On-Board Dynamic Power and Bandwidth Allocation in Next Generation Ka-Band Satellites

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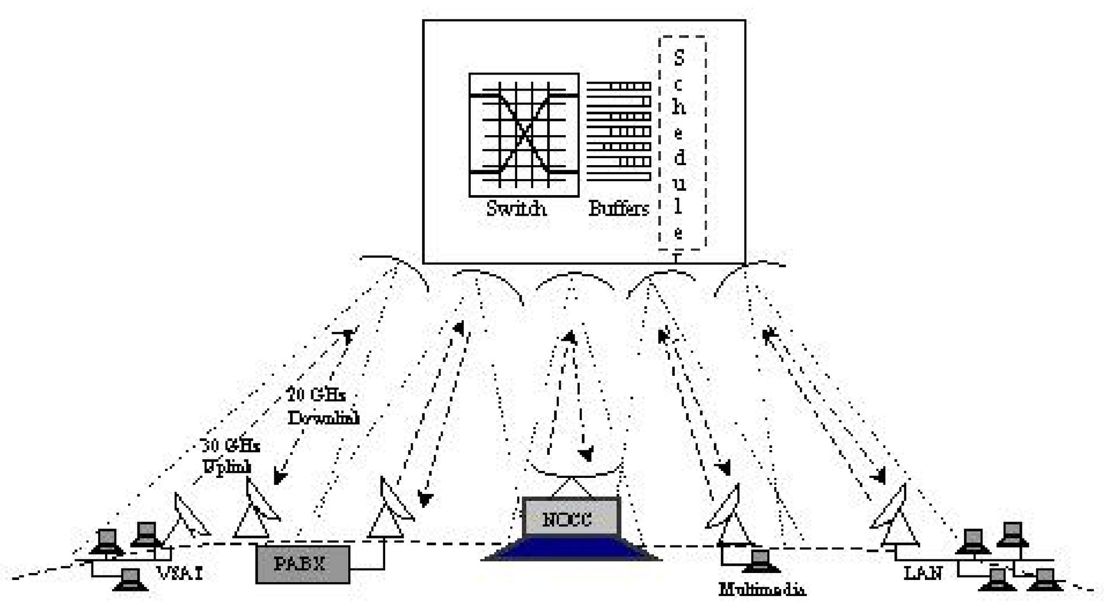
Resource Allocation for Ka-band Satellite Systems



Motivation

Ka-band satellite communications suffer from rain attenuation

Solution via Dynamic Resource Management

Rain compensation by combining increased power allocations to satellite transmit antennas and reduction of transmission rates

MF-TDMA in uplink and TDMA in downlink. Downlink transmission organized into bursts. Transmission rate is a function of the transmission power and weather condition under certain BER constraint.

Want: Fairness and high profit in a round time

Combine: Burst scheduling and power allocation

Multiple-choice Multiple Knapsack Model

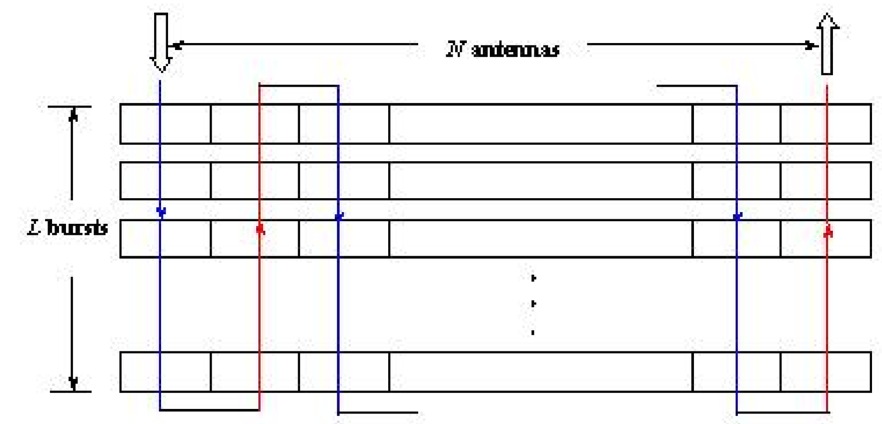
- L bursts ⇔ L knapsacks
  every downlink spot ⇔ individual item set
- Problem: choose exactly one item from each class to pack in L knapsacks, Multiple-choice Multiple Knapsack Problem (MCMKP)
- MCMKP subsumes MKP and MCKP as two special cases. Unlikely that MCMKP can be solved in reasonable comp. time
- Used a heuristic "seeding" in the burst scheduling: decoupled the problem into two separate aspects, burst and power allocation
- Considered two cases of weather conditions:
  Case I: rain fade area $\leqslant$ 10%; Case II: rain fade area > 10%
- Primary allocation steps: Step 1: Base service assignment; Step 2: Burst schedule via seeding; Step 3: MCKP power allocation
- **Patent pending**

Two Cases and Schemes

Case I

Rain fade area less than or equal to 10%

- Step 1: standard rate assigned to each spot
- Step 2: buffers are first sorted, then assigned to bursts



