

# Minutiae Interoperability Exchange Test

(MINEX 04)

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# Exchange of Fingerprint Data

## Images or Templates



## Factors To Consider:

- Accuracy
- Processing time
- Size on card

# Minutiae Example

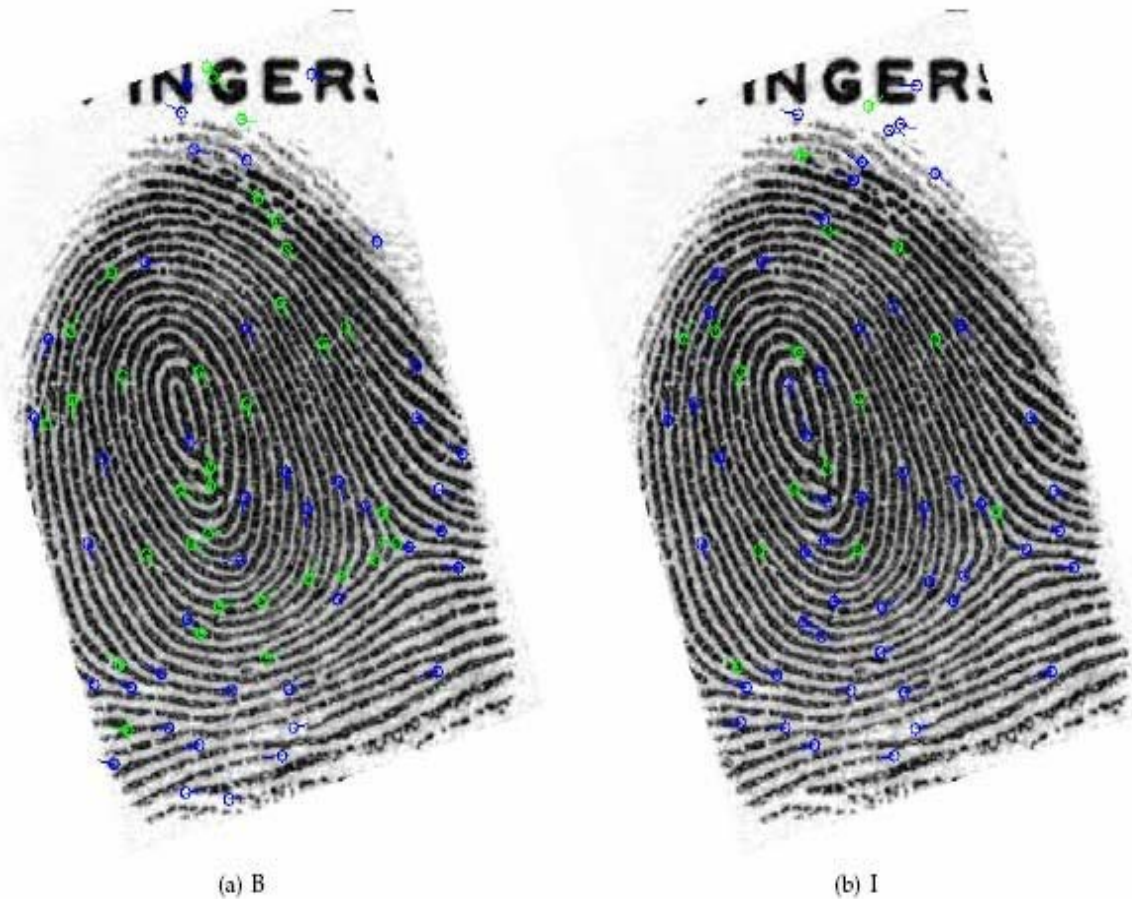


Figure 1: Examples of Minutiae Placement Variation  
A NIST Special Database 29 image annotated with the  $(x, y, \theta, \text{type})$  minutiae points of the MIN:A template generators. Red indicates type "other", green indicates "ridge ending", and blue labels "bifurcation".

# Fingerprint Matching

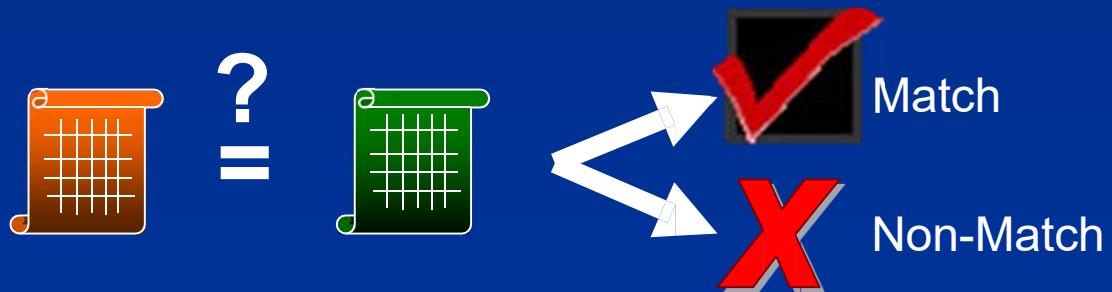
1. Enrollment



2. Subsequent attempts at identity verification



3. Matching



# Types of Templates

- Proprietary templates
  - Individual vendor's representation of images
- Standard templates: INCITS 378 format
  - MIN:A templates
    - codes minutiae coordinates (x, y), angle ( $\theta$ ), type, & quality
  - MIN:B templates
    - MIN:A data plus ridge count, core, and delta information

