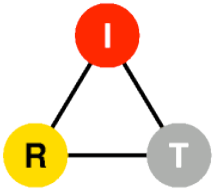


# Deployment Guidelines for Highly Congested IEEE 802.11b/g Networks

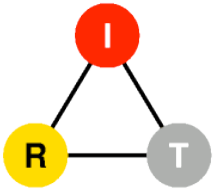
Andrea G. Forte and Henning Schulzrinne  
Columbia University



## Background

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- IEEE 802.11b/g networks ubiquitously deployed
- Mostly uncoordinated deployments
- Channel assignment not trivial
  - conventional wisdom: assign only channels 1, 6, 11
- Our approach
  - test in the field and in testbed
  - practical guidelines for network administrators

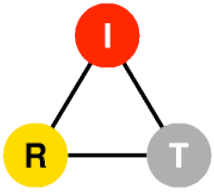


# Wireless Networks

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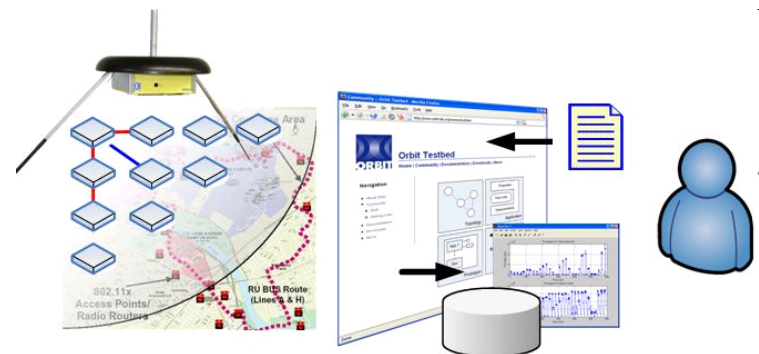
- IEEE 802.11a
  - 5 GHz band
  - 12 non-overlapping channels
  - Rarely used for home networks, never for public access networks
- IEEE 802.11n
  - emerging – likely to be common for residential
- IEEE 802.11b/g
  - 2.4 GHz band
  - 3 non-overlapping channels
  - Dominates residential and public networks

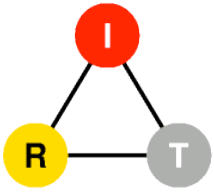
→ We focus on IEEE 802.11b/g



# Experiments

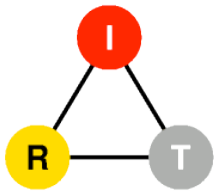
- Experiment 1
  - Testing different channel configurations in existing networks
    - Columbia University campus (site survey)
- Experiment 2
  - Studying co-channel interference in highly congested scenarios (large number of users)
    - ORBIT wireless test-bed





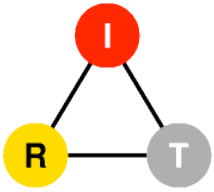
# Site Survey – Columbia University

- Found a total of 668 APs
  - 338 open APs: 49%
  - 350 secure APs: 51%
  - Best signal: -54 dBm
  - Worst signal: -98 dBm
- Sometimes could see >100 APs at once
- Found 365 unique wireless networks
  - “private” wireless networks (single AP): 340
  - “public” networks (not necessarily open): 25
    - Columbia University: 143 APs
    - PubWiFi (Teachers College): 33 APs
    - COWSECURE: 12 APs
    - Columbia University – Law: 11 APs
    - Barnard College: 10 APs



