FIRST STEPS TOWARDS GENERALIZABLE INTERNET-SCALE OBJECT-SECURITY: SECURE MESSAGING FOR TODAY AND TOMORROW

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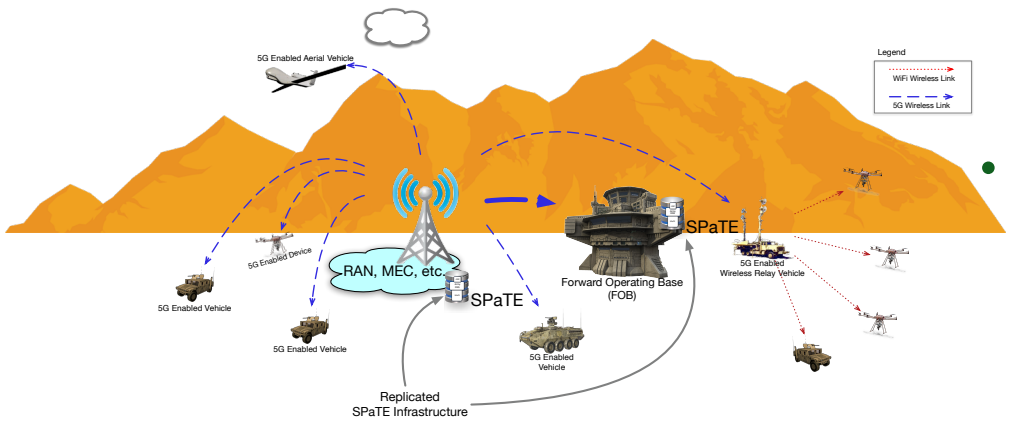
CYBERSECURITY HAS LONG BEEN *MISSING* A CRITICAL TOOL

- Should we protect data in flight, at rest, or both?
  - Shouldn't, actions be taken based on data, not (just) who transmits it?
- Can independent devices/entities auth. and encr. their ***messages*** to each other with 0-trust?
  - Say, a fire engine to a municipal traffic signal, and that signal to my POV Tesla?



- We have transport-layer protections, but they do not protect data
  - Shouldn't the ***messages*** be protected too/instead?
- <u>That</u> is ***object-security***, and it is different (and maybe more powerful) than transport-security

WHAT IS "OBJECT-SECURITY?"

- Well, first, what is a digital "object," on the Internet?
  - It could be 
    an image a file a message an email sensor reading …
- The security/privacy we need for objects is different
  - "Objects" exist/persist "at rest," i.e. beyond "in flight"
  - Example: I create a document, send it over WhatsApp to a friend, and then email it to a colleague
  - If the WhatsApp msg is encrypted, does that protect the doc at rest on my computer, or over email?
- But, the Internet doesn't have a de facto way to do that today (i.e., an architecture)
  - Why can't we encrypt/authenticate objects to anyone, except through WhatsApp, Signal, etc.?

WHAT IS "OBJECT-SECURITY?"

- In this talk, we propose that *we already have* tomorrow's object-security foundation
  - It's in the Internet's core, and it's time to build on it!

The DNS-based Authentication of Named Entities (DANE)

- It's an Internet-scale object-security **foundation**
- It will unlock protections for mHealth, V2X, Smart Cities, and more

THE FOUNDATION MUST SUIT ITS PURPOSE

- To know what Internet-scale object-security ***needs to be***, we need to *evaluate* ***why*** object-security isn't pervasive yet
- So, "why?" We've had mature crypto protections for ***years***: S/MIME, PGP, etc.

What we already know:
our protections have been stymied by a simple limitation:
Our software can't securely (inter-admin) learn the crypto keys

What we ***still*** need to know:
what are the *fundamental* needs + obstacles;
to be sure foundation will bear the Internet's weight

ARCHITECTURE FOR INTERNET OBJECT-SECURITY

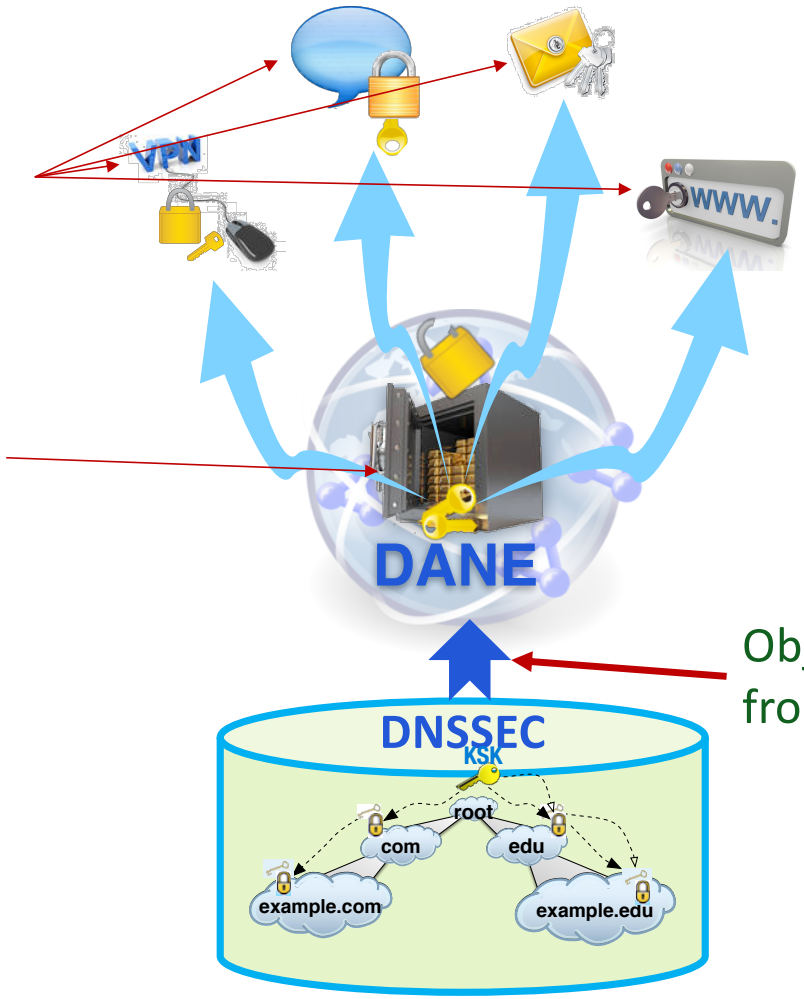
- Examples like IoT, mHealth, V2X, etc. show increasingly repeated requirements:
  - Inter-organizational (e.g., entity at University A to entity at company B)
  - Per-entity (e.g., device, user, etc.) E2E crypto at Internet-scale
  - Usable tools
  - Automation

