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A Novel Admission Control Algorithm for UMTS System

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Outline

- 3G networks features
  - ✓ Services
  - ✓ QoS
- Interference Model
- Admission Control
  - ✓ Static Power
  - ✓ Dynamic Power
- Theoretical Analysis
  - ✓ Single Class Scenario
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- Concluding remarks & On-going Developments

3G Networks Features

- Global coverage means:
  - ✓ Efficient internetworking with existing wireless and wired standards (GSM/GPRS, ATM, TCP/IP)
  - ✓ High mobility and variable traffic load management through dynamic cell planning and system reconfiguration
- Services integration
  - ✓ Multimedia traffics with real time (voice, audio/video streaming) and data (Web services, Data Base queries) applications
  - ✓ Different Quality of Service (QoS) requirements (bandwidth, error rate, delays)
  - ✓ Asymmetric connections handling
  - ✓ Security issues

3G Networks Services

- ***Conversational*** – a human-to-human interaction with typical perceptive constraint:
  - ✓ critical delay sensitiveness, error tolerance;
  - ✓ voice, VoIP.
- ***Streaming*** – a human-to-machine interaction with weaker perceptive constraint:
  - ✓ delay sensitiveness, error tolerance;
  - ✓ audio/video streaming, MPEG4.
- ***Interactive*** – a user-to-remote device interaction:
  - ✓ synchronization pattern, error sensitiveness;
  - ✓ Client-Server applications (HTTP, FTP, SMTP, SSH).
- ***Background*** – two remote device interaction:
  - ✓ delay insensitiveness, error intolerance;
  - ✓ Data Base queries.

CAC Algorithms

- Interference Model
  - ✓ In 3G systems, using CDMA, the interference is mainly devoted to active communications;
  - ✓ User mobility and physical propagation implies asynchronism among users, especially in uplink, that make high Multiple Access Interference (MAI);
  - ✓ MAI has an additive model:

$$MAI_i = I_i \sum_{j \neq i} P_j \qquad j = 1, 2, \ldots\ldots N_{\max\_Users}$$

- Proposed algorithms:
  - ✓ Connection with the same QoS are grouped in traffic classes:

$$MAI_i = I_i \left(\sum_{k \neq i} N_{P_k} P_k + (N_{P_i} - 1) P_i \right) \qquad k = 1, 2, \ldots\ldots N_{\max\_Classes}$$

- Hypotheses:
  - ✓ Isolated Cell: no handover traffic;
  - ✓ Complete reconstruction of multipath fading;
  - ✓ Ideal power control.

CAC Algorithms
Static Power (SP)

- All traffic class has a fixed power level P_i; an incoming call could be accepted if all QoS inequalities are respected.

$$\frac{P_i}{I_i\left[(N_i-1)P_i+\sum_{j\neq i}N_jP_j\right]+n}\geq SINR_{\text{target},i}$$

$$i=1,\ldots N_{\max\_Classes} \qquad N_{\max\_Classes}=6$$

$$\begin{cases}\dfrac{1}{I_1\left[(N_1-1)+N_2+\cdots\cdots\cdots N_6\right]}\geq SINR_{\text{target},1}\\ \dfrac{1}{I_2\left[N_1+(N_2-1)+\cdots\cdots\cdots N_6\right]}\geq SINR_{\text{target},2}\\ \vdots\\ \vdots\\ \dfrac{1}{I_6\left[N_1+N_2+\cdots\cdots\cdots(N_6-1)\right]}\geq SINR_{\text{target},6}\end{cases}$$

CAC Algorithms
Dynamic Power (DP)

- The power P_i of each traffic class is calculated and optimized whenever a new incoming call is arrived.

$$\frac{P_i}{I_i\left[(N_i-1)P_i+\sum_{j\neq i}N_jP_j\right]+n}\geq SINR_{\text{target},i}$$

