How to manipulate standards

Daniel J. Bernstein
Verizon Communications Inc.

Verizon is a global leader delivering innovative communications and technology solutions that improve the way our customers live, work and play.

Our core mission:

Delivering information

from point A to point B.

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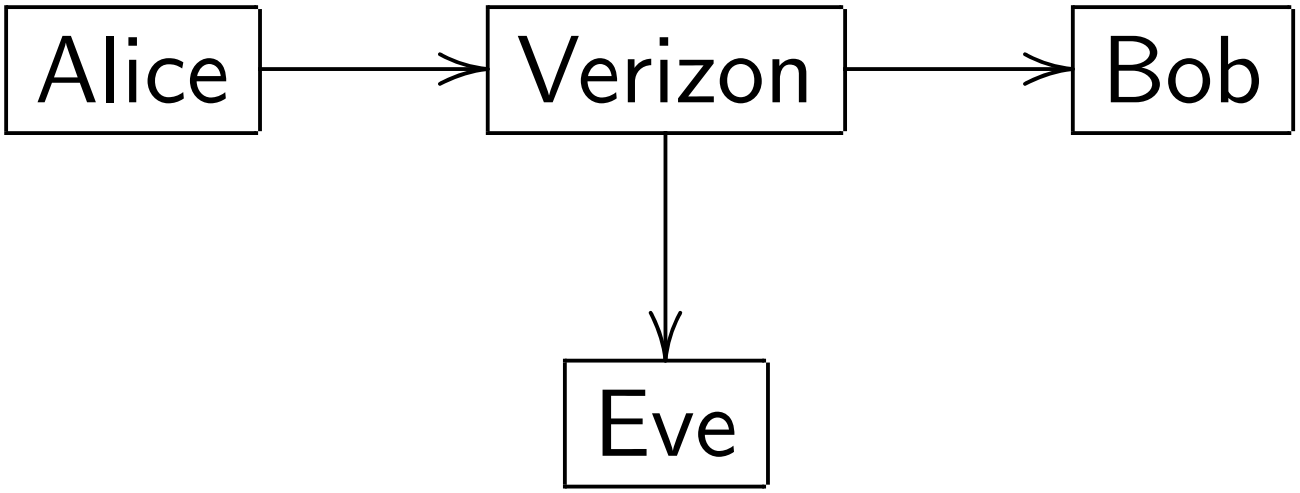

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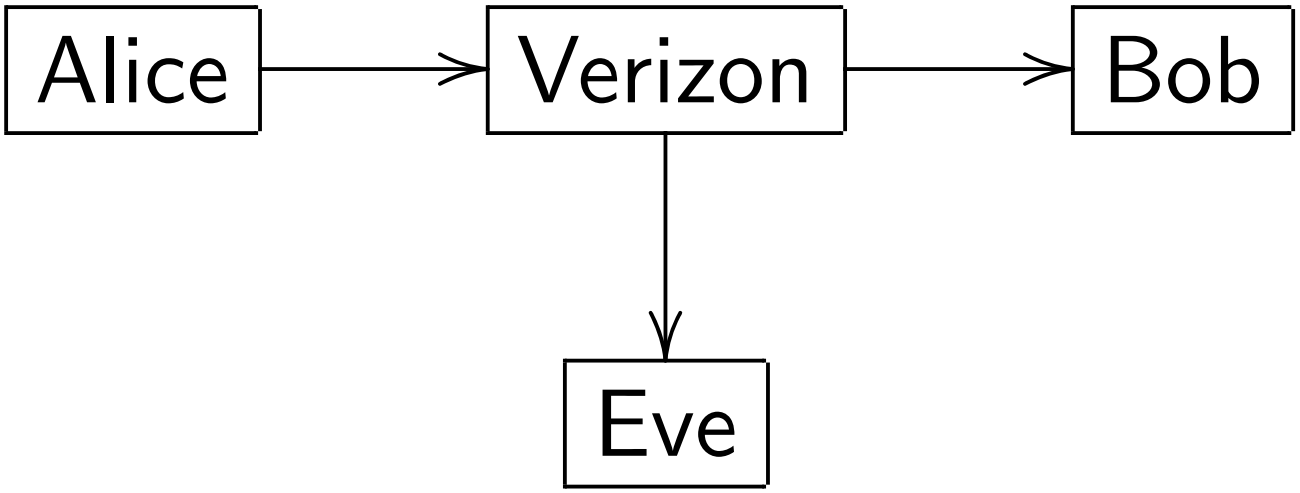