- DNSSEC+DANE: Internet-scale and ideally suited to these requirements
- The Domain Name System's Security Extensions (DNSSEC)
  - 16+ years, ~10^7 global zones, inter-org loosely-federated, etc.
- DNS-based Authentication of Named Entities (DANE)
  - General object-security, ~10 years, per-entity crypto, etc.

"CORE TO TABLE" CYBERSECURITY: RESOURCE CERTIFICATION

Same objects secure **in** and ***between*** apps!

Secure objects **at rest**!



Object-security extends from the Internet's core

INTRODUCING KURER AND DANEPORTAL.NET!

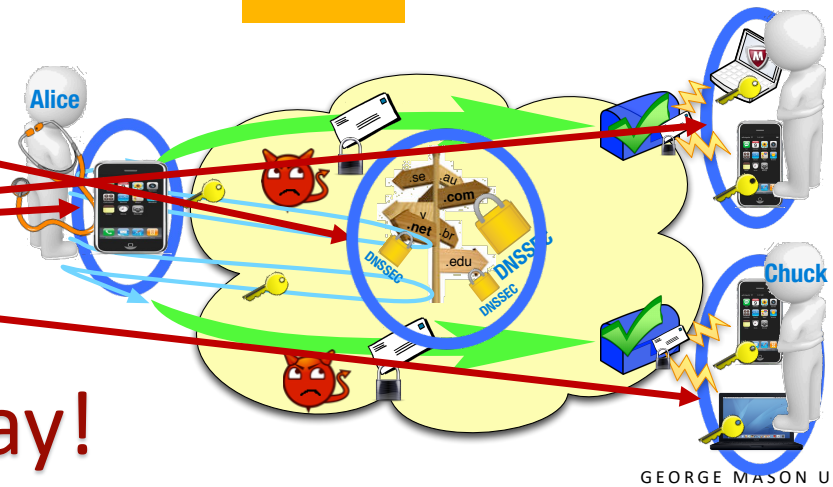
- To do that, we have built a ***live*** experimental apparatus: secure email

- Securing email will vault cybersecurity forward + prove the utility of the underlying architecture
  - An email add-on called **Kurer** and a management portal at **DANEportal.net**
  - Object format for the Internet (using **PKCS7**)!

- Will let us *evaluate* the *fundamental* needs of Internet-scale security and privacy of *digital objects*
  - e.g., messages, files, etc.

INTERNET-SCALE OBJECT SECURITY REQUIREMENTS

- Recall our fundamental requirements (messaging platform, aside):
  - Inter-organization key learning — S/MIME with DANE
  - Per-user crypto key enrollment — DANEportal.net
  - Human-usable tools for e2e protections — Kurer MUA plugins
  - Framework to enable security-automation — NEXT UP — Entity-Security / "invisible security"
- DANEportal.net
  - Management of users' DANE keys
- Kurer
  - User-side DANE software



Tools you can use, today!

WHAT ARE DANEPORTAL.NET AND KURER?

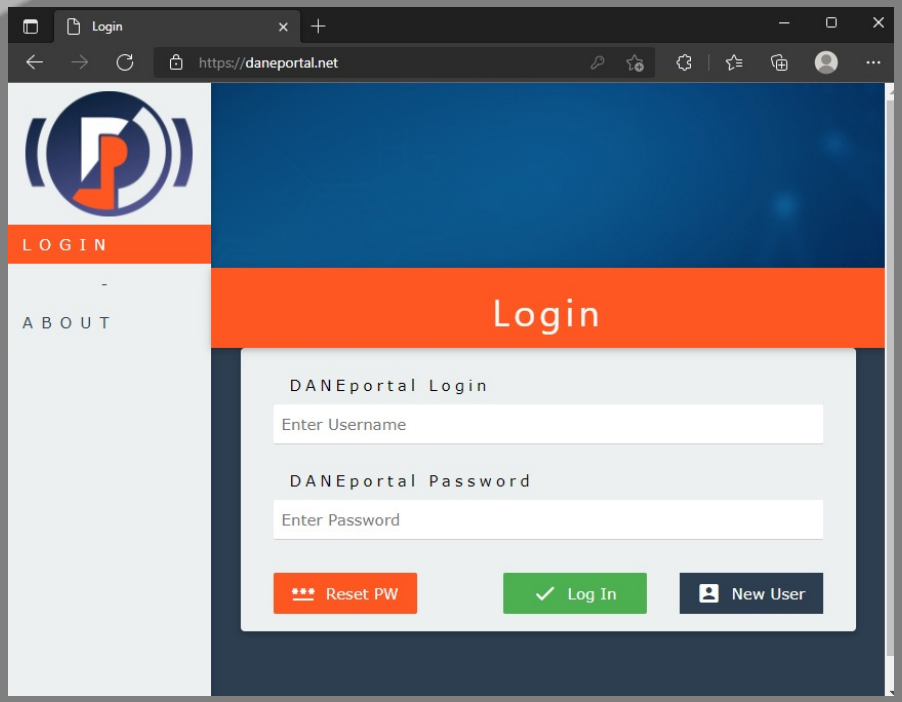
- DANEportal.net is where email users from any domain ("identity holders") can securely make their crypto keys *learnable*
  - Domain holders securely claim their zone (using ACME protocol)
  - DANE is managed for them
  - Email users, under a domain, create accounts and manage their own key life-cycles