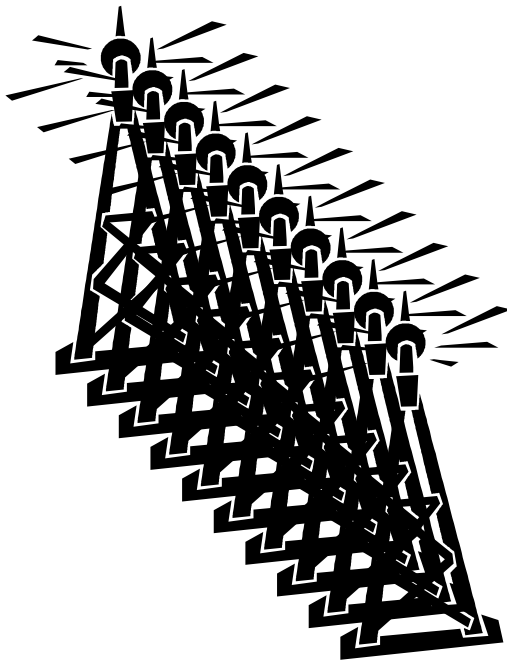
# Measurement area



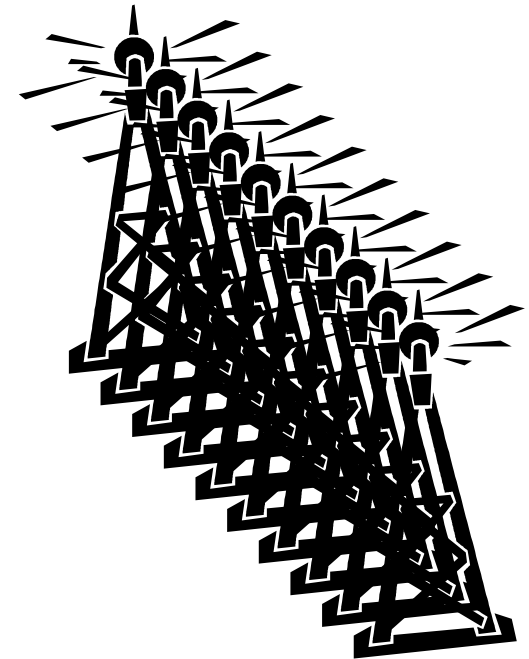
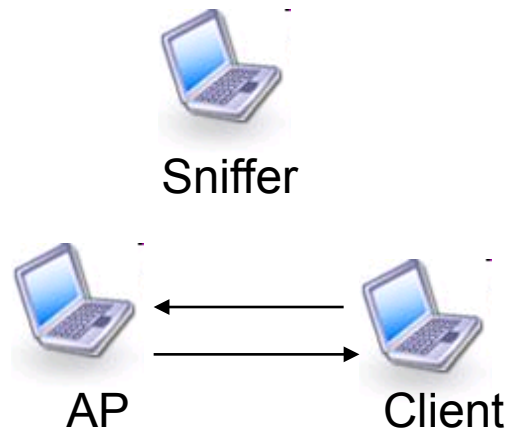