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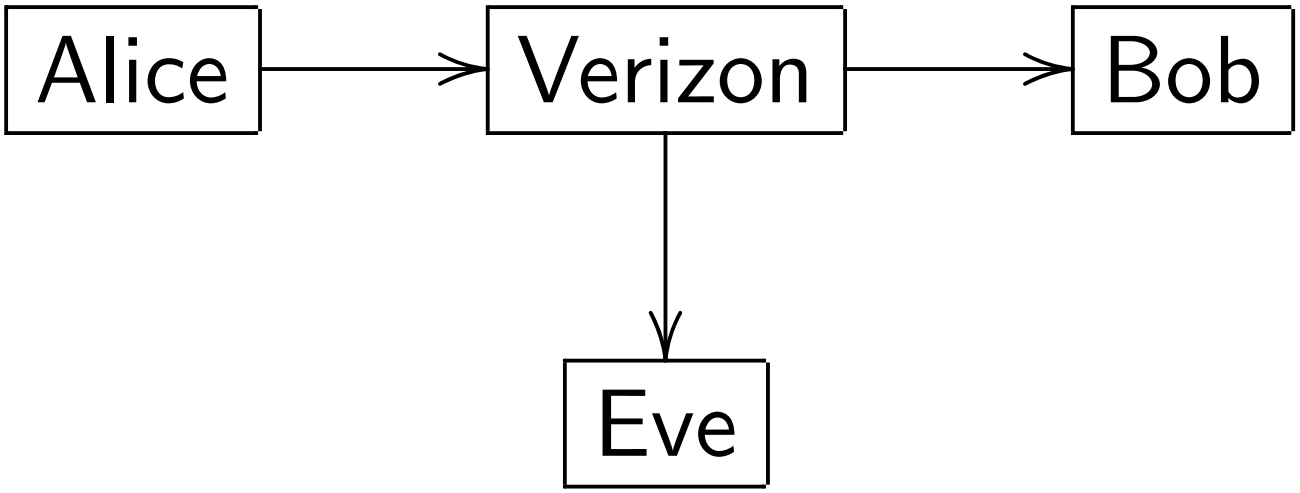

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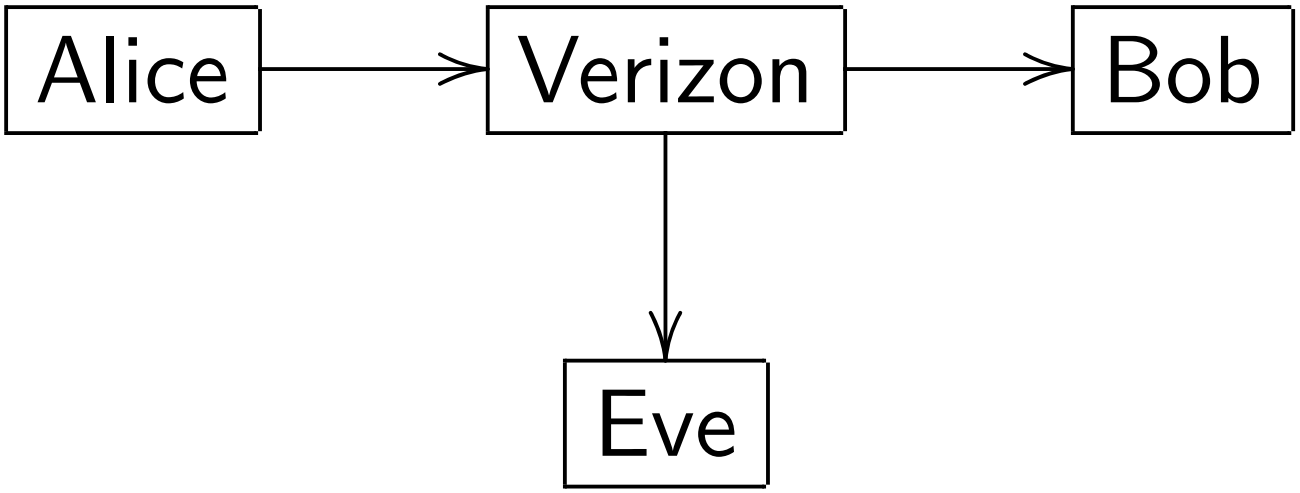

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“We never stop working for you.”

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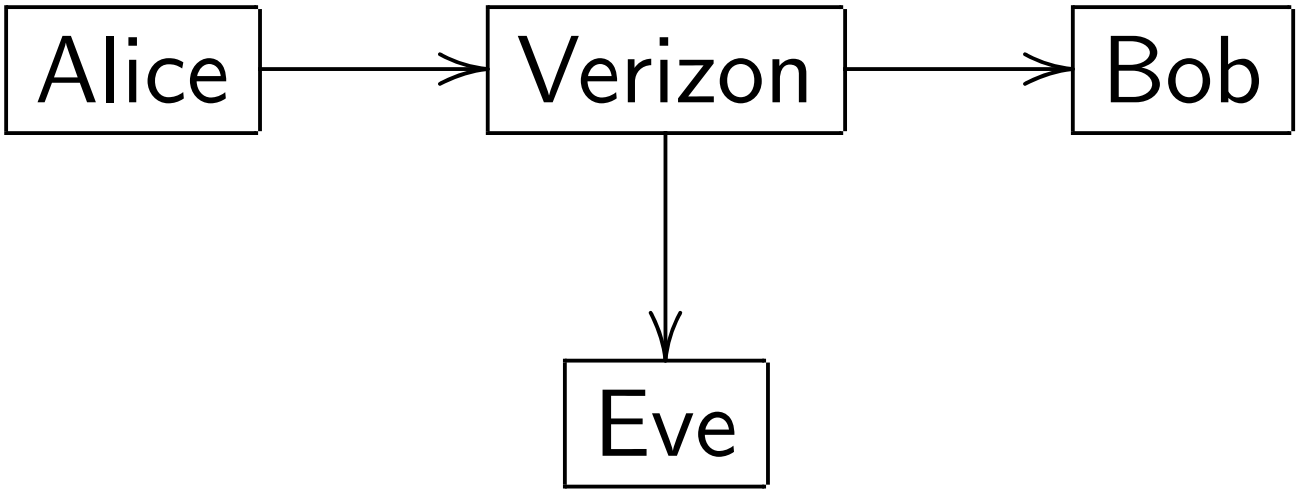

