Practical algorithms and parameters for modification-tolerant signature scheme

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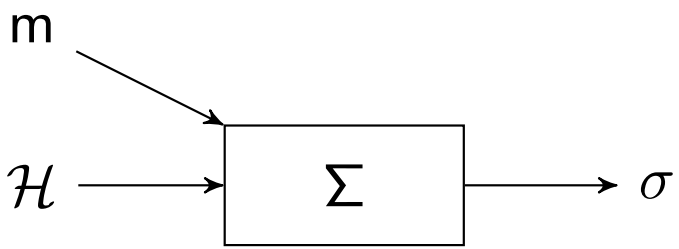
Traditional digital signatures

What happens if we change the signed document?

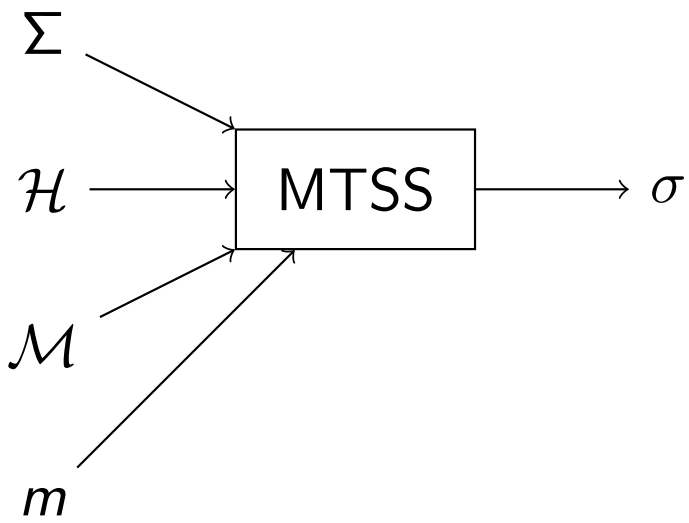
Traditional digital signatures



- $\mathcal{H}$ is a hash function
- Σ is a traditional signature scheme
- σ is the signature

MTSS

Modification-tolerant signature scheme [Idalino et al., 2019]



- $\mathcal{M}$ is a table with special properties

Cover-free families (CFFs)

	a	b	c	d	e	f	g	h	i	j	k	l
1	1	0	0	1	0	0	1	0	0	1	0	0
2	1	0	0	0	1	0	0	1	0	0	1	0
3	1	0	0	0	0	1	0	0	1	0	0	1
4	0	1	0	1	0	0	0	0	1	0	1	0
5	0	1	0	0	1	0	1	0	0	0	0	1
6	0	1	0	0	0	1	0	1	0	1	0	0
7	0	0	1	1	0	0	0	1	0	0	0	1
8	0	0	1	0	1	0	0	0	1	1	0	0
9	0	0	1	0	0	1	1	0	0	0	1	0

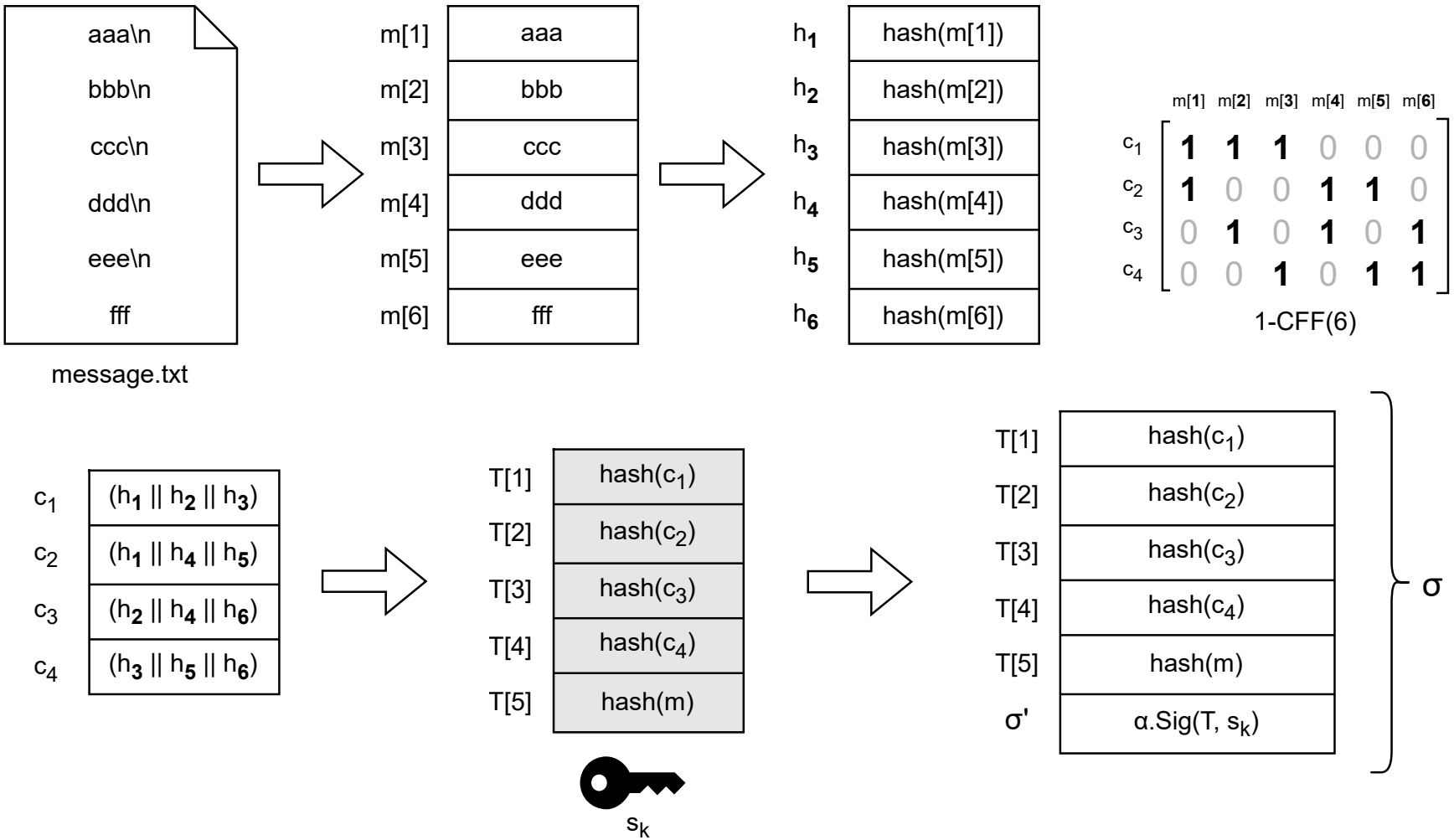
Cover-free families (CFFs)

