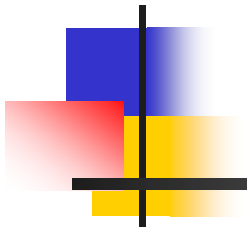
# Rump Session Presentation: Recent Progress on SHA-1

Adi Shamir

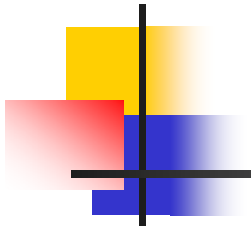
(On behalf of Xiaoyun Wang)



# New Collision Search for SHA-1

by

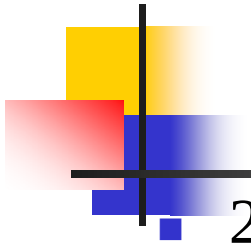
Xiaoyun Wang, Andrew Yao and Frances Yao



# Outline

- Current status: attack of SHA-1 with complexity $2^{69}$
- Obstacles for further improvement
- New collision path for SHA-1
- Comparing new collision path with previous path
- Strategies for message modification
- The complexity for searching collision of SHA-1

# Obstacles for Further Improvement



- $2^{69}$ complexity comes from 68 conditions in the 2-iteration attack
- Can we eliminate even more conditions by applying message modification in steps 10-16 ?
- Difficult, because message space available is tight:

  -- 50 message conditions in steps 17-80

  -- hence 50 message conditions in steps 12-16

  -- resulting in 50 message bit equations

  -- most message bits are involved

  -- in addition, 51 chaining variable conditions in steps 10-16

  -- extra chaining variable conditions and message conditions coming from the message modification

# New Collision Path for SHA-1

- We give a new collision differential path for SHA-1.

- Comparison:

| | Old | New |
|---|---|---|
| 1. Message conditions | 50 | 43 |
| 2. Chaining variable conditions | 51 | 30 |
| 3. Message space in steps 10-16 available for direct modification | $2^{47}$ | $2^{55}$ |
| 4. Message space in steps 10-16 available for searching collision before advanced message modification | $2^{123}$ | $2^{151}$ |

# Strategies for Message Modification

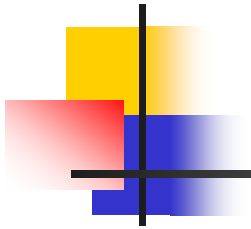
- Determine which message bits are *possible candidates* for modification.

- The message modification process *must respect* all chaining variable conditions and message conditions.

  --may require adding *extra chaining variable* conditions in steps 1-16 and message conditions.

  -- message modification follow certain *topological order* coming from correlations among chaining variable conditions.

# Complexity Estimation for New Collision Search of SHA-1



- There are 83 conditions in steps 17-80
- Message modification can correct about 18 chaining variable conditions in steps 17-26
- Searching for three conditions in steps 26-27 by one computation
- Relax one condition in the final step
- 61 conditions left
- Factor of 4 from 2 iterations and error correction

→ $2^{63}$ complexity