https://daneportal.net/

- Kurer is an add-on/plugin for Mail User Agents (MUAs, Outlook and Thunderbird)
  - Email users install Kurer
  - Configure their crypto keys
  - And go secure… To anyone, anywhere, anytime
- Observation: secure email builds from core Internet security up to users
  - Ideally positioned to extended further… more later

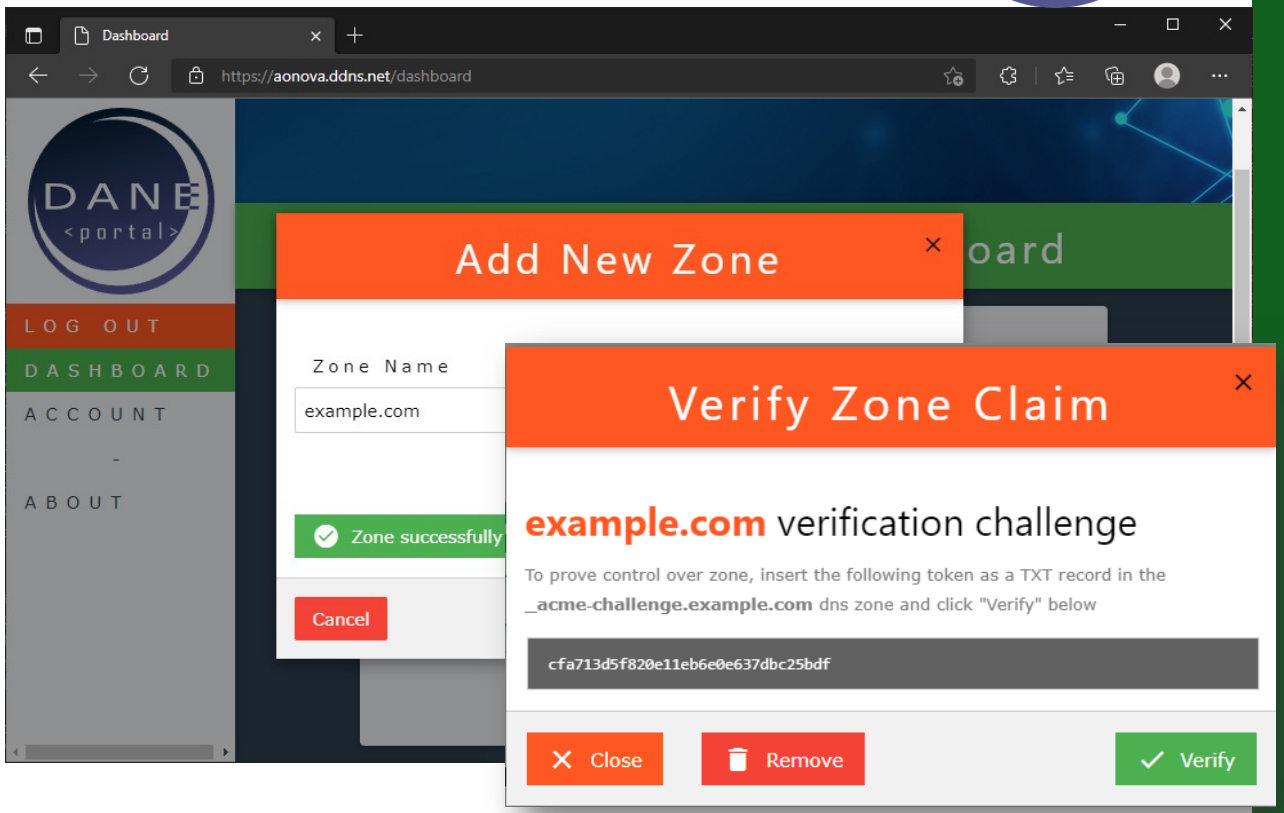
HTTPS://DANEPORTAL.NET/

OVERVIEW, FULL GUIDE AVAILABLE ONLINE…



ADD YOUR OWN ZONE

- Create a portal user account
- Add your zone
- Claim your zone using ACME protocol to verify proof of administration



DELEGATE FROM YOUR ZONE TO DANEPORTAL

- Add NS and DS to your zone using your zone management tools
  - Zone cut at "_smimecert"