# Experiment 1

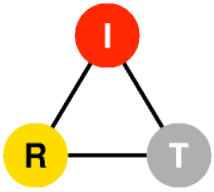
## Experimental setup



Surrounding APs

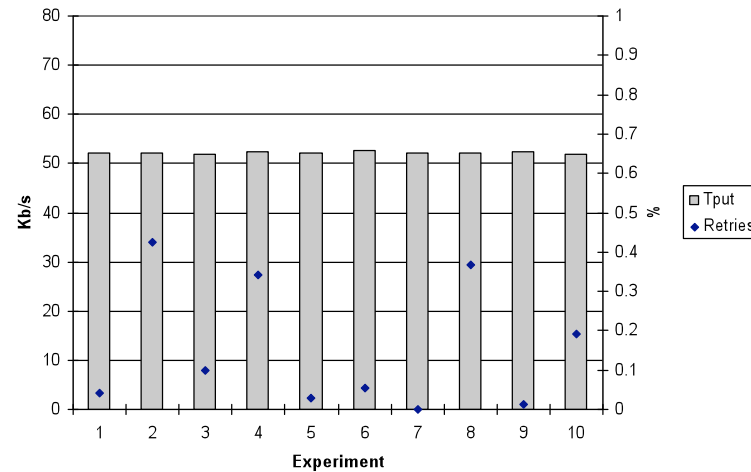


Surrounding APs



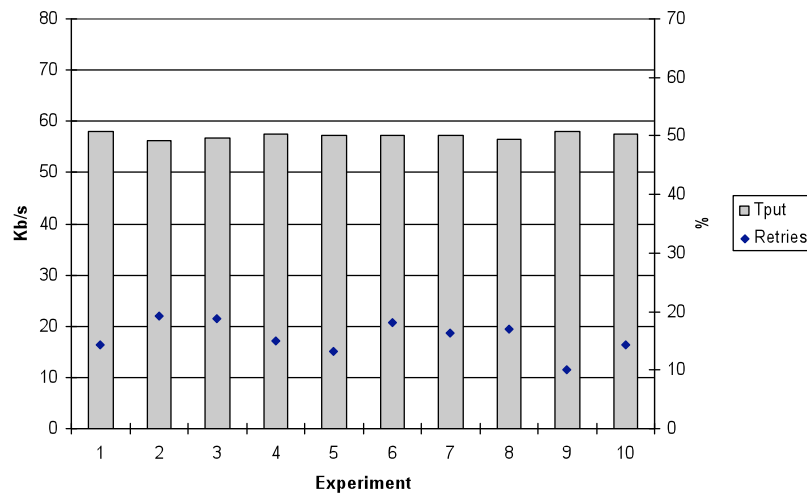
# Experiment 1 – Results (1/3)

Using non-overlapping channels

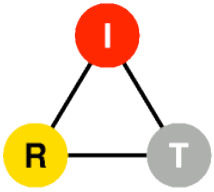


- Throughput and retry rate with no interference

→ Same for any channel

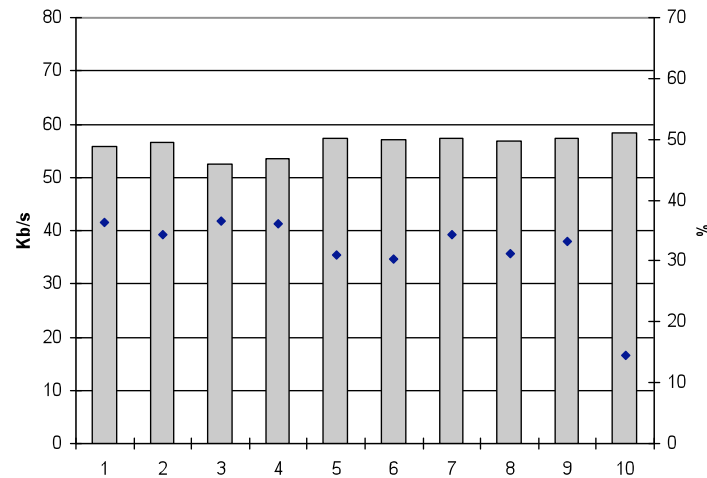


- Throughput and retry rate with interference on channel 1



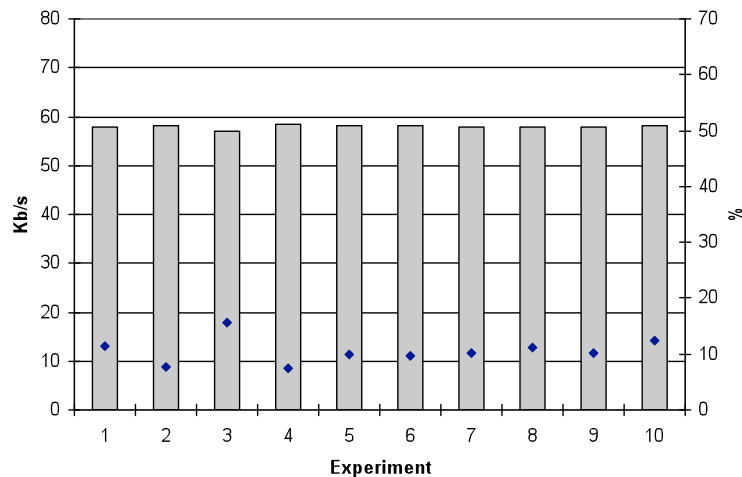
# Experiment 1 – Results (2/3)

Using non-overlapping channels

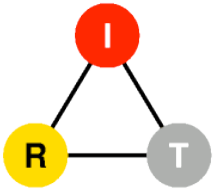


- Throughput and retry rate with interference on channel 6

→ Most congested!