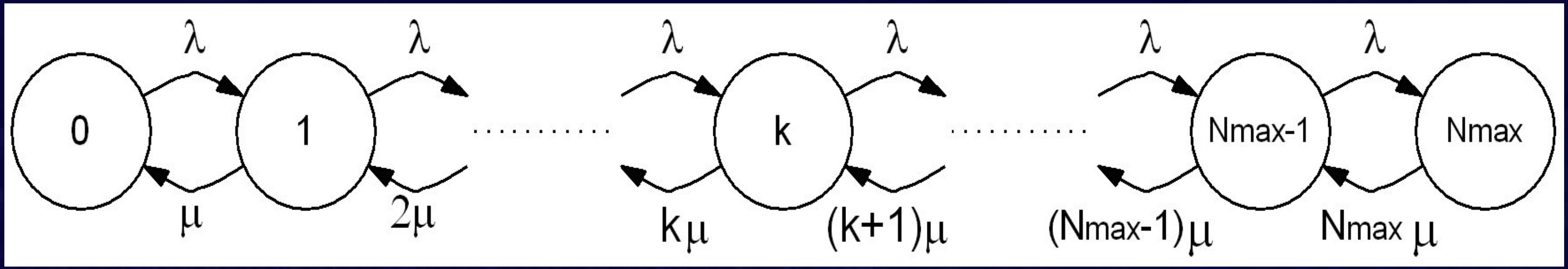
$$i=1,\ldots.N_{\max\_Classes} \qquad N_{\max\_Classes}=6$$

$$\begin{cases}\dfrac{P_1}{I_1\left[(N_1-1)P_1+N_2P_2+\cdots\cdots\cdots N_6P_6\right]+n}=SINR_{\text{target},1}\\ \dfrac{P_2}{I_2\left[N_1P_1+(N_2-1)P_2+\cdots\cdots\cdots N_6P_6\right]+n}=SINR_{\text{target},2}\\ \vdots\\ \vdots\\ \dfrac{P_6}{I_6\left[N_1P_1+N_2P_2+\cdots\cdots\cdots(N_6-1)P_6\right]+n}=SINR_{\text{target},6}\end{cases}$$

Single Class System Model

- It characterize scenarios with one active traffic class inside the cell;
- Discrete-time Markov chain;
- Presence of CAC SP;
- Calculate $P_{calldrop}$;
- M/M/N/N model;
- N is the maximum number of contemporary active users;
- State *i* corresponds to the number of active users inside the cell, $i=0,1,\ldots N_{max}$

$$N_{\max,i} = \left\lfloor 1 + \frac{1}{SINR_{\text{target,i}} \cdot I_i} \right\rfloor$$



Single Class System Model

$$\lambda_k = \begin{cases} \lambda, & k < N_{\max} \\ 0, & k \geq N_{\max} \end{cases}$$