"Can you hear me now? Good."
"Can they hear you now? Good."
"We never stop working for you."
"Rule the air."

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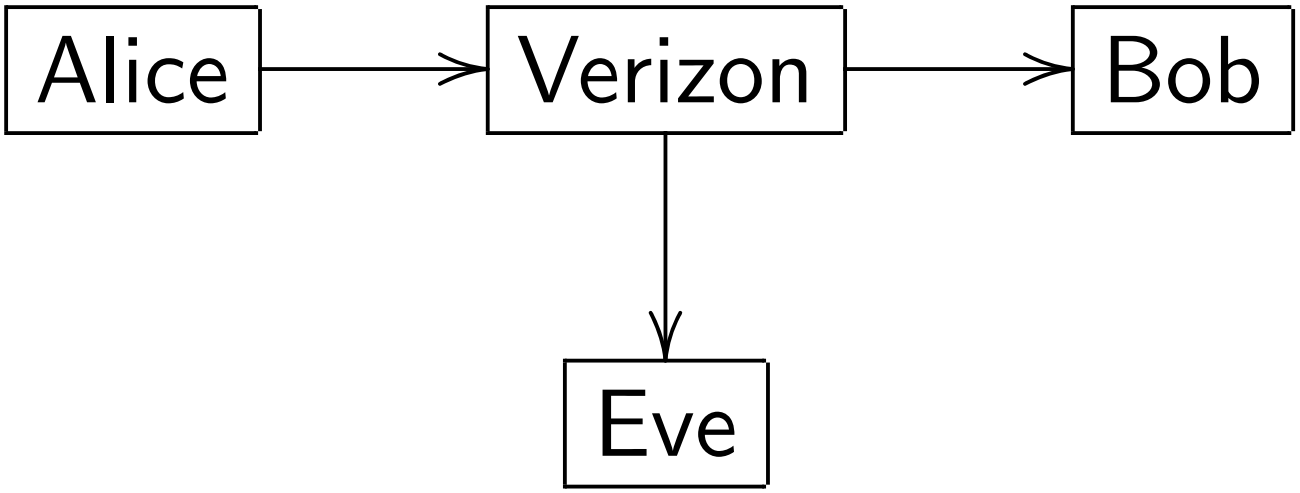

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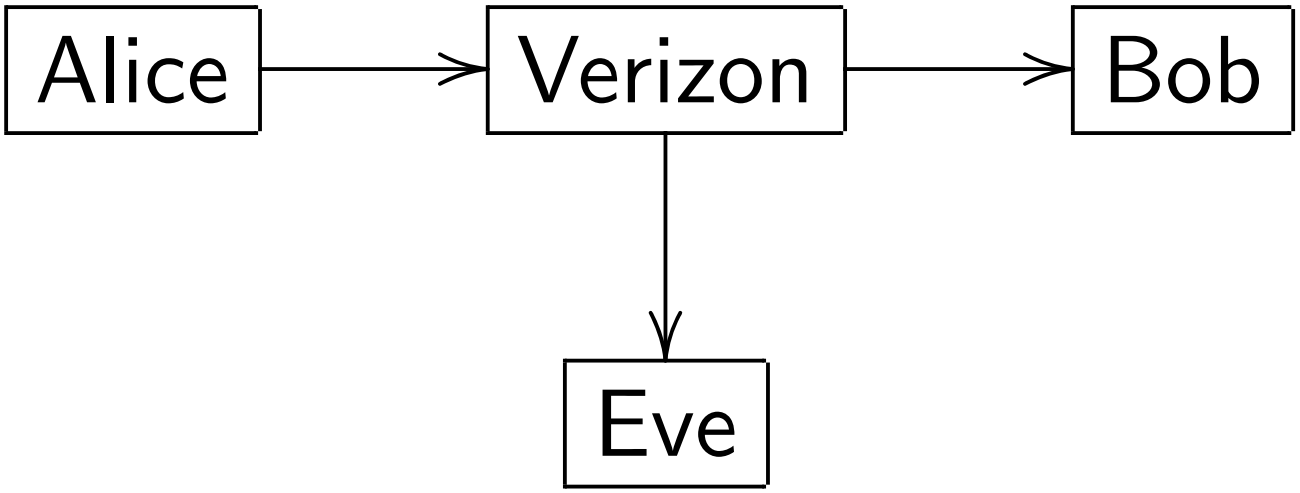

"Can you hear me now? Good."
"Can they hear you now? Good."
"We never stop working for you."
"Rule the air."
"Never settle."
"I am the man in the middle."