# Largest Biometric Test to Date...

- 4 datasets:
  - POEBVA, DHS2, POE, and DOS
- Number of Samples
  - >60,000 matched fingerprint pairs
  - >120,000 non-match fingerprints
- 14 vendors
  - Six participants in MIN:B testing
- 4.4 billion comparisons resulting in >45 GB of scores & >1 terabyte of data in total

# Vendors

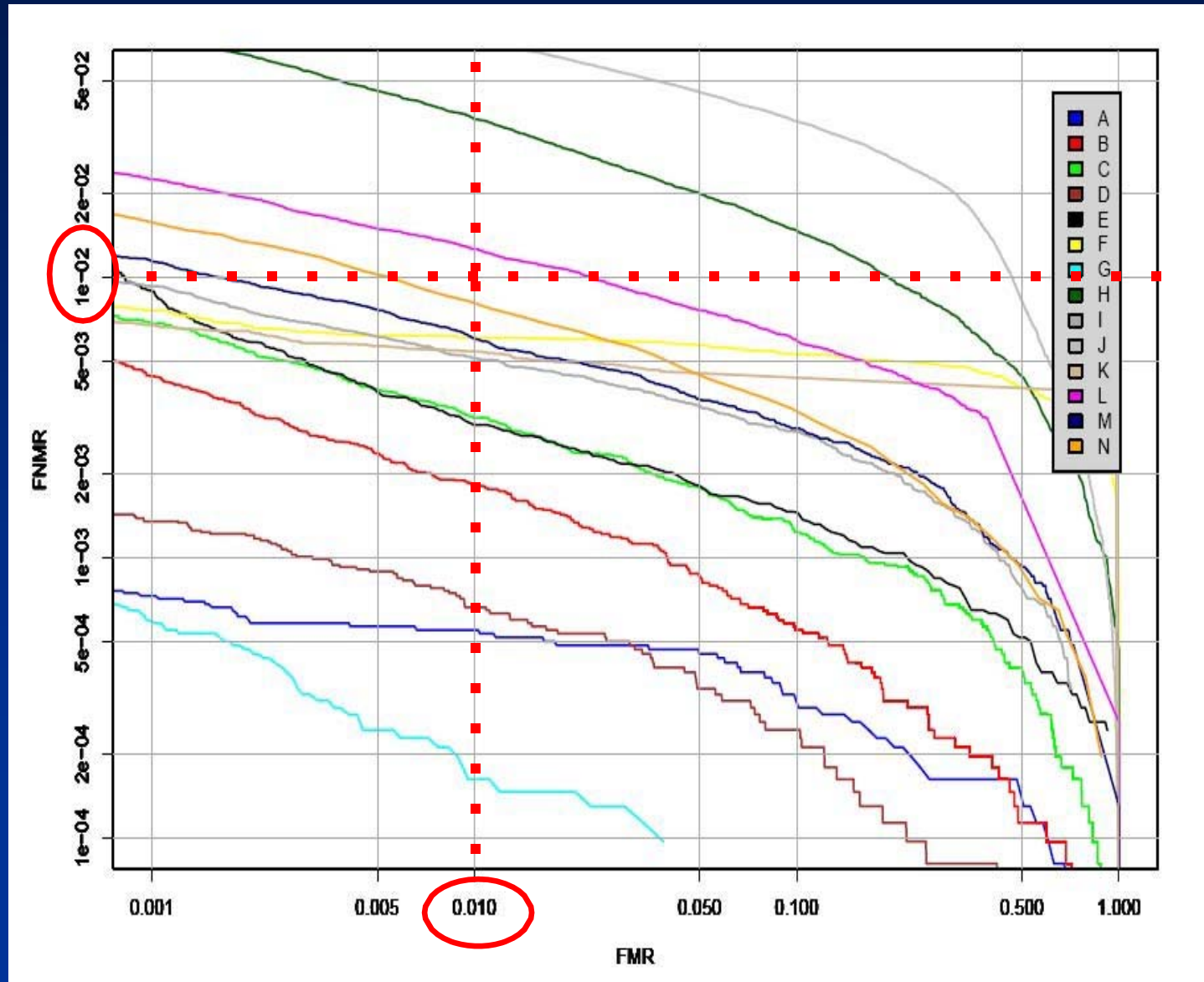
- A. Cogent Systems Incorporated
- B. Dermalog Identification Systems GMBH
- C. Bioscrypt Incorporated
- D. Sagem Morpho Incorporated
- E. Neurotechnologija
- F. Innovatrics
- G. NEC Corporation
- H. Technoimagia Corporation
- I. Identix Incorporated
- J. Biologica Sistemas
- K. SPEX Forensics
- L. Secugen Corporation
- M. NITGen Corporation
- N. Cross Match Technologies

# MINEX Questions

- Do standard templates give accuracy comparable with proprietary (image-based) implementations?
- Can template data be generated and matched by different vendors without increase in error rates?