Zone

https://daneportal.net/zone?id=182

aonova.net - s/mime zone

status - **Active**

delegation records

Serve these records with your delegating name server to close the loop

ns record

```
_smimecert.aonova.net. IN NS dane-dns.care.gmu.edu.
```

ds record

```
_smimecert.aonova.net. IN DS 27730 13 2 F51CB0967533B6916C1A3A4EE1E916A3A560B8EC5AC5E3987239E1B729C82A06
```

template

Baseline record served for the DANE zone

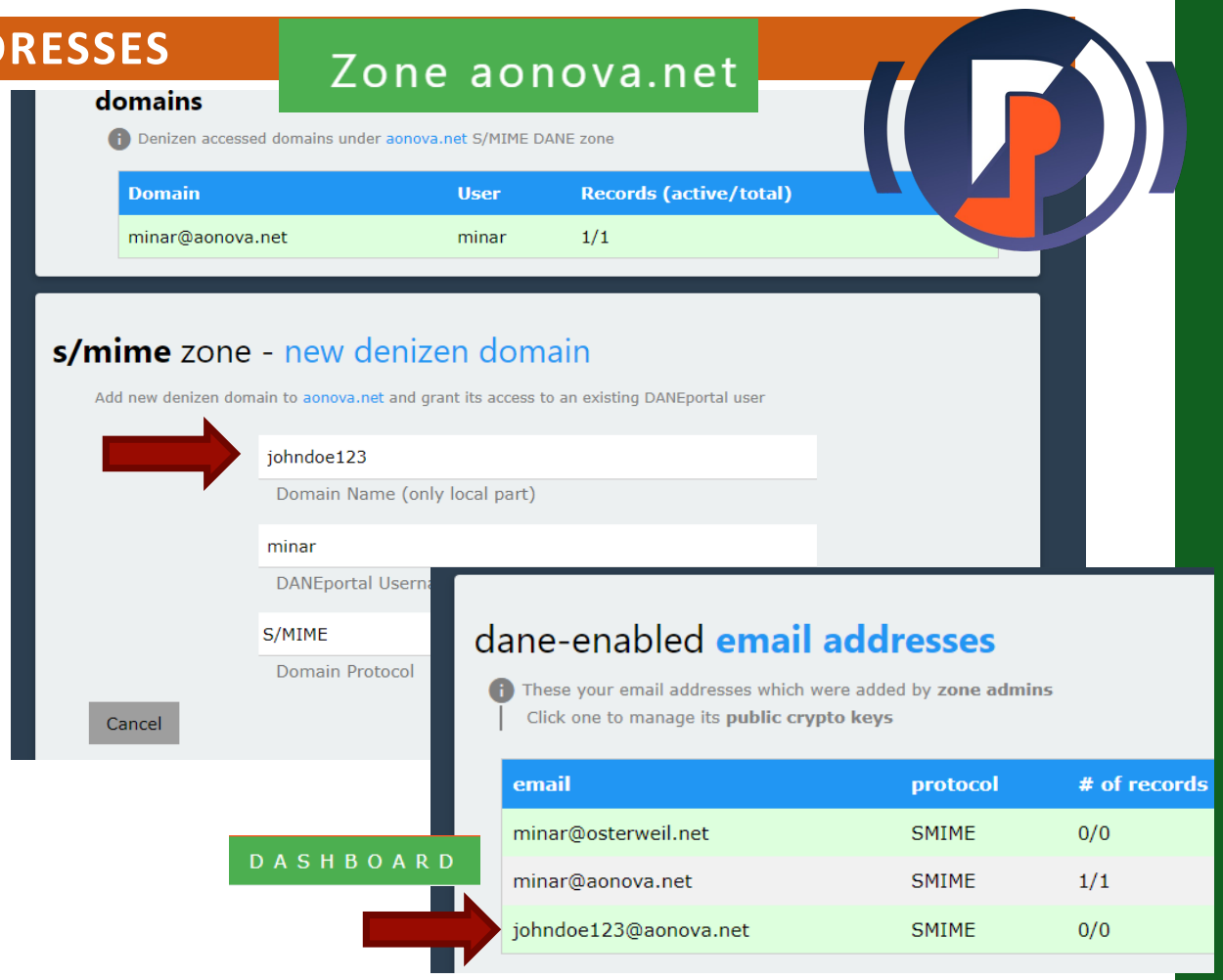
```
$ORIGIN _smimecert.aonova.net.
$TTL 3600
@ IN SOA dane-dns.care.gmu.edu. mail.daneportal.ddns.net. ( 2022040400 7200 3600 1209600 3600 )
@ IN NS dane-dns.care.gmu.edu.
```

Host name	Type	TTL	Data
_smimecert.aonova.net	DS	1 hour	27730 13 2 f51cb0967533b6916c1a3a4ee1e916a3a560b8ec5ac5e3987239e1b729c82a06
_smimecert.aonova.net	NS	1 hour	dane-dns.care.gmu.edu.

