, 2015, https://electrical-engineering-portal.com/sizing-a-static-ups-system-in-data-center
- APC, Avoiding Costs From Oversizing Dana Center and Network Room Infrastructure, White Paper #37
- R. McFarlane, How do I size a UPS unit?, TechTarget, Oct 2019
- N. Rasmussen, Watts and Volt-Amps: Powerful Confusion, 2011, https://www.apc.com/salestools/SADE-5TNQYF/SADE-5TNQYF_R1_EN.pdf
- J. Seymour, The Seven Types of Power Problems, https://www.apc.com/salestools/VAVR-5WKLPK/VAVR-5WKLPK_R1_EN.pdf

LITERATURA

- FSSA, Fire Safety Systems Protecting Data Centers
- S. Chuang, A Case Study for Substation Lightning Protection and Risk Evaluation, November 8, 2016
- DOE Data Center Energy Efficiency Program and Tool Strategy, US Department of Energy, 2010
- D. Cole, Data Center Energy Efficiency Looking Beyond PUE, No Limits Software, file:///D:/HROUG%202019/Datacenter/Power%20efficiency/WP_LinkedIN%20DataCenterEnergy.pdf
- N. Khasawneh and R. A. Dasan, Keeping It Cool, pptx, https://slideplayer.com/slide/3901569/
- R. W. Sawyer, Calculating Total Power Requirements for Data Centers, https://www.apc.com/salestools/vavr-5tdtef/vavr-5tdtef_r1_en.pdf%3Fsdirect%3Dtrue
- A. Bhatia, HVAC Cooling Systems for Dana Centers
- K. Ilal, Advantages of Inrow Cooling Systems Against Perimeter (CRAC&CRAH) Cooling Systems, Canovate Group, 2017
- G. Stockton, Heat Matters in Cooling Data Centers, Stockton Infrared Thermographic Services, Inc. & United Infrared, Inc., https://irinfo.org/06-01-2011-stockton/
- I. Bitterlin, How useful is CFD for data centers?, Leeds University, https://www.datacenterdynamics.com/opinions/how-useful-is-cfd-for-data-centers/
- J. Podlipnik, Projektiranje i rješavanje vanjske gromobranske zaštite, http://work.opacelica.si/hermi/bs/p/resitve-2-2/projektanti-i-izvodaci-2/neprimjetni-gromobrani-1-2/clanci-2/loveci-sistem-2/
- J. Crispino, Rolling Spheres Method for Lightning Protection, https://hibp.ecse.rpi.edu/~connor/education/Surge/Presentations/Joe%20Crispino%20-%20Surge%20Presentation.pdf
- Surge protection circuit principle and design, ElectronicsBeliever - Your Online Teacher, http://electronicsbeliever.com/surge-protection-circuit-principle-design/
- M. Dayarathna, Y. Wen and R. Fan, Data Center Energy Consumption Modeling: A Survey, Published in IEEE Communications Surveys & Tutorials 2016 https://www.semanticscholar.org/paper/Data-Center-Energy-Consumption-Modeling%3A-A-Survey-Dayarathna-Wen/381c7853690a0fee6f00d2608a7779737f1365f9
- Cisco Unified Computing System, Site Planning Guide: Data Center Power and Cooling
- D. Miljković, Noise within a Data Center; MIPRO 2016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