# Detection Error Tradeoff Curves



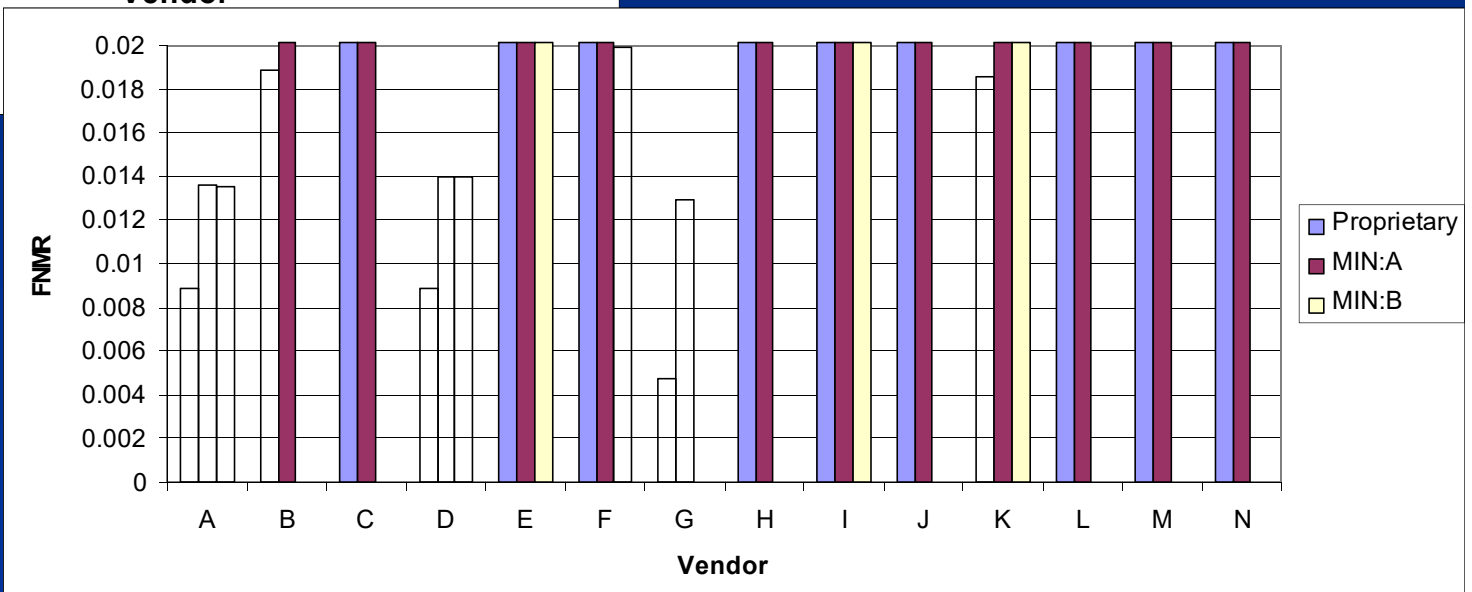
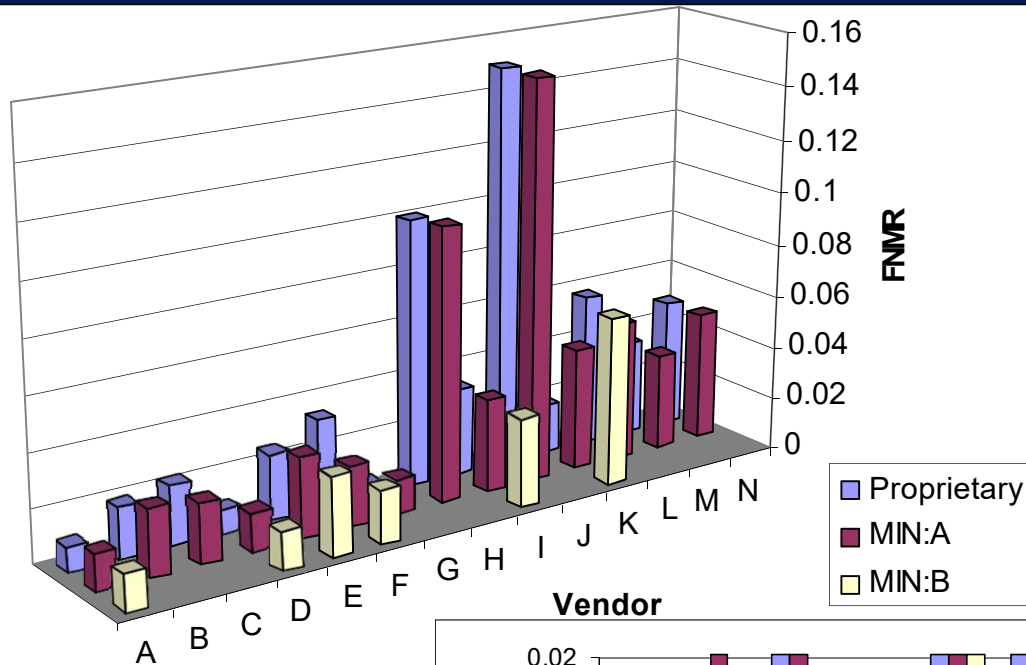
# Types of Tests

- Single- v. Two- Finger
- Proprietary v. Native
- Native v. Interoperable (Scenario 1)
- Scenarios 2,3,&4
- Four datasets of different quality