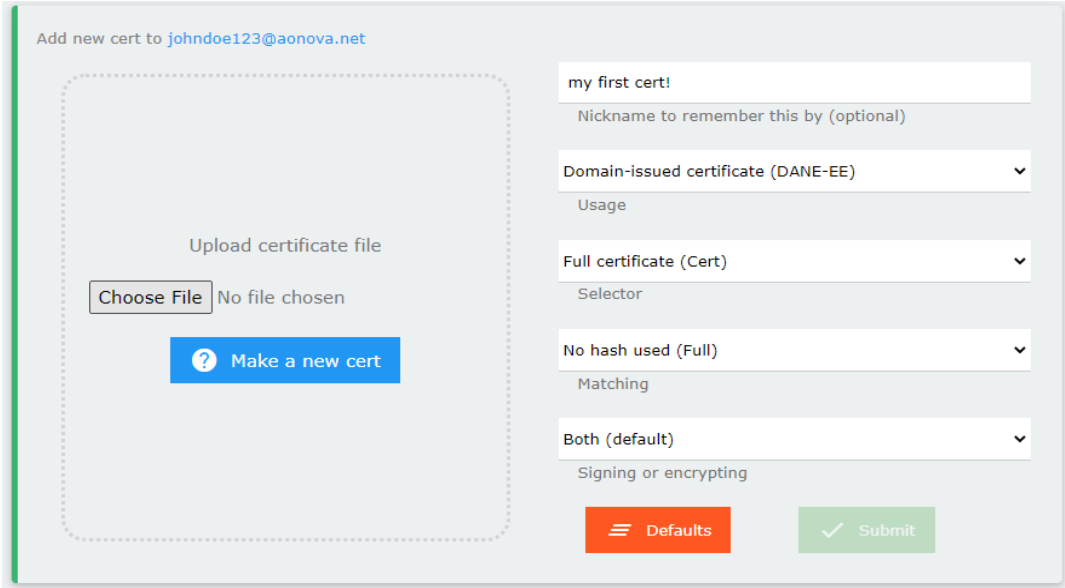
Google Domains

NOW, ADD USERS' EMAIL ADDRESSES

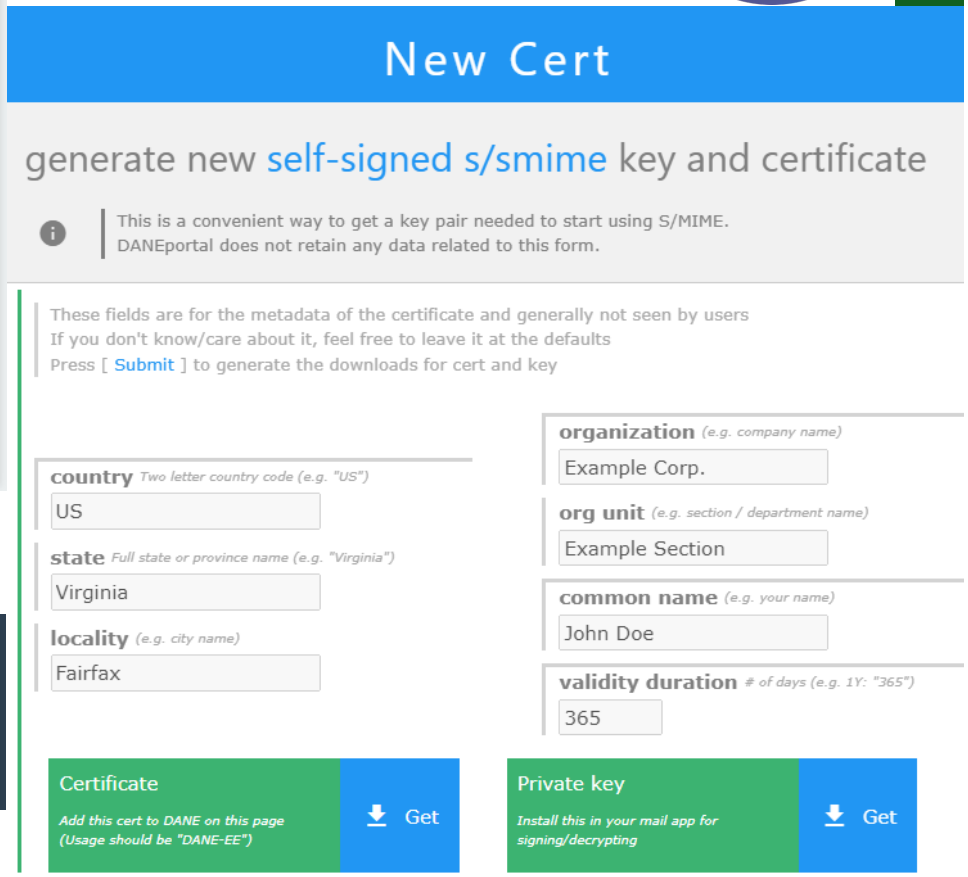
- Users create DANEportal accounts
- Zone admins authorize portal users as "**denizens**"
  - **i.e.,** email addresses under a zone
- **Denizens** are your **email users**
  - Users add S/MIME records to **your** DANE zone
  - Admins do **not** lose any control