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"Precision Market Insights, Verizon's data marketing arm . . . will now sell its tool to advertisers for mobile ad campaigns that target Verizon's massive subscriber base based on demographics, interests and geography."

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rely on **your browser**
to send data to Eve.

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“Libert has discovered that the vast majority of health sites, from the for-profit WebMD.com to the government-run CDC.gov, are loaded with tracking elements that are sending records of your health inquiries to the likes of web giants like Google, Facebook, and Pinterest, and data brokers like Experian and Acxiom.”

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You **give us** your data.

We **redirect it** to Eve.

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"In an effort to better serve advertisers, Verizon Wireless has been silently modifying its users' web traffic on its network to inject a cookie-like tracker. This tracker, included in an HTTP header called X-UIDH, is sent to every unencrypted website a Verizon customer visits from a mobile device."

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"Verizon has partnerships with marketing data providers like Experian Marketing Services and Oracle's BlueKai to enable anonymous matches between the Precision ID identifier and third-party data. Although there's deterministic linkage back to the hashed ID, Verizon's data partners are not able to collect or save the data profiles." ... "Rather than a universal ID, I think there will probably be really rich algorithms that can tie multiple IDs together into a rationalized campaign."

Political backlash?

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"Experian, the massive data-broker with far-reaching influence over your ability to get a mortgage, credit-card, or job, sold extensive consumer records to an identity thieves' service."

Solution: **Talk about** privacy.

No need to **protect** privacy.

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"Verizon said it is not using or selling its first-party subscriber data, but rather deploying partnerships with third-party data providers to target Verizon's massive consumer base."

"We will never sacrifice our core business and our commitment to privacy because there's an additional dollar to be made by pumping data out into the ecosystem."

Technical backlash?

Increasing problem for us:

Crypto.

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Technical backlash?

Increasing problem for us: **Crypto**. This "breaks network management, content distribution and network services"; creates "congestion" and "latency"; "limits the ability of network providers to protect customers from web attacks"; breaks "UIDH (unique client identifier) insertion" and "data collection for analytics"; breaks "value-add services that are based on access to header and payload content from individual sessions"; etc.

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"Opportunistic encryption"

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Almost as good for us:

Signatures on some data.

We can still see everything.

Can also censor quite selectively.

Can't modify signed data but

can track in many other ways.

More troublesome: End-to-end authenticated encryption.
But we still see metadata—adequate for most surveillance.

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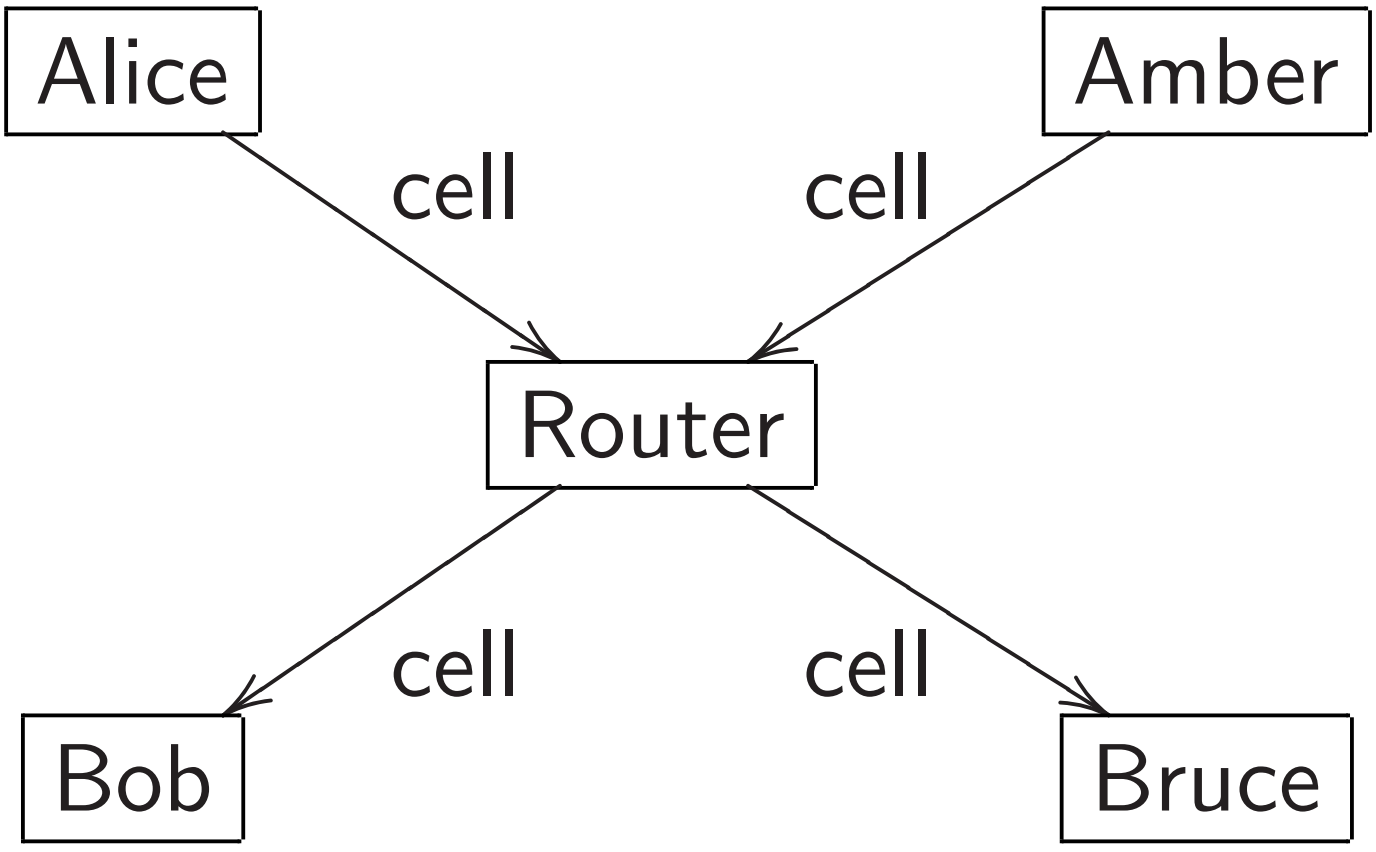
Nightmare scenario: Scrambling unidentifiable encrypted cells—Tor has multiple layers of this:



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We've started working with
experts in crypto sabotage.

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Make crypto protocols
so complicated that
nobody will get them right.
Standards committees rarely
fight against complications.

Sabotaging crypto details

How to
manipulate curve standards:
a white paper for the black hat

Daniel J. Bernstein
Tung Chou
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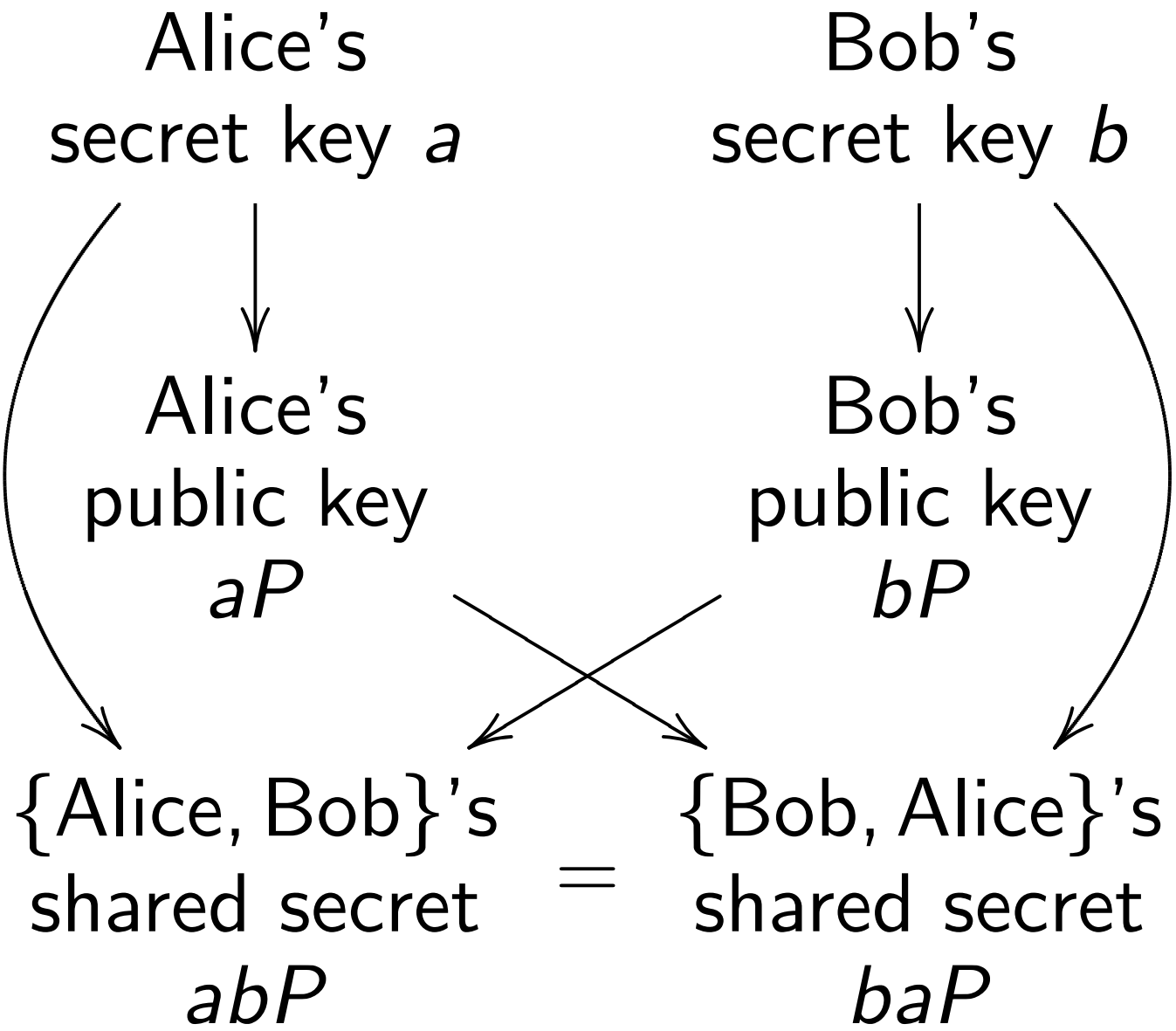
Andreas Hülsing
Tanja Lange
Ruben Niederhagen
Christine van Vredendaal

safecurves.cr.yp.to
/bada55.html

Textbook key exchange
using standard point P
on a standard elliptic curve E:



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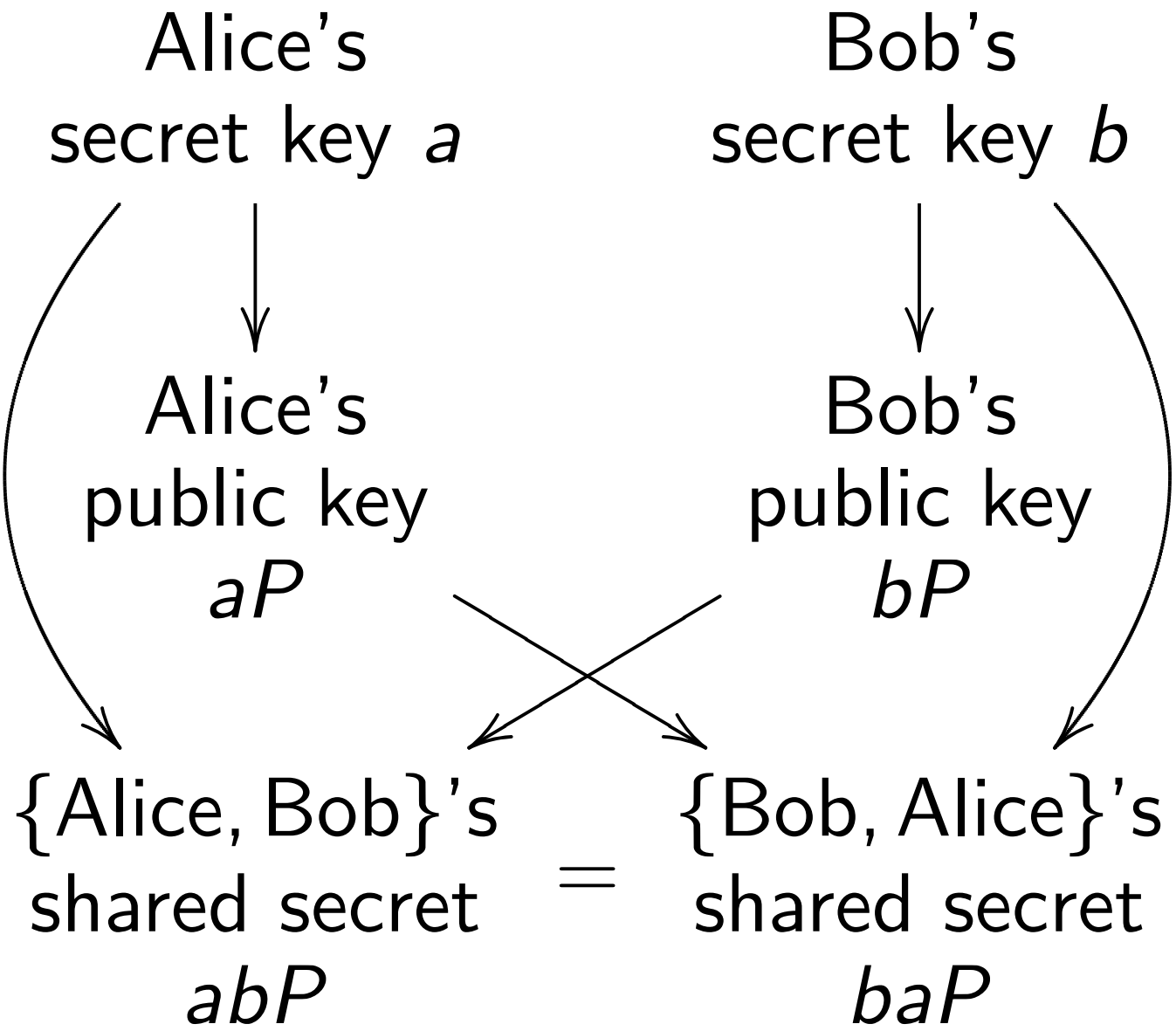
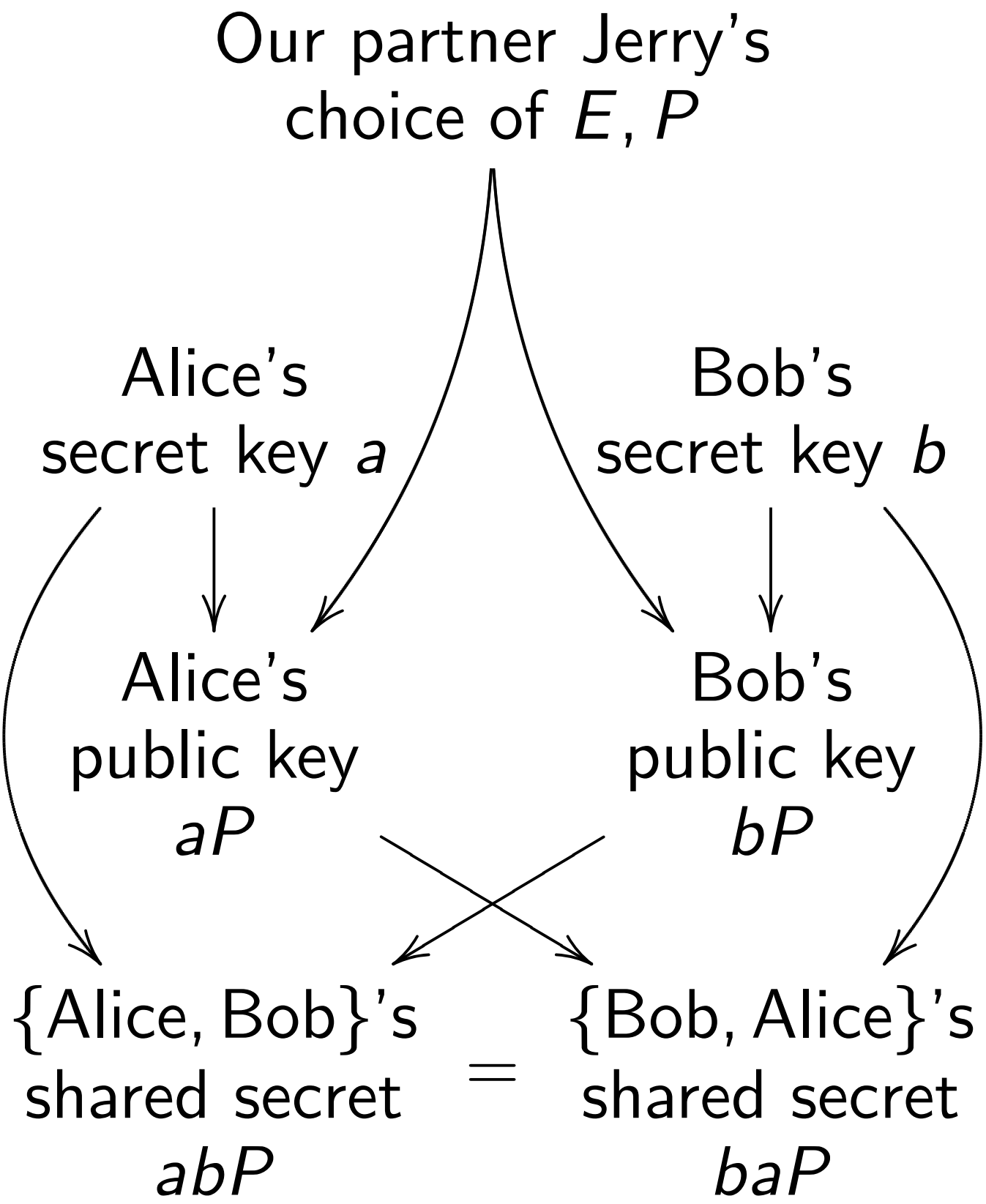