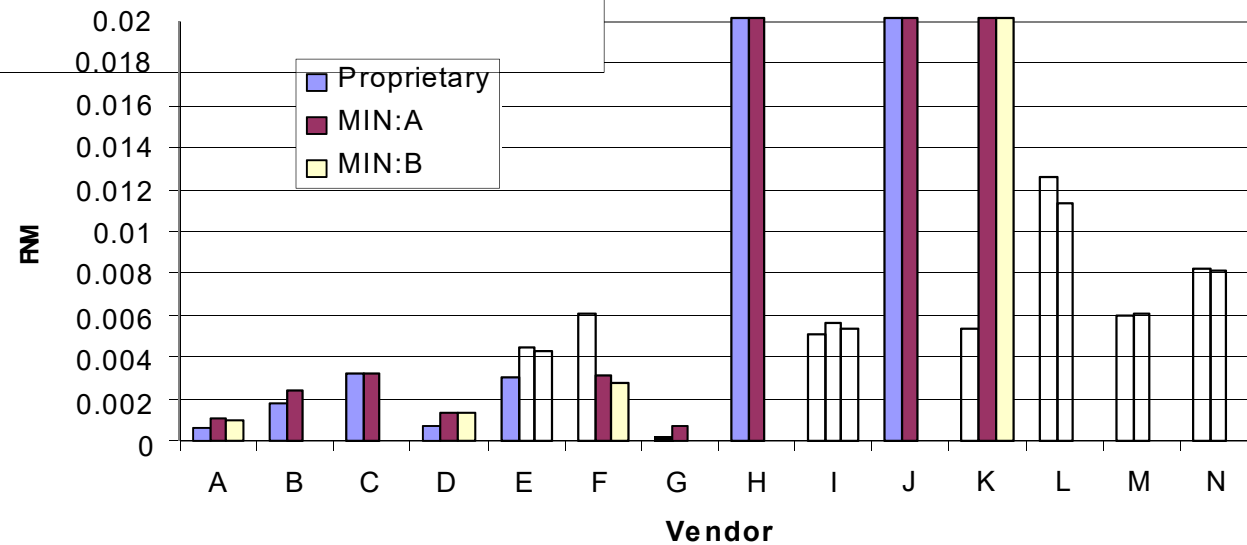
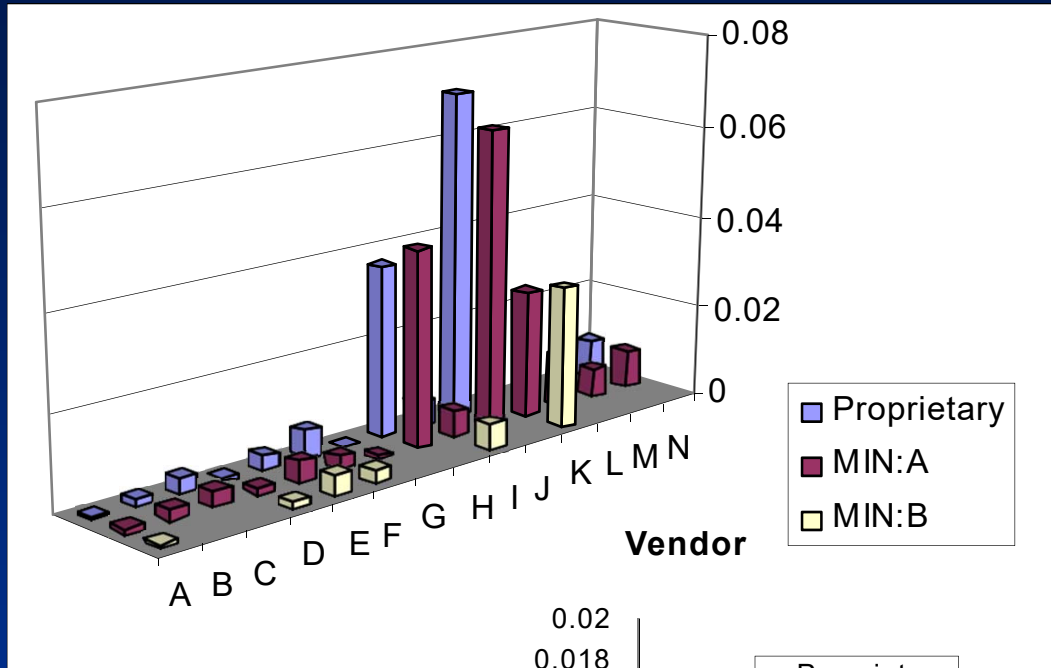
# Results 1

- The best proprietary templates are superior to the MIN:A & MIN:B templates in accuracy.
- The enhanced MIN:B template performed similarly to the basic MIN:A template.