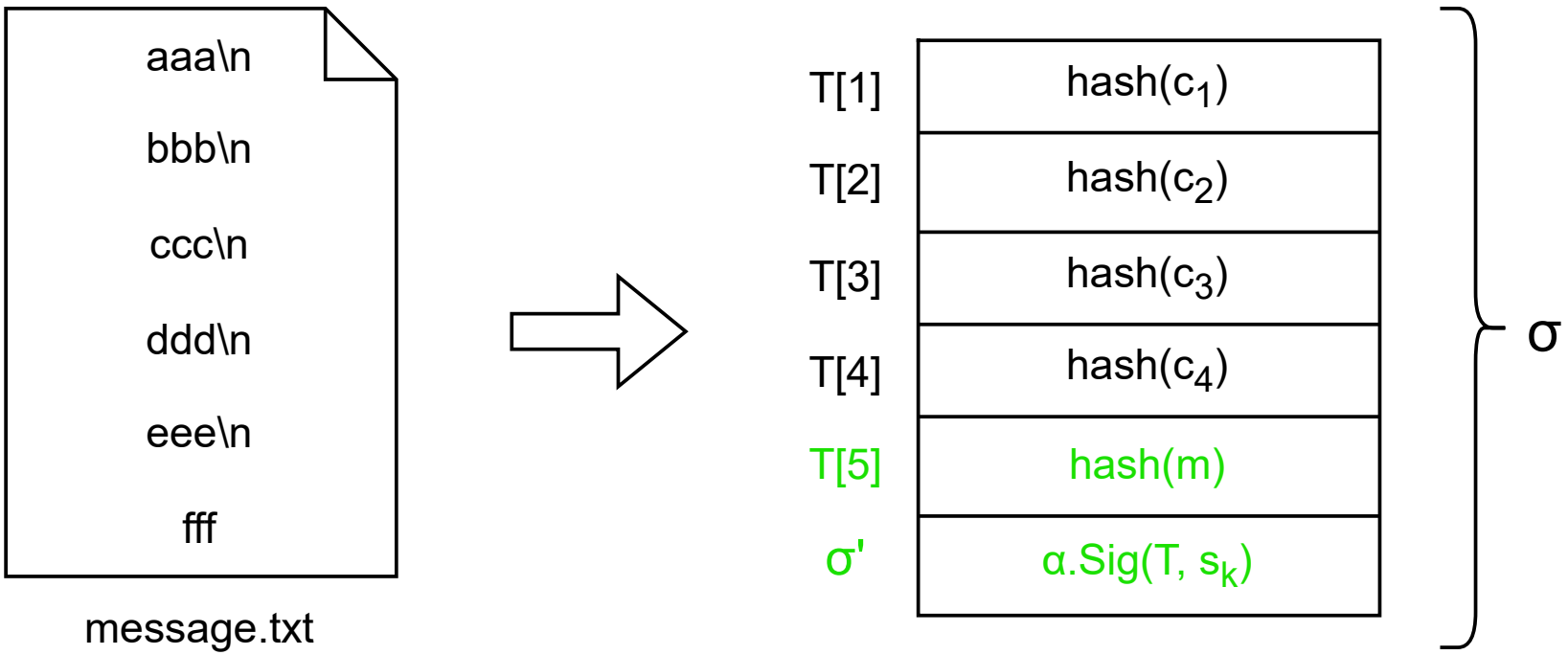
Identifying defects using CFFs

	a	b	c	d	e	f	g	h	i	j	k	l
Test 1 ✗	1	0	0	1	0	0	1	0	0	1	0	0
Test 2 ✗	1	0	0	0	1	0	0	1	0	0	1	0
Test 3 ✓	1	0	0	0	0	1	0	0	1	0	0	1
Test 4 ✗	0	1	0	1	0	0	0	0	1	0	1	0
Test 5 ✓	0	1	0	0	1	0	1	0	0	0	0	1
Test 6 ✗	0	1	0	0	0	1	0	1	0	1	0	0
Test 7 ✗	0	0	1	1	0	0	0	1	0	0	0	1