EMAIL USERS CAN CREATE/MANAGE THEIR OWN CERTIFICATES

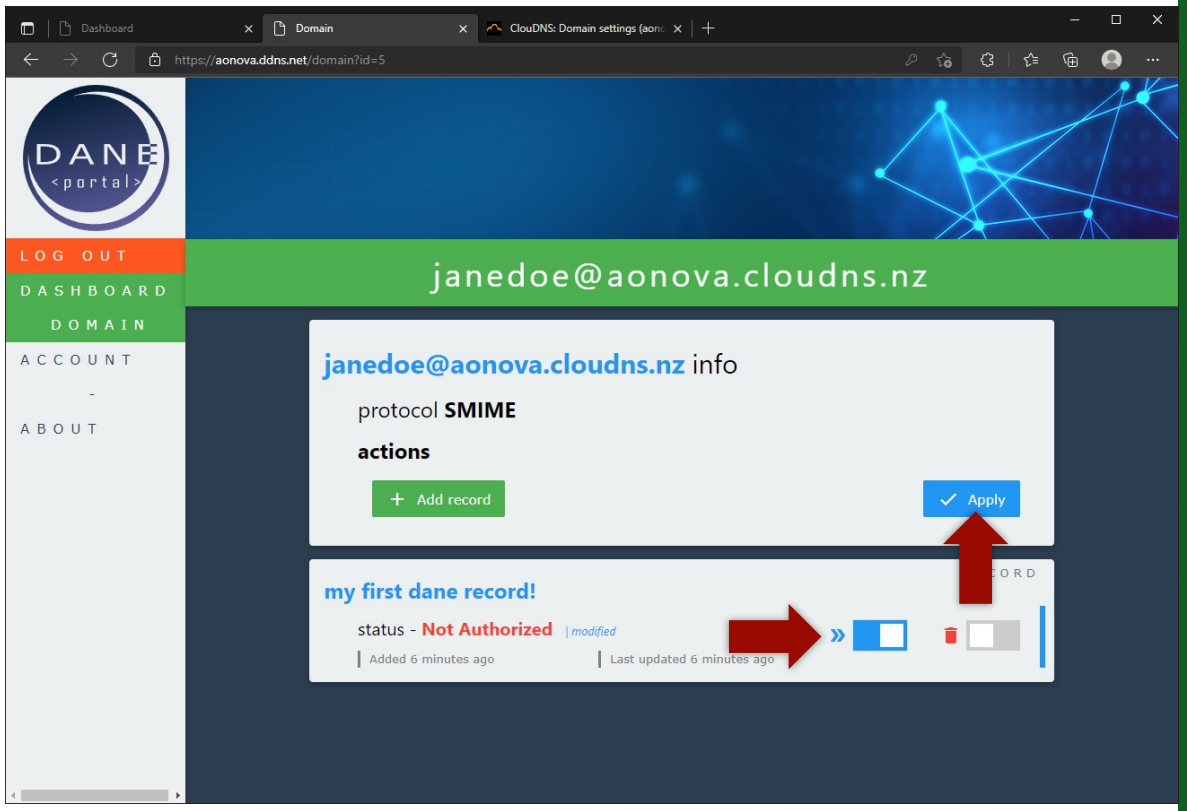


- For now, toggle the **authorize** switch to the right and click



NOW, ADD EMAIL ADDRESSES/USERS

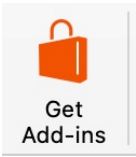
- Manage records by toggling its authorization state or deleting it permanently
- DANE allows “de-authorization” of keys
  - Not revocation, and faster
- For now, toggle the **authorize** switch to the right and click [Apply]

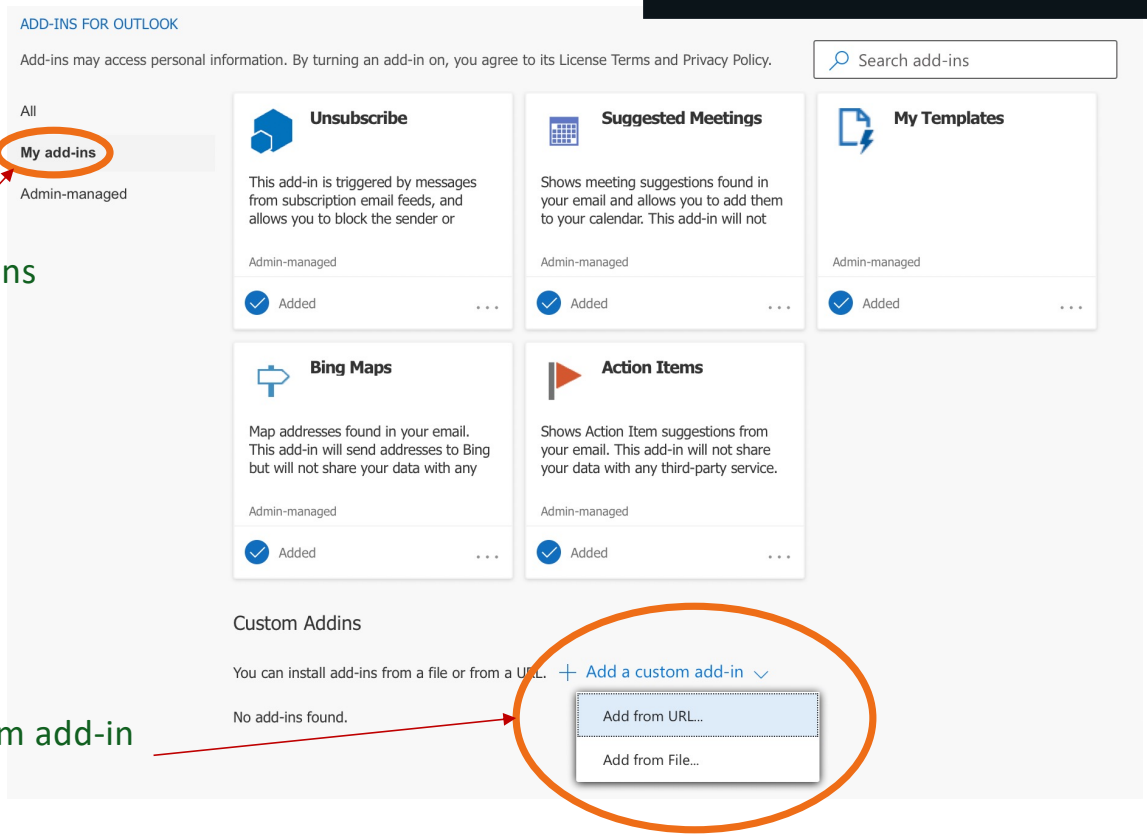


KURER: SECURE EMAIL FOR EVERYONE!

GETTING KURER ON OUTLOOK IS A SNAP!