Security depends on choice of E.


Our partner Jerry's
choice of E, P
Alice's
secret key a
Bob's
secret key b
Alice's
public key
aP
Bob's
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bP
{Alice, Bob}'s
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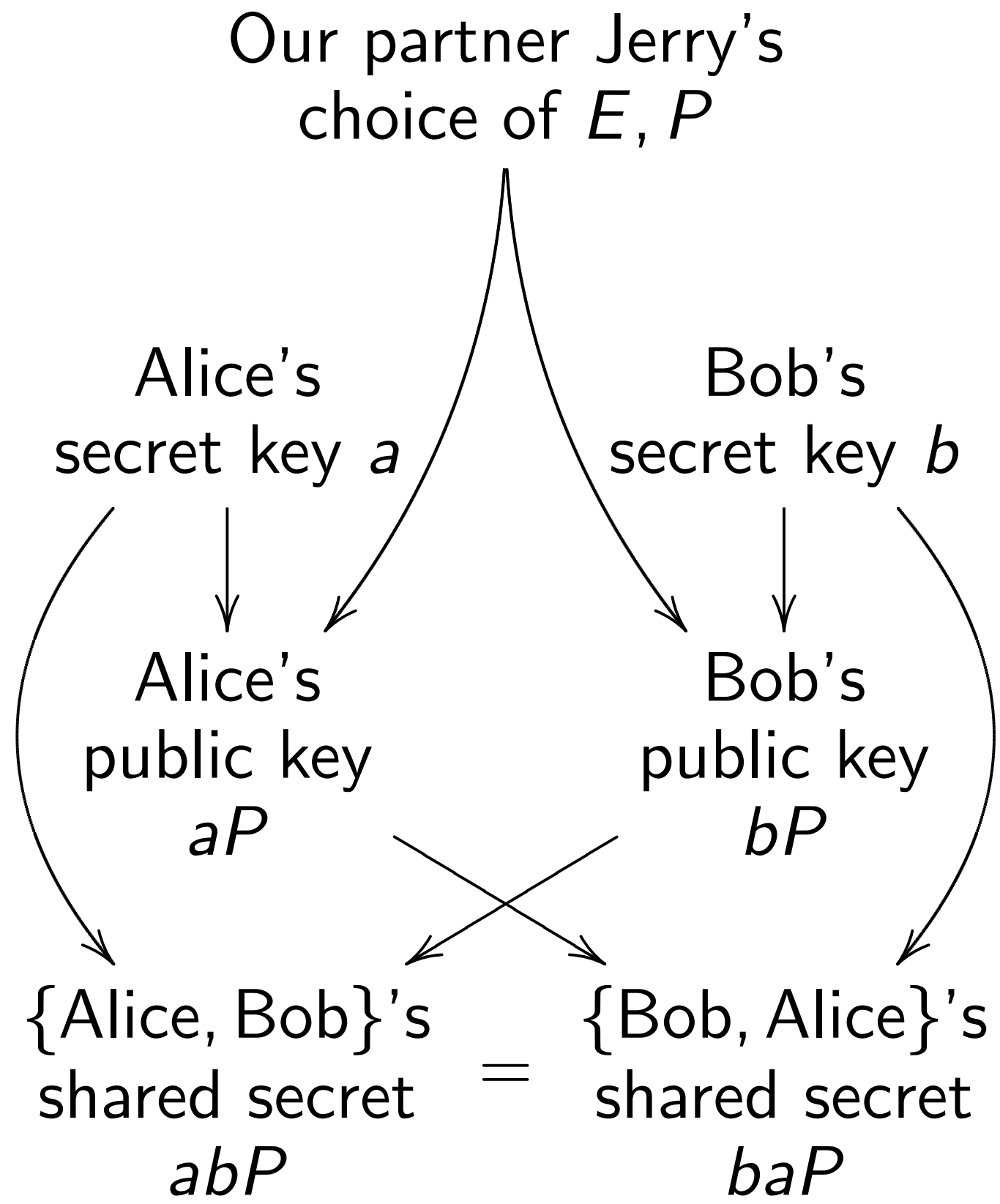

Can we exploit this picture?

Depends on public criteria
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Extensive ECC literature:
Pollard rho breaks small E,
Pohlig–Hellman breaks most E,
MOV/FR breaks some E,
SmartASS breaks some E, etc.

Assume that public will accept
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Jerry standardizes this curve.
Alice and Bob use it.

Is first assumption plausible?

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Earlier example:
Chinese OSCCA SM2 (2010).

Maybe public is more demanding outside France and China:
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Examples: ANSI X9.62 (1999) "selecting an elliptic curve verifiably at random"; Certicom SEC 2 1.0 (2000) "verifiably random parameters offer some additional conservative features"—"parameters cannot be predetermined"; NIST FIPS 186-2 (2000); ANSI X9.63 (2001); Certicom SEC 2 2.0 (2010).

What exactly is H?

NIST defines curve E as $y^2 = x^3 - 3x + b$ where $b^2c = -27$; c is a hash of s; hash is SHA-1 concatenation.

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Examples: Brainpool (2005)
uses $c = g^3/h^2$ where
g and h are separate hashes.
NIST FIPS 186-4 (2013) requires
an "approved hash function, as
specified in FIPS 180";
no longer allows SHA-1!

1999 Scott: "Consider now the possibility that one in a million of all curves have an exploitable structure that 'they' know about, but we don't. Then 'they' simply generate a million random seeds until they find one that generates one of 'their' curves. Then they get us to use them."

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New: Optimized this computation using Keccak on cluster of 41 GTX780 GPUs. In 7 hours found "secure+twist-secure" $b = \texttt{0x}$ BADA55ECD8BBEAD3ADD6C534F92197DE B47FCEB9BE7E0E702A8D1DD56B5D0B0C.

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Brainpool standard:
"The choice of the seeds
from which the [NIST] curve
parameters have been derived is
not motivated leaving an essential
part of the security analysis
open. . . .
Verifiably pseudo-random.
The [Brainpool] curves shall be
generated in a pseudo-random
manner using seeds that are
generated in a systematic and
comprehensive way."

Wikipedia: "In cryptography, **nothing up my sleeve numbers** are any numbers which, by their construction, are above suspicion of hidden properties."

Microsoft "NUMS" curves (2014): "generated deterministically from the security level".

Albertini–Aumasson–Eichlseder–Mendel–Schläffer "Malicious hashing" (2014): "constants in hash functions are normally expected to be identifiable as nothing-up-your-sleeve numbers".

New: We generated a BADA55 curve "BADA55-VPR-224" with a Brainpool-like explanation.

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Example of underlying flexibility: Brainpool generates seeds from exp(1) and primes from arctan(1); MD5 generates constants from sin(1); BADA55-VPR-224 generated a seed from cos(1).

Many jobs available!