Test 8 ✓	0	0	1	0	1	0	0	0	1	1	0	0
Test 9 ✓	0	0	1	0	0	1	1	0	0	0	1	0

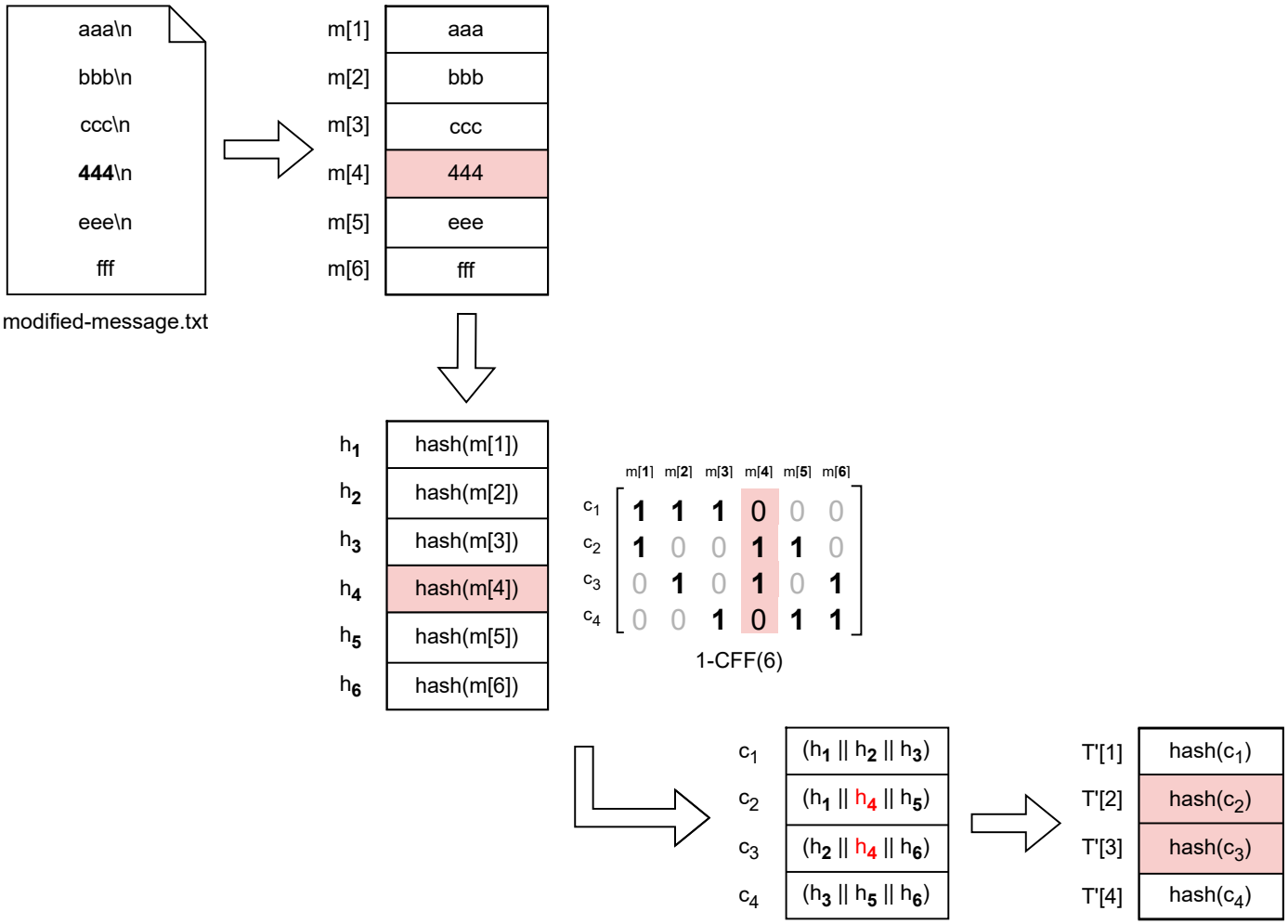
- 2-CFF$(9, 12)$

Signature process - Algorithm Sig




aaa\n
bbb\n
ccc\n
ddd\n
eee\n
fff
message.txt
T[1]
hash(c1)
T[2]
hash(c2)
T[3]
hash(c3)
T[4]
hash(c4)
T[5]
hash(m)
σ'
α.Sig(T, sk)
σ