Full install directions: https://kurer.daneportal.net/install



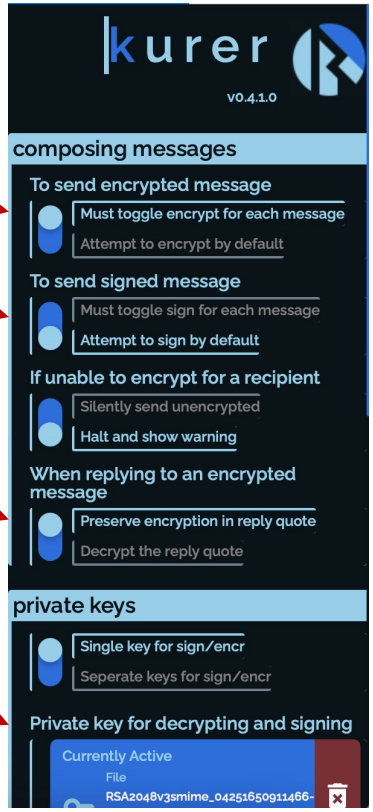


My add-ins

Add a custom add-in from URL:

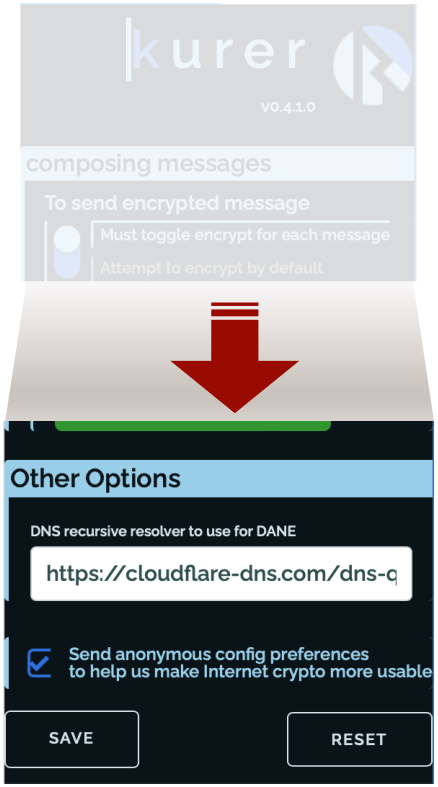
BASIC CONFIGURATION

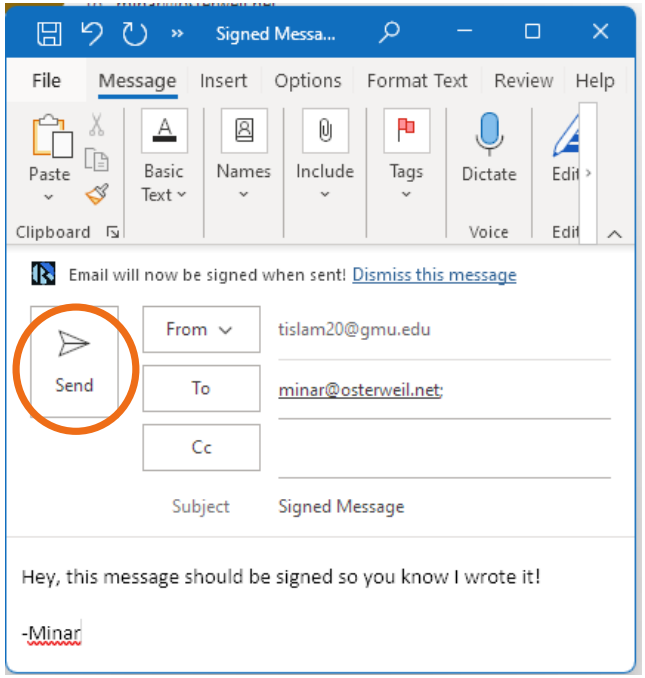
- Set default actions:
  - Always/never encrypt
  - Always/never sign emails
  - Preserve encryption
  - Add your key(s)
  - …