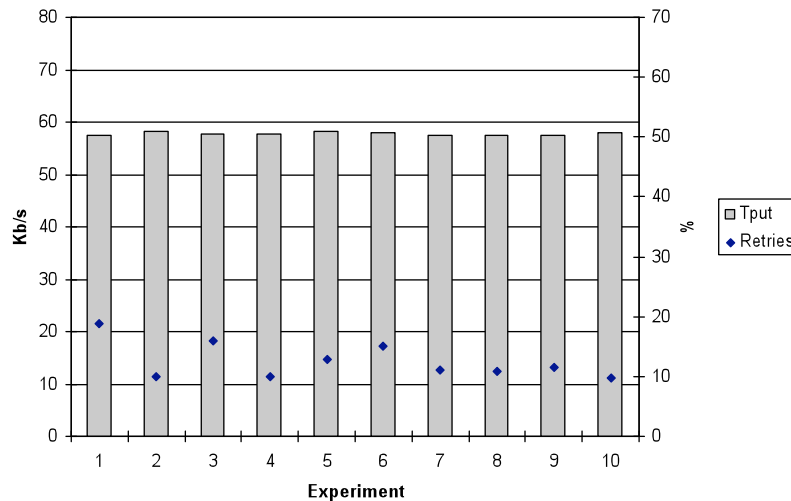


- Throughput and retry rate with interference on channel 11



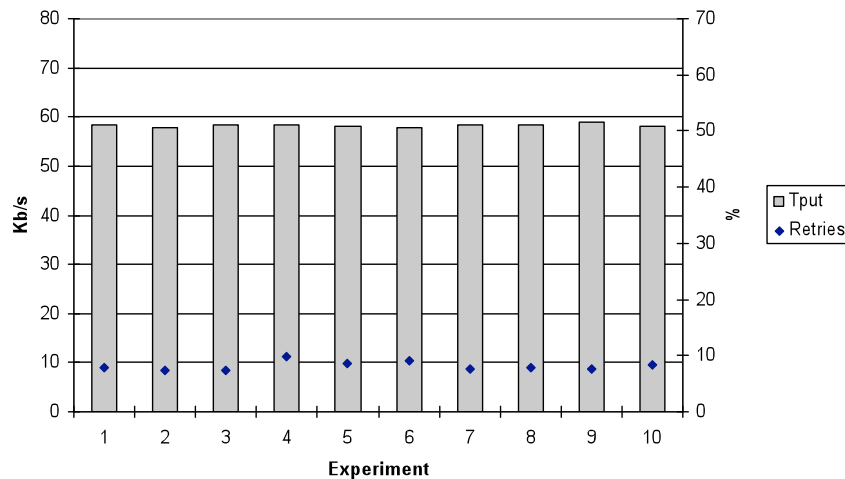
# Experiment 1 – Results (3/3)

Using overlapping channels



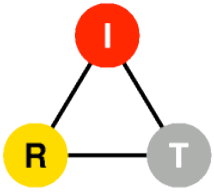
- Throughput and retry rate with interference on channel 4

→ Better than channel 6



- Throughput and retry rate with interference on channel 8

→ Better than channel 6



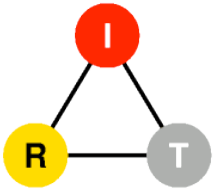
# Experiment 1

## Conclusions

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- Using overlapping channels does not affect performance negatively
  - In the experiments channel 4 and channel 8 are a much better choice than channel 6
- Use at least channels 1, 4, 8 and 11 (minimum overlapping in band)
  - better spatial re-use
  - no significant decrease in performance