# Proprietary and Native Performance for Single-Finger Test at FMR=0.01 for POEBVA data



# Proprietary and Native Performance for Two-Finger Test at FMR=0.01 for POEBVA data



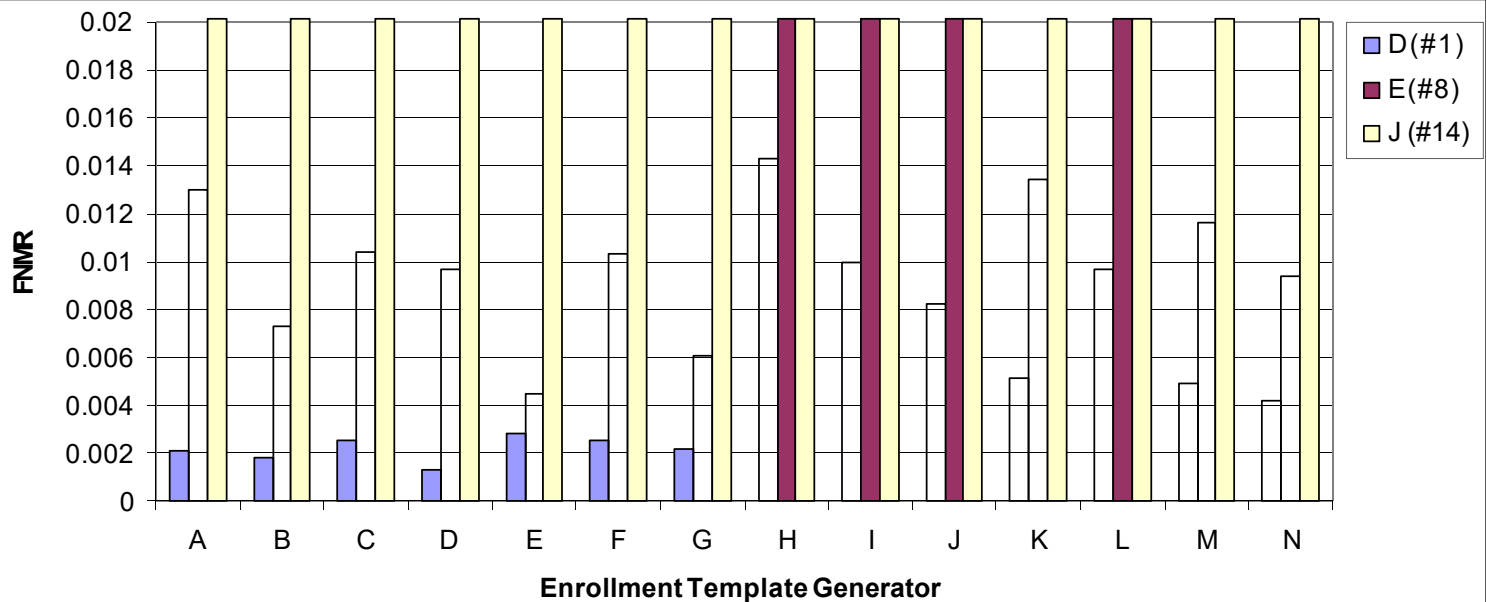
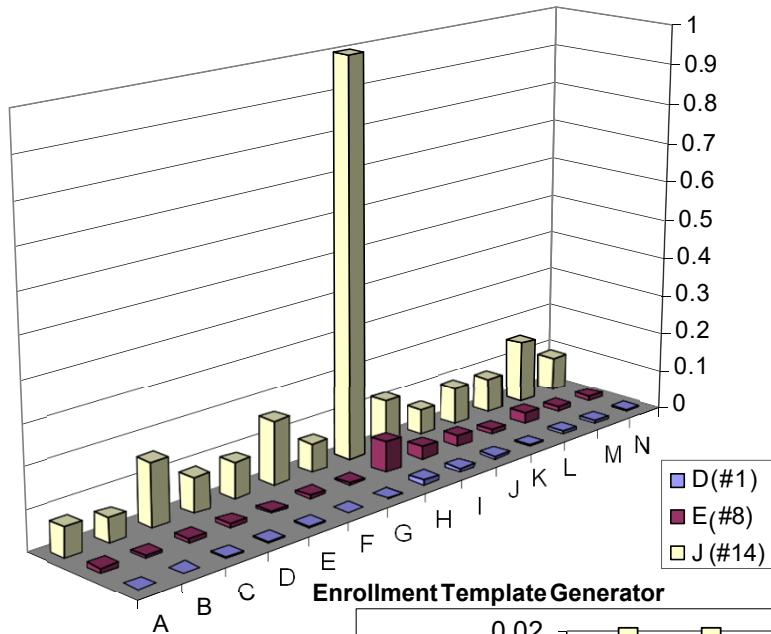
# Results 2

- As with most recent tests (by NIST and others), the error rates between matching algorithms vary by at least an order of magnitude.
- Two-finger authentication with standard templates can achieve the accuracy of single-finger authentication with proprietary templates.

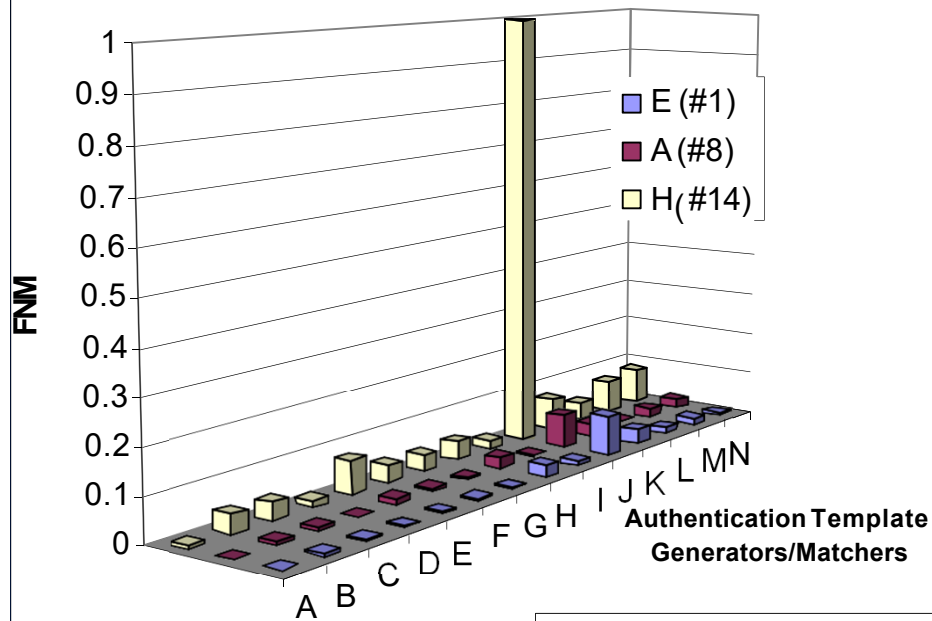
# Interoperability Example 1

## FNMRs @ FMR=0.01 for...

- Scenario 1, Two-Finger, POEBVA data
  - Vendors of Rank 1, 8, & 14 for authentication template generation/matching
- v.
- All enrollment template generators