$$\rho = \frac{\lambda}{\mu}$$

$$\mu_k = k\mu, \quad k = 1, 2, \ldots N_{\max}$$

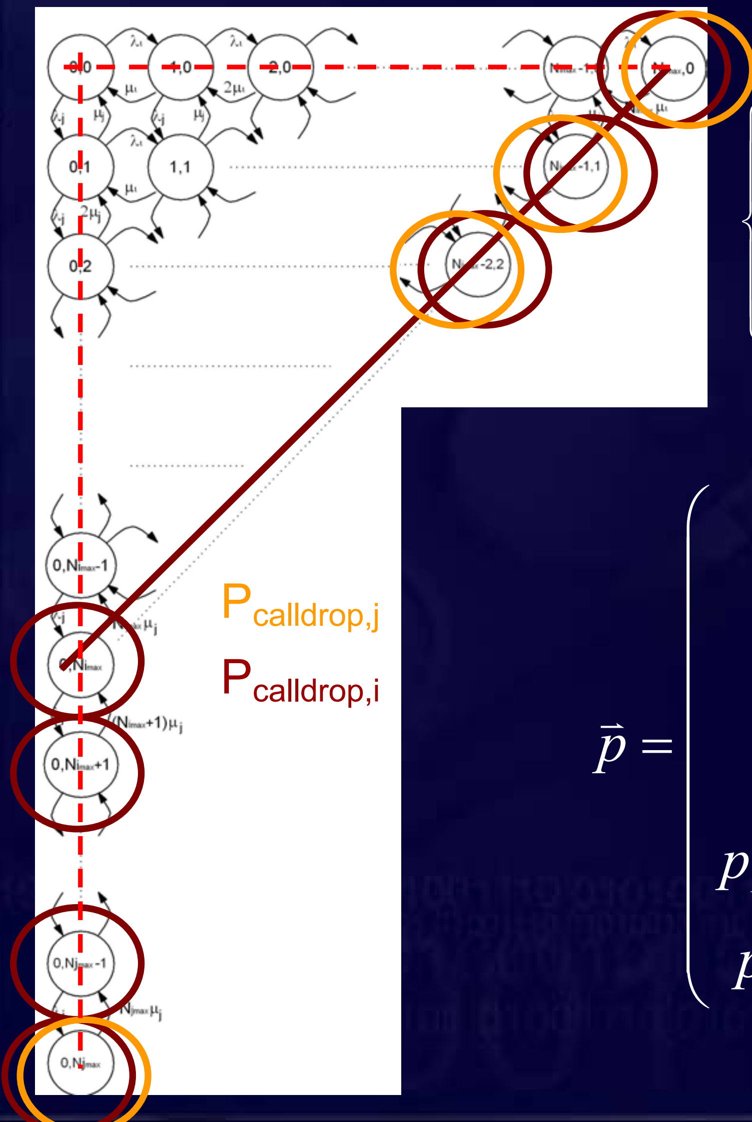
$$\sum_{k=0}^{N_{\max}} P_k = 1$$

$$P_{calldrop} = P_k, \quad k = N_{\max}$$

$$P_{calldrop} = \frac{\rho^{N_{\max}} / N_{\max}!}{\sum_{k=0}^{N_{\max}} \rho^k / k!}$$

$$P_{outage} = 1 - e^{-\rho} \sum_{k=0}^{N_{\max}} \frac{\rho^k}{k!}$$

Two classes System Model



$$\begin{cases} \dfrac{1}{I_i\left[(n_i-1)+n_j+1\right]} \geq SINR_{\text{target,i}} \\ \dfrac{1}{I_j\left[(n_i+1)+(n_j-1)\right]} \geq SINR_{\text{target,j}} \end{cases} \Rightarrow \begin{cases} (n_i+n_j) \leq N_{\max,i} \\ (n_i+n_j) \leq N_{\max,j} \end{cases}$$

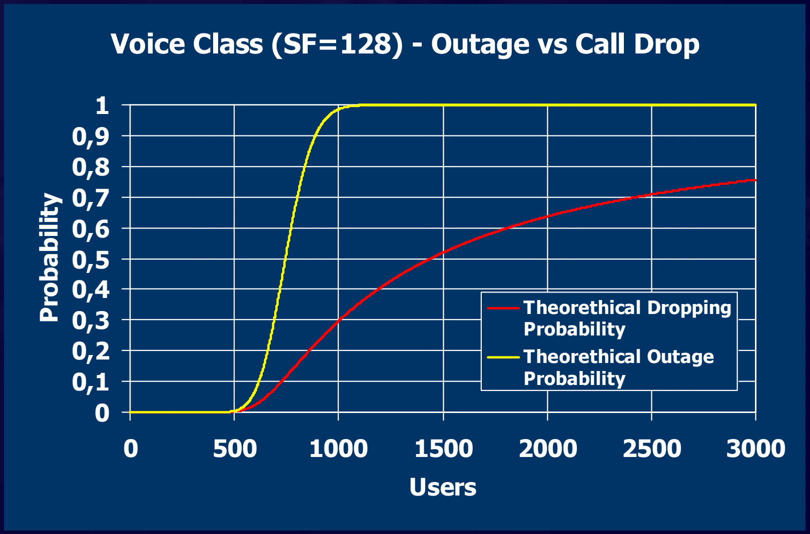
$$\vec{p} = \begin{pmatrix} p_{0,0} \\ p_{0,1} \\ \vdots \\ \vdots \\ p_{N_{\max,i}-1,0} \\ p_{N_{\max,i},0} \end{pmatrix}$$