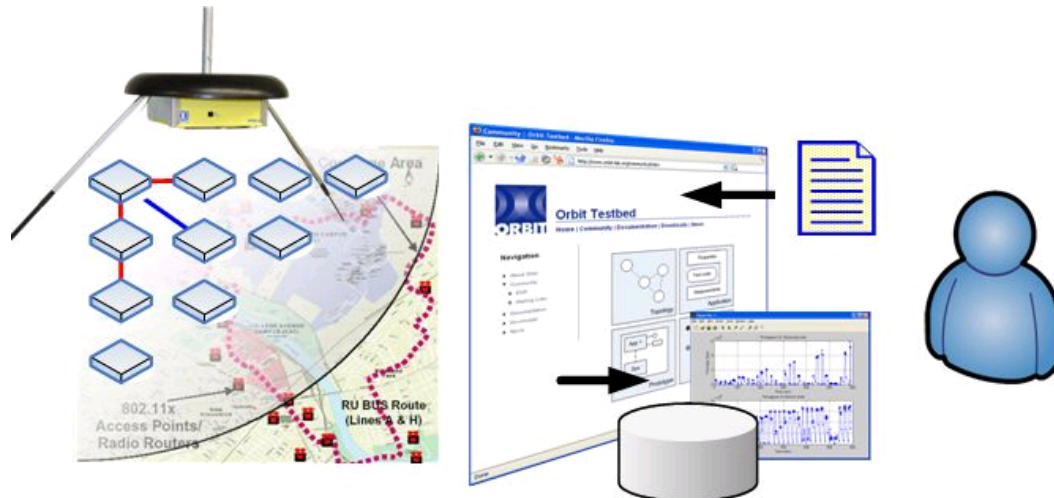
→ *Use overlapping channels!*

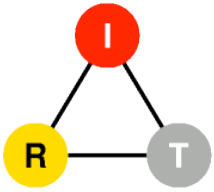


# Experiment 2

## Experimental setup

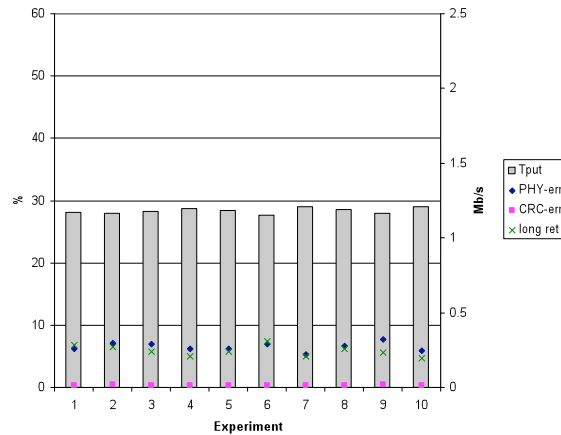
- ORBIT wireless test-bed
  - Grid of 20x20 wireless nodes
  - Used only maximum bit-rate of 11 Mb/s (no ARF)
  - G.711 CBR VoIP calls
  - Number of clients always exceeding the network capacity (CBR @ 11Mb/s → 10 concurrent calls)