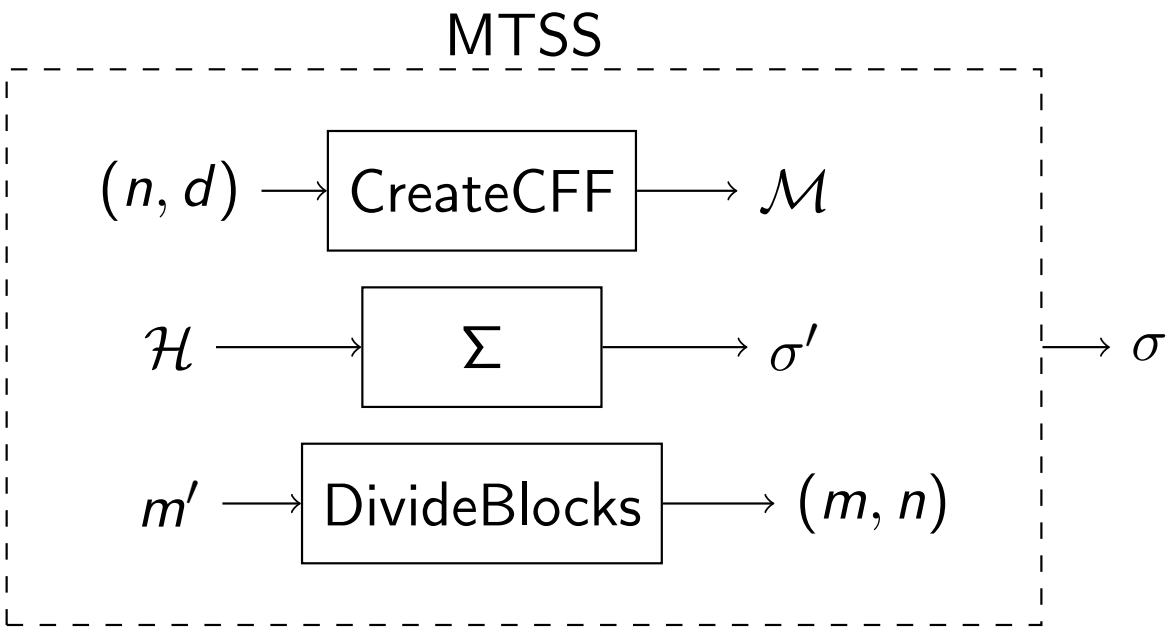
Locating process - Algorithm Ver



Our contributions

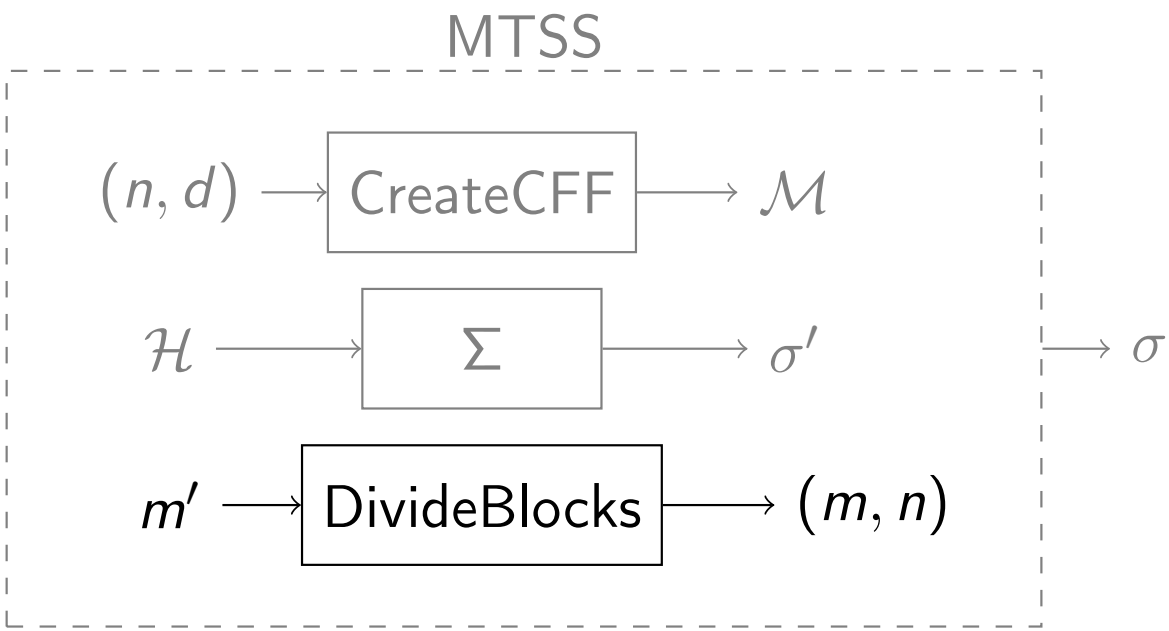
- Complementing the MTSS framework [Idalino et al., 2019]
  - High-level implementation
  - Performance statistics
  - CFF parameters
  - How to efficiently divide a document into blocks
- New usage for MTSS: provide integrity and authenticity of any part of a signed document without ownership of the whole message