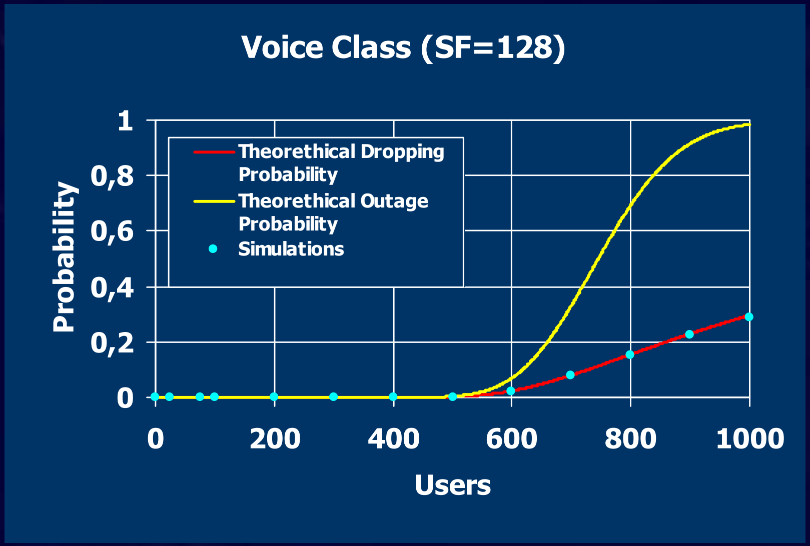
$$\begin{cases} \vec{p} = P \cdot \vec{p}, \quad P \in R^2 \\ \sum_i \sum_j p_{i,j} = 1 \end{cases}$$

Numerical Results

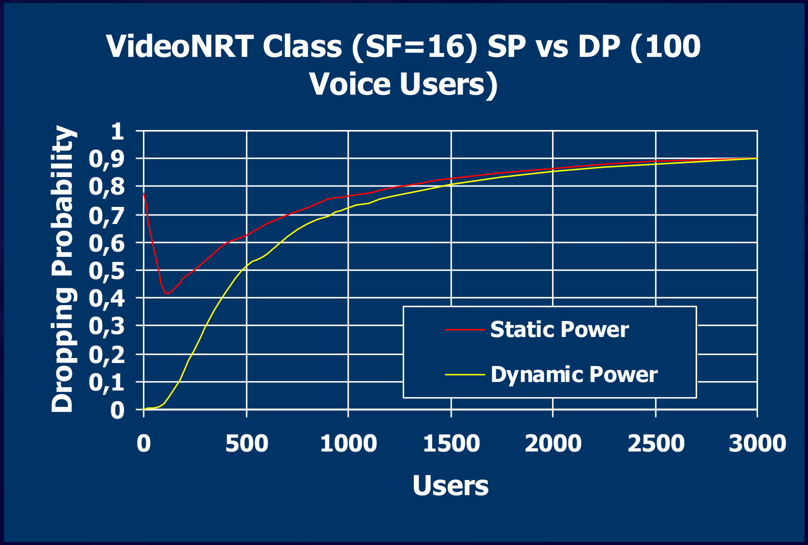
- Classes with variable bit rate from 15 to 480 kbps (SF=256 $\div$ 8)
- Considered Classes:
  - ✓ Voice: 30 kbps (SF = 8)
  - ✓ Real-Time Streaming (VideoRT): 60 kbps (SF = 16)
  - ✓ No Real Time Streaming (VideoNRT): 240 kbps (SF = 64)
  - ✓ Web Traffic (WWW30): 30 kbps (SF = 8)
  - ✓ Web Traffic (WWW60): 60 kbps (SF = 16)
  - ✓ Web Traffic (WWW120): 120 kbps (SF = 32)
  - ✓ Web Traffic (WWW480): 480 kbps (SF = 128)
- Management up to 3 simultaneously active classes
- Numerical results with variable number of active users (N=1 $\div$ 3000)