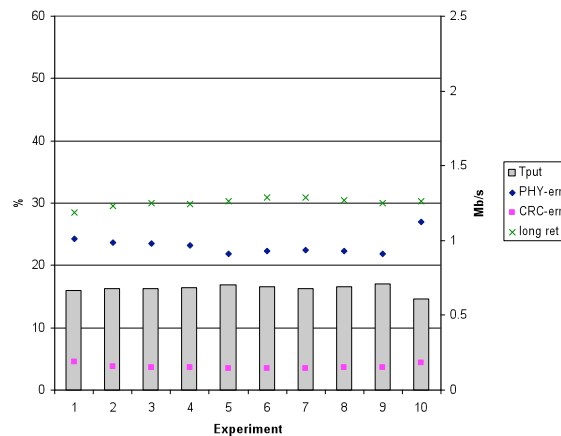


# Experiments 2 – Results (1/2)

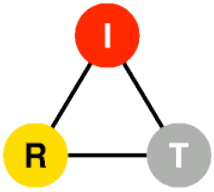
## Non-overlapping channels



- AP1 using Ch. 1
- AP2 using Ch.6
- Num. of clients: 43

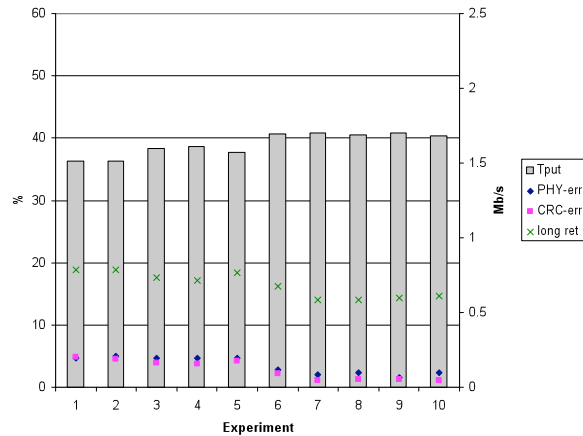


- AP1 and AP2 using Ch. 1
- Num. of clients: 43

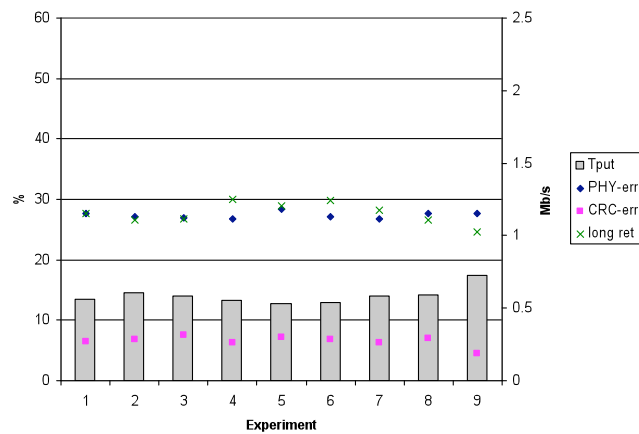


# Experiments 2 – Results (2/2)

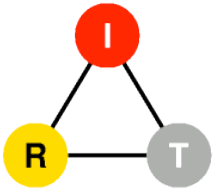
## Overlapping channels



- AP1 using Ch. 1
- AP2 using Ch. 4
- Num. of clients: 67



- AP1 and AP2 using Ch. 4
- Num. of clients: 67

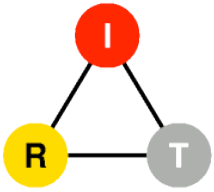


# Experiment 2

## Conclusions

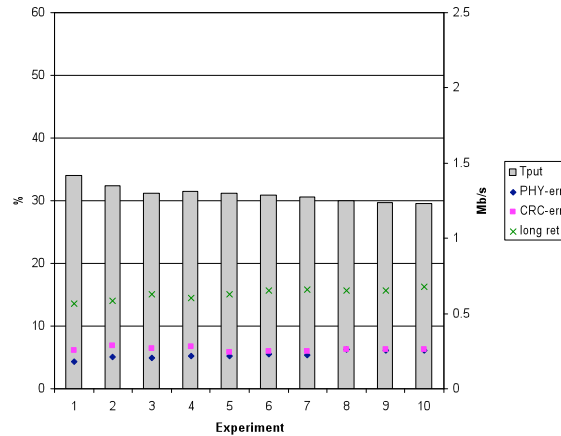
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- When using two APs on the same channel
  - Throughput decreases drastically
  - Physical-error rate and retry rate increase
- Using two APs on two overlapping channels performs much better than using the same non-overlapping channel
  - Do not deploy multiple APs on the same non-overlapping channels
  - Use overlapping channels!

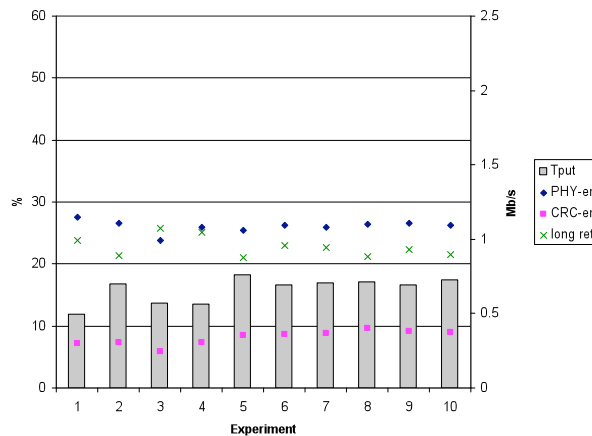


# One AP vs. many

## Very high number of users

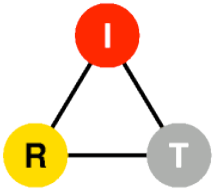


- Network performance with single AP in highly congested scenarios



- Network performance with two APs on the same channel in highly congested scenario

→ Using two APs on the same channel performs worse than using a single AP!



# Conclusions & recommendations

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- Using overlapping channels does not affect performance negatively
    - Use at least channels 1, 4, 8 and 11
  - Do not deploy multiple APs on the same non-overlapping channels
  - Using two APs on the same channel performs worse than using a single AP!
    - Just increasing the number of APs does not help
- *Use overlapping channels!*