MTSS in practice



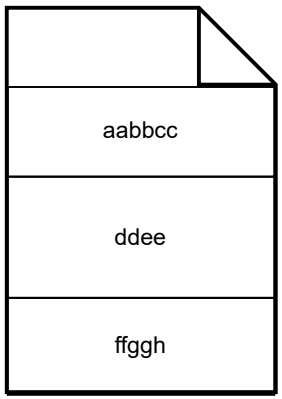
MTSS in practice

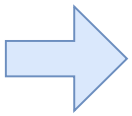
Dividing blocks



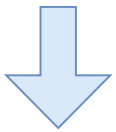
MTSS in practice

Dividing blocks: approaches





aa	bb	cc	dd
1e	ef	fg	gh



aabbccdd**1**eeffggh

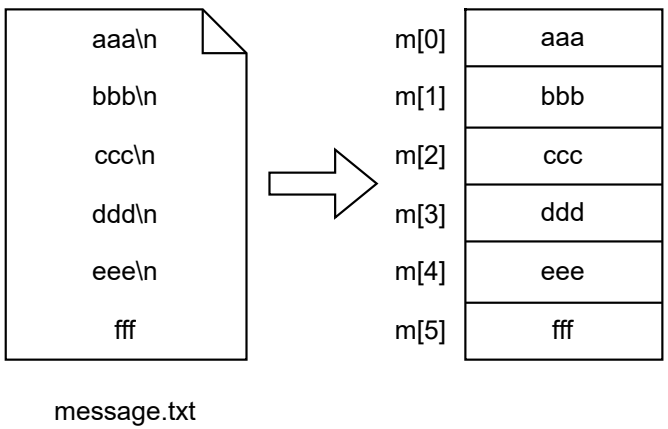
aabbccdd
1eeffggh