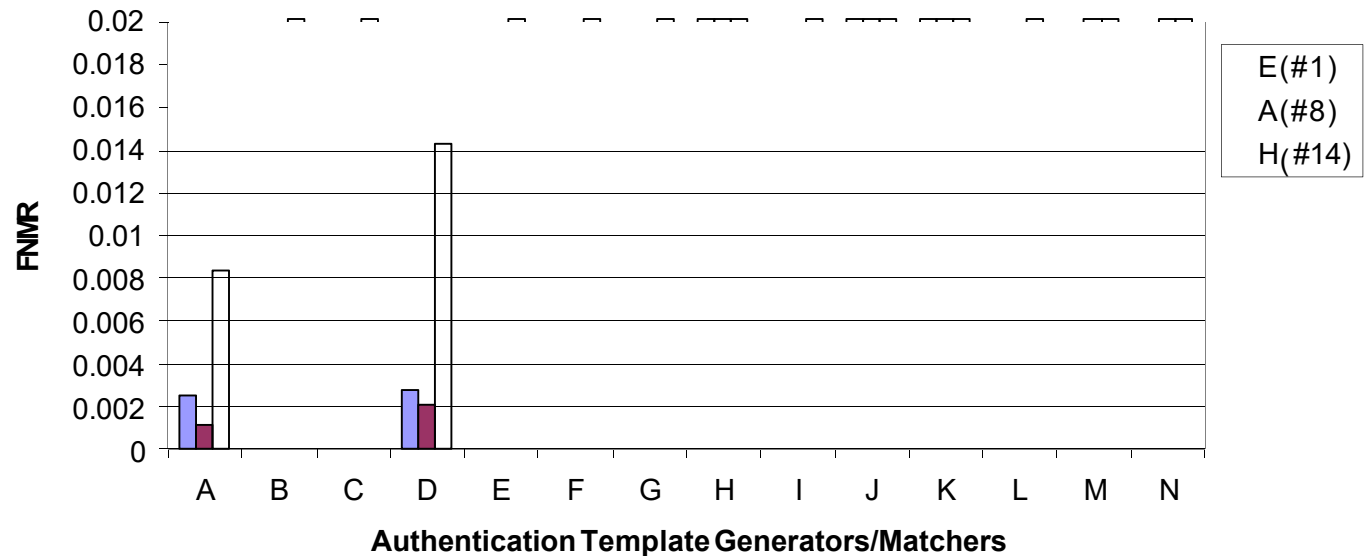


# Interoperability Example 2



## FNMRs @ FMR=0.01 for...

- Scenario 1, Two-Finger, POEBVA data
- Vendors of Rank 1, 8, & 14 for enrollment template generation v.
- All authentication template generators/matchers





# Results 3

- The leading vendors in template generation are not always the leaders in matching and vice-versa.
  - Some template generators produce standard templates that are matched more accurately than others. Some combination of templates fail completely.
  - Some matchers compare templates more accurately than others.

# Finding the Largest Interoperable Group



NF = 2	A	B	C	D	E	F	G	H	I	J	K	L	M	N	Mean	Rank	Med.	Rank
A	0.0011	0.0092	0.0080	0.0021	0.0130	0.0079	0.0049	0.0248	0.0049	0.0755	0.0292	0.0161	0.0213	0.0210	0.0171	4	0.0111	8
B	0.0027	0.0024	0.0072	0.0018	0.0073	0.0071	0.0017	0.0456	0.0049	0.0589	0.0588	0.0105	0.0083	0.0096	0.0162	1	0.0072	2
C	0.0052	0.0057	0.0032	0.0025	0.0104	0.0031	0.0039	0.0851	0.0081	0.1571	0.1048	0.0177	0.0099	0.0133	0.0307	8	0.0090	6
D	0.0021	0.0046	0.0045	0.0013	0.0097	0.0044	0.0035	0.0325	0.0062	0.0877	0.0442	0.0154	0.0126	0.0103	0.0171	5	0.0080	4
E	0.0025	0.0061	0.0056	0.0028	0.0045	0.0054	0.0035	0.0280	0.0102	0.0900	0.0362	0.0163	0.0147	0.0053	0.0165	2	0.0059	1
F	0.0054	0.0060	0.0032	0.0025	0.0103	0.0031	0.0038	0.0855	0.0081	0.1597	0.1058	0.0177	0.0097	0.0131	0.0310	9	0.0089	5
G	0.0040	0.0032	0.0085	0.0022	0.0061	0.0085	0.0007	0.0308	0.0068	0.0715	0.0693	0.0116	0.0074	0.0084	0.0171	3	0.0079	3
H	0.0084	0.0421	0.0393	0.0143	0.0767	0.0395	0.0384	0.0422	0.0210	0.9999	0.0724	0.0413	0.0753	0.0831	0.1139	14	0.0417	14
I	0.0073	0.0184	0.0252	0.0100	0.0333	0.0249	0.0083	0.1137	0.0056	0.1206	0.1170	0.0207	0.0313	0.0415	0.0413	12	0.0250	12
J	0.0077	0.0119	0.0259	0.0082	0.0276	0.0257	0.0070	0.1572	0.0103	0.0640	0.5736	0.0198	0.0296	0.0297	0.0713	13	0.0258	13
K	0.0018	0.0130	0.0108	0.0051	0.0134	0.0109	0.0049	0.0280	0.0068	0.0929	0.0275	0.0270	0.0313	0.0234	0.0212	7	0.0132	10
L	0.0115	0.0109	0.0218	0.0097	0.0258	0.0213	0.0066	0.0795	0.0105	0.0861	0.1123	0.0113	0.0267	0.0254	0.0328	10	0.0216	11
M	0.0099	0.0096	0.0106	0.0049	0.0116	0.0108	0.0039	0.1007	0.0134	0.1573	0.1929	0.0247	0.0061	0.0211	0.0413	11	0.0112	9
N	0.0063	0.0077	0.0086	0.0042	0.0094	0.0087	0.0056	0.0368	0.0104	0.0862	0.0353	0.0169	0.0157	0.0081	0.0186	6	0.0090	7
Mean	0.0054	0.0108	0.0130	0.0051	0.0185	0.0129	0.0069	0.0636	0.0091	0.1648	0.1128	0.0191	0.0214	0.0224				
Rank	2	5	7	1	8	6	3	12	4	14	13	9	10	11				
Med.	0.0053	0.0084	0.0086	0.0035	0.0110	0.0086	0.0044	0.0439	0.0081	0.0889	0.0709	0.0173	0.0152	0.0171				
Rank	3	5	6	1	8	7	2	12	4	14	13	11	9	10				