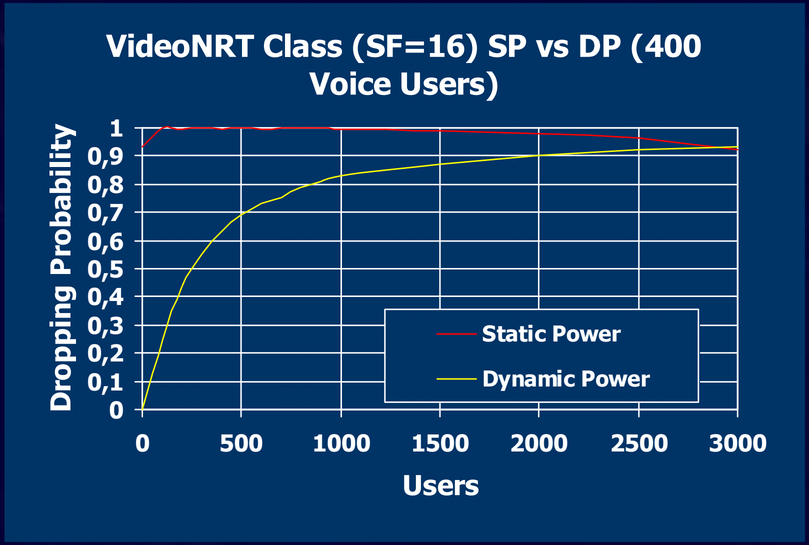
Single Class Scenario



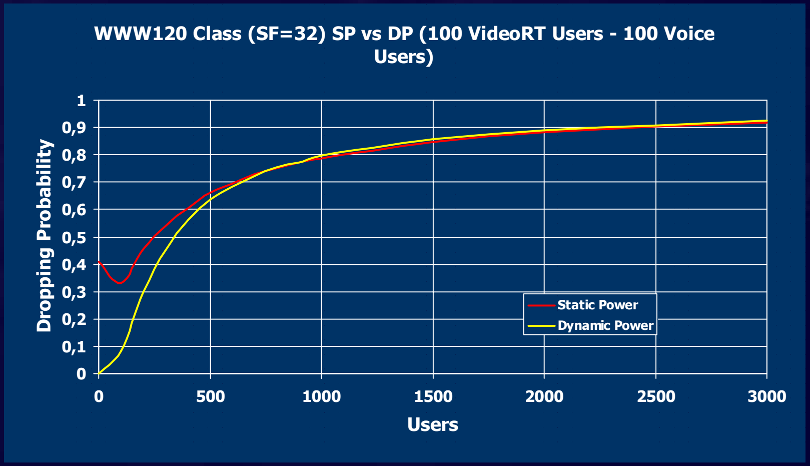


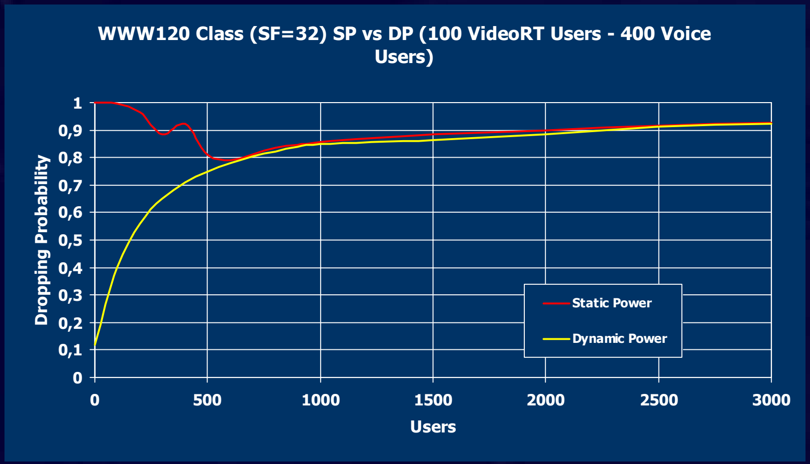
Two Classes Scenarios
CAC SP-DP





Three Classes Scenarios CAC SP-DP





Conclusive remarks

- In 3G systems the QoS management needs efficient and adaptive policies;
- The CAC algorithms are very important because they are proactive;
- We have proposed two Admission Control algorithms:
  - ✓ Static Power CAC;
  - ✓ Dynamic Power CAC.
- A flexible power reallocation increase the capacity and the robustness without degrading the QoS.

On-going Developments

- Dynamic Rate Selection based on the network congestion;
- Prioritized Admission control
  - ✓Handover Calls;
  - ✓Different QoS parameters.
- Traffic burstness.