aabb
ccdd
1eef
fggh

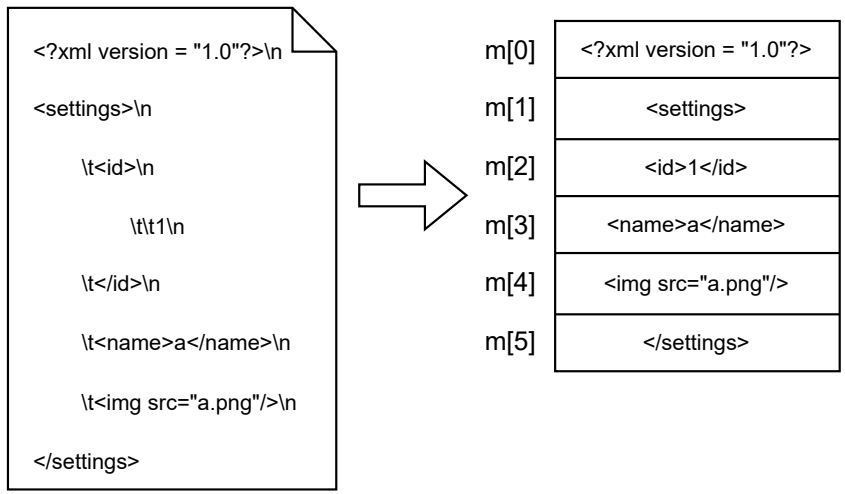
aa
bb
cc
dd
1e
ef
fg
gh

MTSS in practice

Dividing blocks: our approach



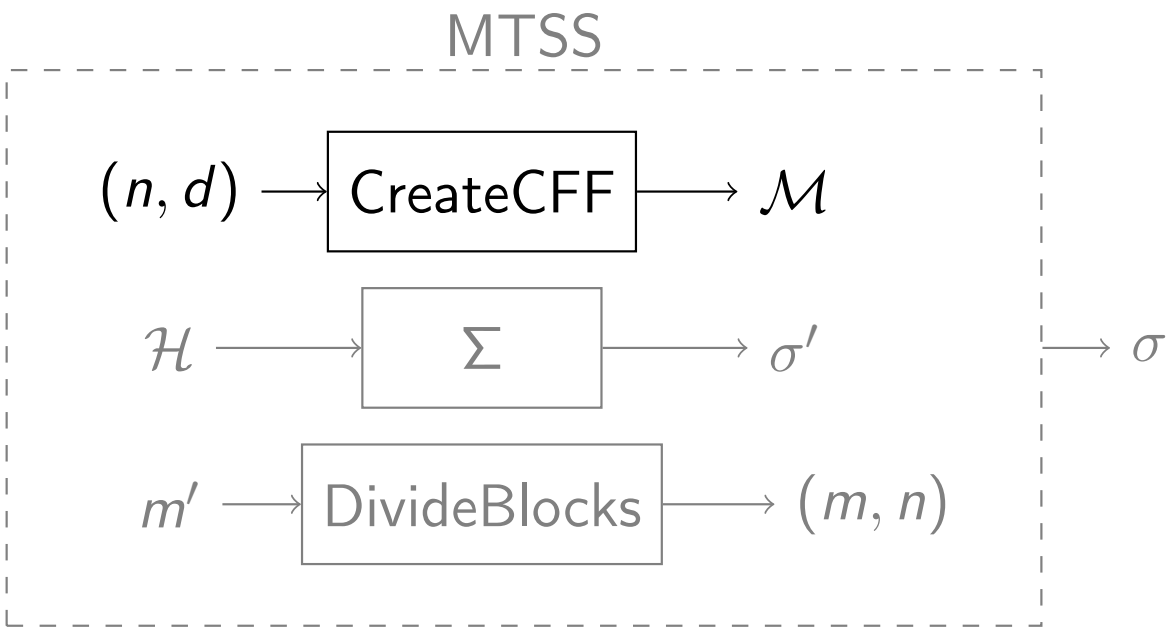
message.txt



message.xml

MTSS in practice

Creating CFFs

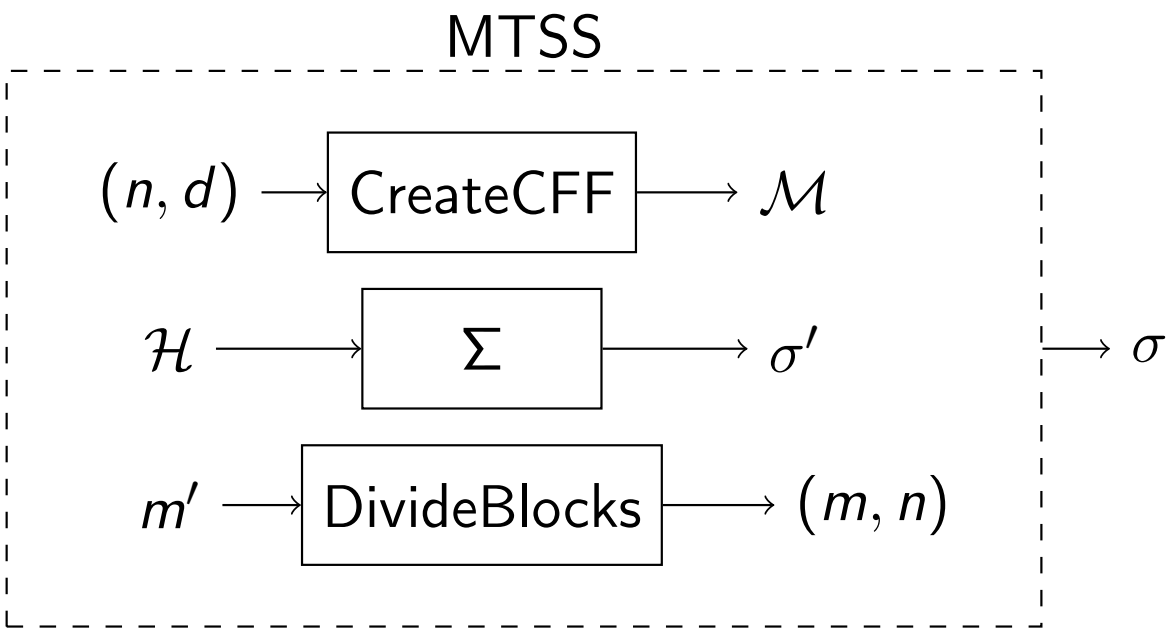


Result: poor performance generation

Solution: cache!!