*FNMRs at FMR=0.01  
for Scenario 1, Two-Finger, POEBVA data*

# Finding the Largest Interoperable Group

NF = 2	A	B	C	D	E	F	G	H	I	J	K	L	M	N	Mean	Rank	Med.	Rank
A	0.0011	0.0092	0.0080	0.0021	0.0130	0.0079	0.0049	0.0248	0.0049	0.0755	0.0292	0.0161	0.0213	0.0210	0.0171	4	0.0111	8
B	0.0027	0.0024	0.0072	0.0018	0.0073	0.0071	0.0017	0.0456	0.0049	0.0589	0.0588	0.0105	0.0083	0.0096	0.0162	1	0.0072	2
C	0.0052	0.0057	0.0032	0.0025	0.0104	0.0031	0.0039	0.0851	0.0081	0.1571	0.1048	0.0177	0.0099	0.0133	0.0307	8	0.0090	6
D	0.0021	0.0046	0.0045	0.0013	0.0097	0.0044	0.0035	0.0325	0.0062	0.0877	0.0442	0.0154	0.0126	0.0103	0.0171	5	0.0080	4
E	0.0025	0.0061	0.0056	0.0028	0.0045	0.0054	0.0035	0.0280	0.0102	0.0900	0.0362	0.0163	0.0147	0.0053	0.0165	2	0.0059	1
F	0.0054	0.0060	0.0032	0.0025	0.0103	0.0031	0.0038	0.0855	0.0081	0.1597	0.1058	0.0177	0.0097	0.0131	0.0310	9	0.0089	5
G	0.0040	0.0032	0.0085	0.0022	0.0061	0.0085	0.0007	0.0308	0.0068	0.0715	0.0693	0.0116	0.0074	0.0084	0.0171	3	0.0079	3
H	0.0084	0.0421	0.0393	0.0143	0.0767	0.0395	0.0384	0.0422	0.0210	0.9999	0.0724	0.0413	0.0753	0.0831	0.1139	14	0.0417	14
I	0.0073	0.0184	0.0252	0.0100	0.0333	0.0249	0.0083	0.1137	0.0056	0.1206	0.1170	0.0207	0.0313	0.0415	0.0413	12	0.0250	12
J	0.0077	0.0119	0.0259	0.0082	0.0276	0.0257	0.0070	0.1572	0.0103	0.0640	0.5736	0.0198	0.0296	0.0297	0.0713	13	0.0258	13
K	0.0018	0.0130	0.0108	0.0051	0.0134	0.0109	0.0049	0.0280	0.0068	0.0929	0.0275	0.0270	0.0313	0.0234	0.0212	7	0.0132	10
L	0.0115	0.0109	0.0218	0.0097	0.0258	0.0213	0.0066	0.0795	0.0105	0.0861	0.1123	0.0113	0.0267	0.0254	0.0328	10	0.0216	11
M	0.0099	0.0096	0.0106	0.0049	0.0116	0.0108	0.0039	0.1007	0.0134	0.1573	0.1929	0.0247	0.0061	0.0211	0.0413	11	0.0112	9
N	0.0063	0.0077	0.0086	0.0042	0.0094	0.0087	0.0056	0.0368	0.0104	0.0862	0.0353	0.0169	0.0157	0.0081	0.0186	6	0.0090	7
Mean	0.0054	0.0108	0.0130	0.0051	0.0185	0.0129	0.0069	0.0636	0.0091	0.1648	0.1128	0.0191	0.0214	0.0224				
Rank	2	5	7	1	8	6	3	12	4	14	13	9	10	11				
Med.	0.0053	0.0084	0.0086	0.0035	0.0110	0.0086	0.0044	0.0439	0.0081	0.0889	0.0709	0.0173	0.0152	0.0171				
Rank	3	5	6	1	8	7	2	12	4	14	13	11	9	10				

*FNMRs at FMR=0.01  
for Scenario 1, Two-Finger, POEBVA data*

# Finding the Largest Interoperable Group

NF = 2	A	B	C	D	E	F	G	H	I	J	K	L	M	N	Mean	Rank	Med.	Rank
A															0.0171	4	0.0111	8
B															0.0162	1	0.0072	2
C															0.007	8	0.0090	6
D															0.007	5	0.0080	4
E															0.007	2	0.0059	1
F															0.007	3	0.0089	5
G															0.007	3	0.0079	3
H															0.007	3	0.0079	3
I															0.007	3	0.0079	3
J															0.007	3	0.0079	3
K															0.007	3	0.0079	3
L															0.007	3	0.0079	3
M															0.007	3	0.0079	3
N															0.007	3	0.0079	3
Mean																		
Rank																		
Med.															0.0053			
Rank															3			