- Step 3: allocate power in each burst by solving MCKP

Case II

Rain fade area more than 10%

- Step 1: minimum power is assigned to each spot
- Step 2: buffers are first sorted, then assigned to bursts as in Case I.
- Step 3: allocate power in each burst as in Case I with different item sets

Performance Under Different Rain Conditions

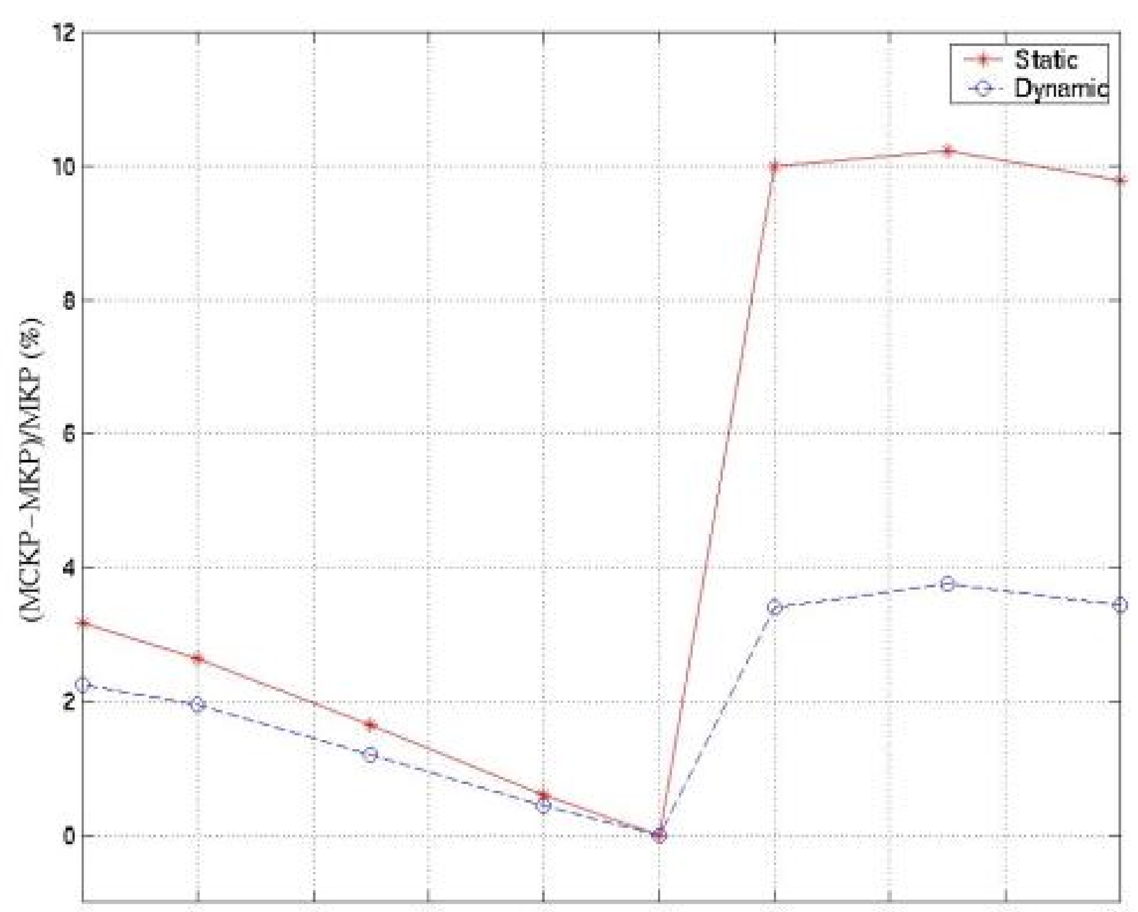


Figure shows the difference of the two schemes under various rain conditions, where the **red line** stands for the static case and **blue** for dynamic case.

Timing Performance of Two Algorithms

We simulated these two schemes and compared their performance as illustrated in the following tables and figures

Rain Area	MCKP (ms)				MKP (ms)
	Sorting	Single MCKP	35 MCKP	Total	
0	0.61	0.34	11.84	12.45	109.80
2%	0.62	0.36	12.58	13.20	281.40
5%	0.61	0.32	11.33	11.94	279.39
8%	0.65	0.33	11.44	12.09	283.01
10%	0.62	0.33	11.47	12.09	287.06
12%	0.60	0.33	11.66	12.26	317.87
15%	0.61	0.35	12.26	12.87	631.56
18%	0.63	0.35	12.33	12.96	275.61

Table shows the computing time of these two schemes

Resource Utilization and Fairness Performance of Two Algorithms

Rain Area	Power Utilization		Antenna Utilization		Service Missing	
	MCKP	MKP	MCKP	MKP	MCKP	MKP
0	99.8%	96.6%	100%	100%	No	No
2%	99.8%	97.3%	100%	100%	No	No
5%	99.8%	98.2%	100%	100%	No	No
8%	99.8%	99.2%	100%	100%	No	No
10%	99.8%	99.4%	100%	100%	No	No
12%	99.8%	99.4%	100%	99.6%	No	Yes
15%	99.8%	99.5%	100%	98.9%	No	Yes
18%	99.8%	99.4%	100%	98.3%	No	Yes

Table shows the utilization of resources and service missing situations in two schemes