MTSS in practice

Experiments using different Σ and $\mathcal{H}$



MTSS in practice

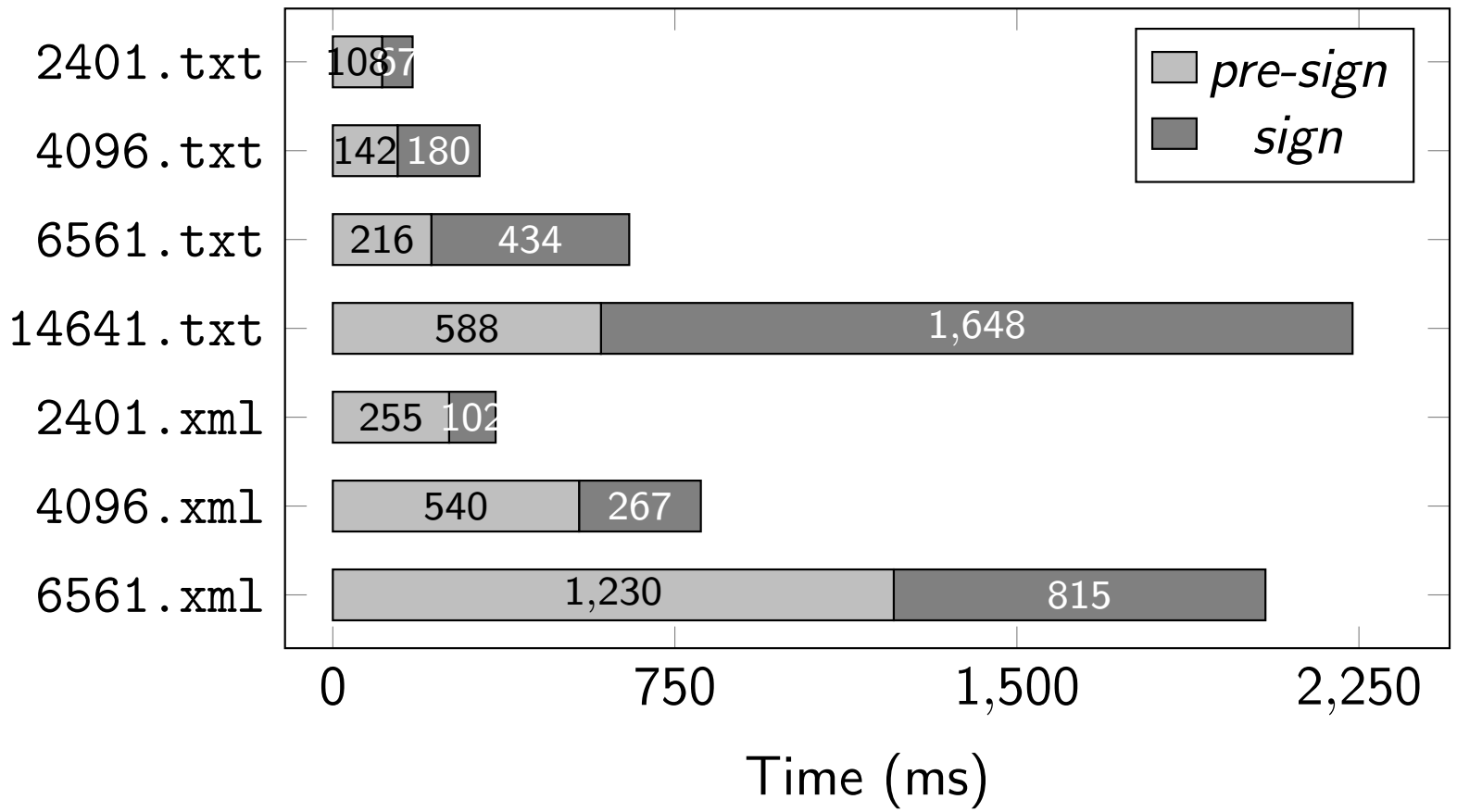
Sig algorithm

	Σ	Sig time (ms)						$\lvert\sigma\rvert$ (bytes)	
		SHA-2		SHA-3		BLAKE			
		256	512	256	512	2s	2b	256	512
Raw Σ	RSA-2048	4.83	3.63	3.93	6.42	2.49	3.32	256	256
	ML-DSA-44	3.93	2.67	2.96	5.49	1.54	2.36	2360	2360
	Ed25519		3.08						64
MTSS	RSA-2048	27.35	19.42	21.76	36.85	10.86	15.63	1088	1880
	ML-DSA-44	26.44	18.85	21.27	36.04	10.36	15.2	3180	3990
	Ed25519		19.99						1690

Using $\mathcal{M} = \text{2-CFF}(25, 125)$

MTSS in practice

Sig with DivideBlocks and CreateCFF



MTSS in practice

Ver algorithm

	Σ	Ver time (ms)					
		SHA-2		SHA-3		BLAKE	
		256	512	256	512	2s	2b
Raw Σ	RSA-2048	4.09	2.87	3.15	5.66	3.21	4.84
	ML-DSA-44	3.88	2.61	2.90	5.47	1.51	2.30
	Ed25519		3.84				
$\lvert I\rvert = 0$	RSA-2048	4.16	2.95	3.25	5.80	1.81	2.64
	ML-DSA-44	3.94	2.69	3.00	5.55	1.55	2.37
	Ed25519		3.90				
$\lvert I\rvert = 1$	RSA-2048	159.95	174.53	162.22	162.29	153.15	162.94
	ML-DSA-44	156.93	177.55	159.49	165.35	163.51	154.37
	Ed25519		165.41				