	C	E
B	0.0072	0.0073
F	0.0032	0.0103
N	0.0086	0.0094

*FNMRs at FMR=0.01  
for Scenario 1, Two-Finger, POEBVA data*

# Largest Group for 2-Finger POEBVA s.t. the max FNMR ≤ 0.01 @ FMR = 0.01

NF = 2	A	B	C	D	E	F	G	H	I	J	K	L	M	N	Mean	Rank	Med.	Rank
A	0.0011	0.0092	0.0080	0.0021	0.0130	0.0079	0.0049	0.0248	0.0049	0.0755	0.0292	0.0161	0.0213	0.0219	0.0171	4	0.0111	8
B	0.0027	0.0024	0.0072	0.0018	0.0073	0.0071	0.0017	0.0456	0.0049	0.0589	0.0588	0.0105	0.0083	0.0079	0.0162	1	0.0072	2
C	0.0052	0.0057	0.0032	0.0025	0.0104	0.0031	0.0039	0.0851	0.0081	0.1571	0.1048	0.0177	0.0099	0.0133	0.0307	8	0.0090	6
D	0.0021	0.0046	0.0045	0.0013	0.0097	0.0044	0.0035	0.0325	0.0062	0.0877	0.0442	0.0154	0.0126	0.0103	0.0171	5	0.0080	4
E	0.0025	0.0061	0.0056	0.0028	0.0045	0.0054	0.0035	0.0280	0.0102	0.0900	0.0362	0.0163	0.0147	0.0053	0.0165	2	0.0059	1
F	0.0054	0.0060	0.0032	0.0025	0.0103	0.0031	0.0038	0.0855	0.0081	0.1597	0.1058	0.0177	0.0097	0.0131	0.0310	9	0.0089	5
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I	0.0073	0.0184	0.0252	0.0100	0.0333	0.0249	0.0083	0.1137	0.0056	0.1206	0.1170	0.0207	0.0373	0.0415	0.0413	12	0.0250	12
J	0.0077	0.0119	0.0259	0.0082	0.0276	0.0257	0.0070	0.1572	0.0103	0.0640	0.5736	0.0198	0.0296	0.0297	0.0713	13	0.0258	13
K	0.0018	0.0130	0.0108	0.0051	0.0134	0.0109	0.0049	0.0280	0.0068	0.0929	0.0275	0.0270	0.0313	0.0234	0.0212	7	0.0132	10
L	0.0115	0.0109	0.0218	0.0097	0.0258	0.0213	0.0066	0.0795	0.0105	0.0861	0.1123	0.0113	0.0267	0.0254	0.0328	10	0.0216	11
M	0.0099	0.0096	0.0106	0.0049	0.0116	0.0108	0.0039	0.1007	0.0134	0.1573	0.1929	0.0247	0.0067	0.0211	0.0413	11	0.0112	9
N	0.0063	0.0077	0.0086	0.0042	0.0094	0.0087	0.0056	0.0368	0.0104	0.0862	0.0353	0.0169	0.0157	0.0081	0.0186	6	0.0090	7
Mean	0.0054	0.0108	0.0130	0.0051	0.0185	0.0129	0.0069	0.0636	0.0091	0.1648	0.1128	0.0197	0.0214	0.0224				
Rank	2	5	7	1	8	6	3	12	4	14	13	9	10	11				
Med.	0.0053	0.0084	0.0086	0.0035	0.0110	0.0086	0.0044	0.0439	0.0081	0.0889	0.0709	0.0173	0.0152	0.0171				
Rank	3	3	6	1	8	7	2	12	4	14	13	11	9	10				

	A	B	C	D	F	G
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C	0.0052	0.0057	0.0032	0.0025	0.0031	0.0039
D	0.0021	0.0046	0.0045	0.0013	0.0044	0.0035
E	0.0025	0.0061	0.0056	0.0028	0.0054	0.0035
F	0.0054	0.0060	0.0032	0.0025	0.0031	0.0038
G	0.0040	0.0032	0.0085	0.0022	0.0085	0.0007
N	0.0063	0.0077	0.0086	0.0042	0.0087	0.0056

# Interoperable Template Generators and Matchers

<u>Dataset</u>	<u>Criterion</u> (s.t. FNMR $\leq$ 0.01 @ FMR=0.01)	<u>Value of Criterion</u>	<u>Temp. Gen's</u>	<u>#</u>	<u>Temp. Matchers</u>	<u>#</u>
POEBVA	group max	0.0087	A,B,C, D,E,F, G,N	8	A,B,C,D,F,G	6
POEBVA	group mean	0.0094	A,B,C, D,E,F, G,K,L, M,N	11	A,B,C,D,E,F, G,I,L,M,N	11
DHS2	group max	0.0081	B,D,N	3	A,D	2
DHS2	group mean	0.0095	B,D,K N	4	A,C,D,F,G	5

# Results 4

- Certification of an interoperable group of products requires some prior specification of the required accuracy.
  - More products will interoperate when the accuracy requirement is low and vice versa.
  - More products can be certified if the group's mean error rate is below a threshold than if their worst interoperable pair is used for certification.

# Results 5

- Performance is sensitive to the quality of the dataset.
  - Applies to both proprietary and interoperable templates.
  - Two higher quality datasets (POEBVA and POE) provide reasonable interoperability. Two lower quality datasets (DOS and DHS2) do not.



# For more information

- See the report online

<http://fingerprint.nist.gov/minex04/>

- Contact

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# Proprietary and Native Performance