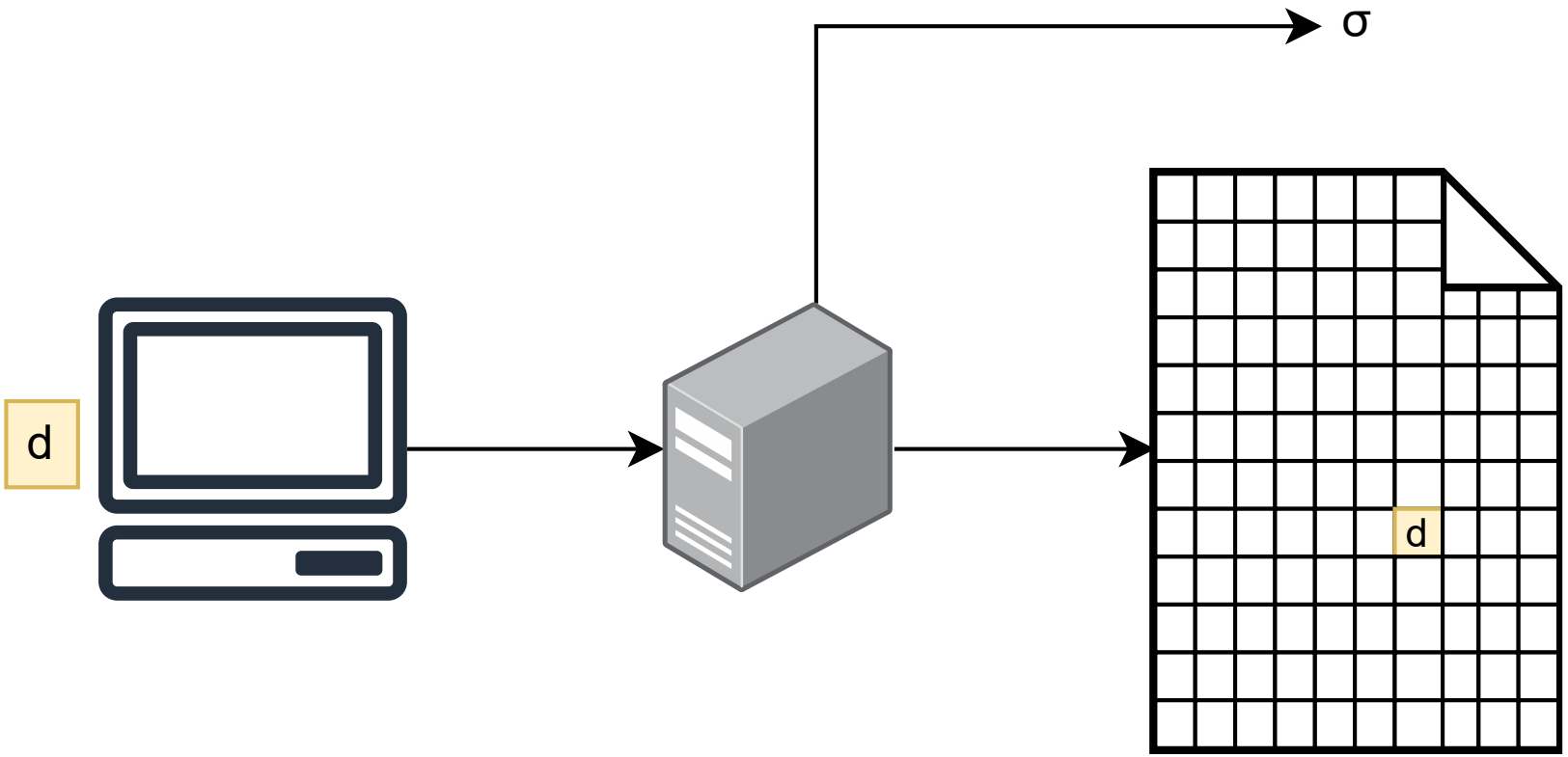
Using $\mathcal{M} = \text{2-CFF}(25, 125)$

New usage for MTSS

What if we did not need to sign every page of the Brazilian Federal Register (Diário Oficial da União) to verify one page's integrity and authenticity?

Ensuring data integrity for individual blocks

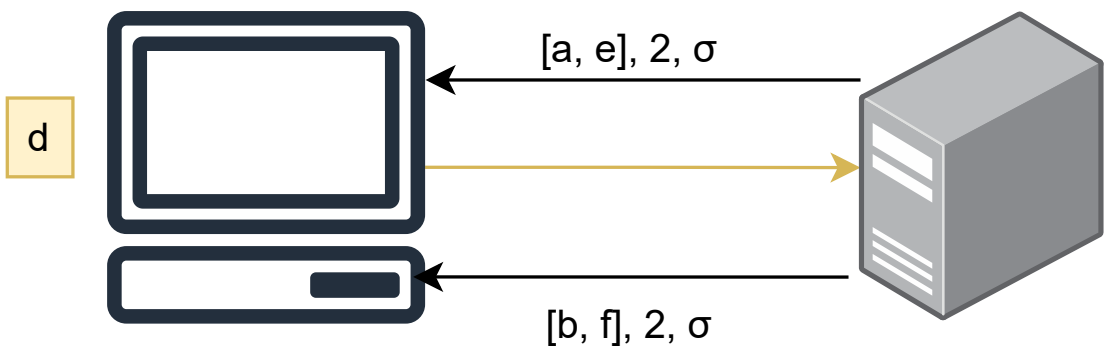
Using MTSS



Ensuring data integrity for individual blocks

Using MTSS

	a	b	c	d	e	f
1	1	1	1	0	0	0
2	1	0	0	1	1	0
3	0	1	0	1	0	1
4	0	0	1	0	1	1



References I


Idalino, T. B., Moura, L., and Adams, C. (2019).
Modification tolerant signature schemes: location and correction.
In *International Conference on Cryptology in India*, pages 23–44. Springer.

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- Repository: `https://github.com/AnthonyKamers/mtss-signer`

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Questions?