CONFIGURE USER-STUDY

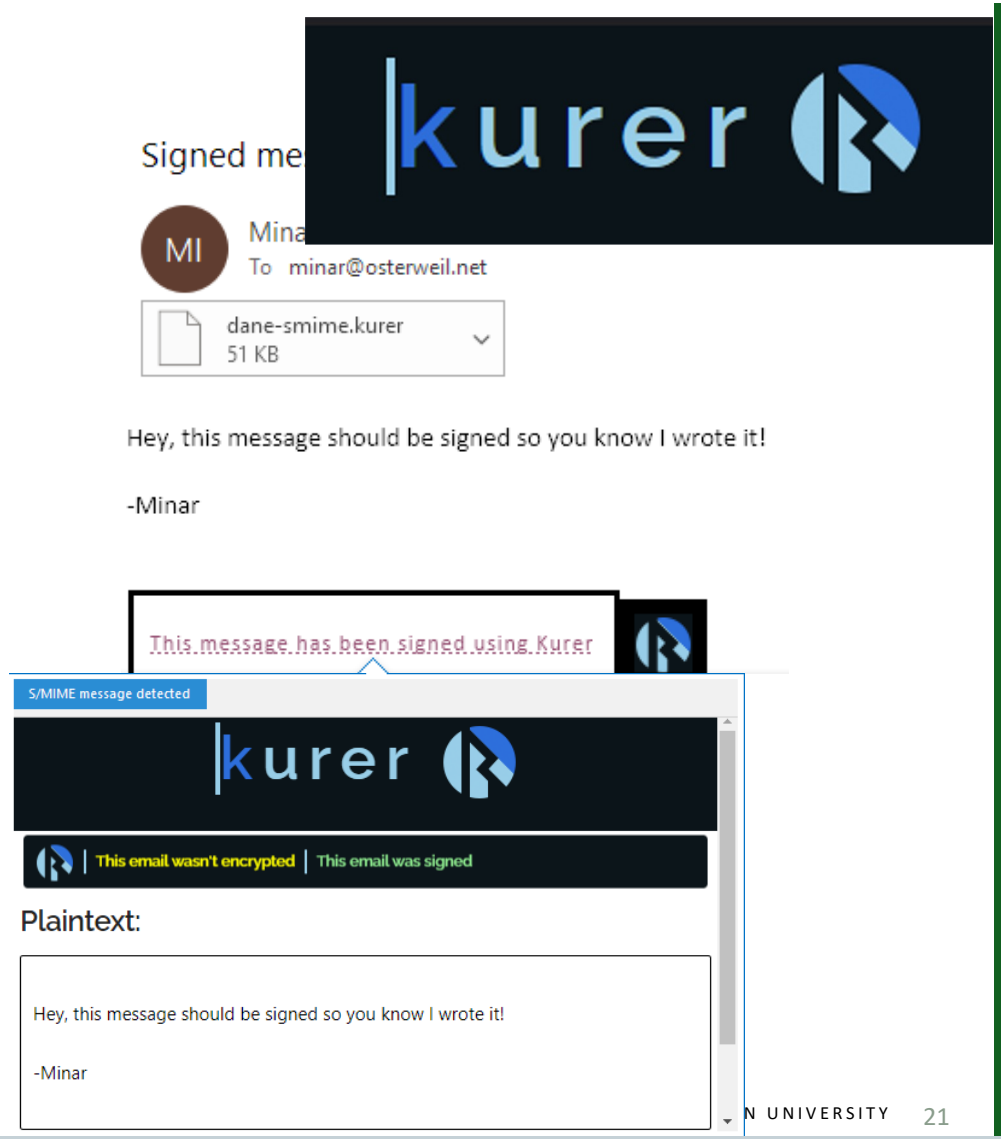
- Optionally, participate in configuration stu
  - We want to *evaluate* what security is needed
  - "Invisible security" project
  - *Private!* No information about your email is ever sent through us, observed by us, recorded by us, etc.



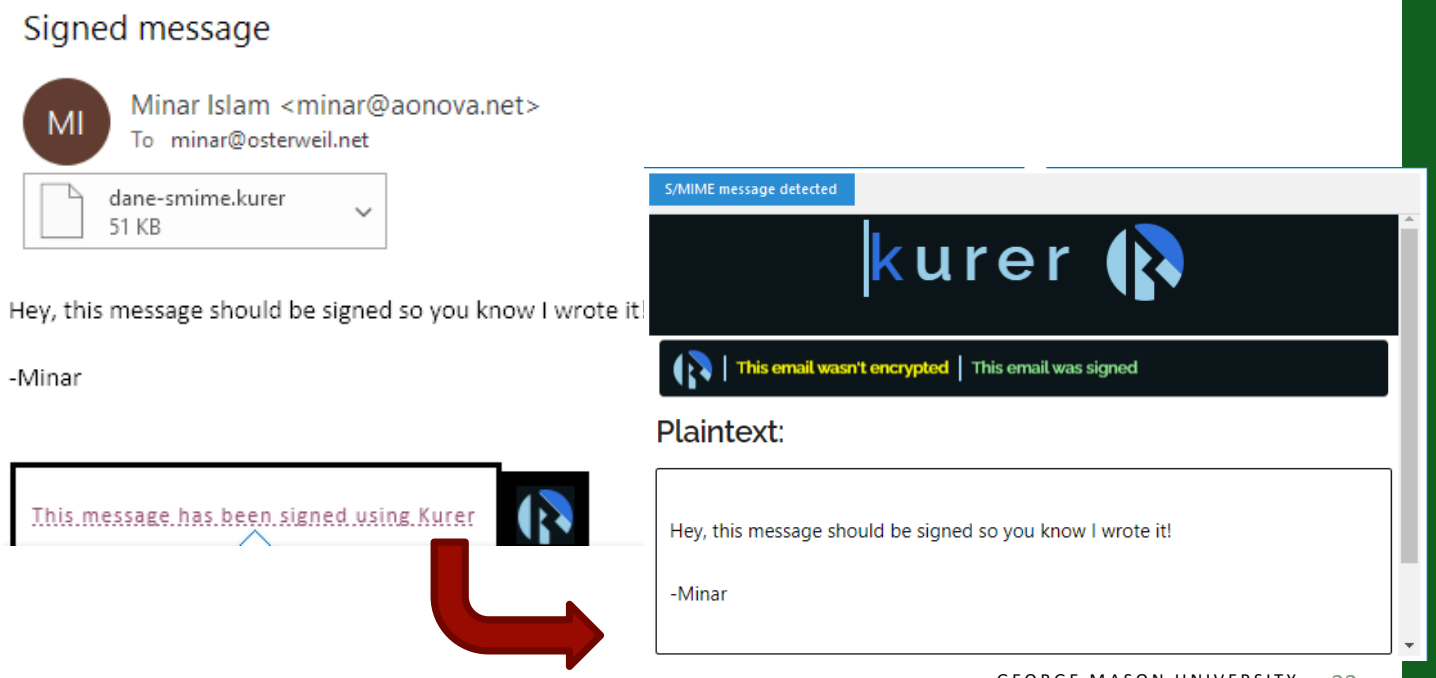


Sending

Receiving



- Automatically detect if incoming emails are encrypted or signed
- Simply click the text to automatically decrypt the email and view the plaintext
  - New reply buttons with additional functionality



STATUS

- DANEportal.net is live, today

  https://daneportal.net/

- Kurer is in ***alpha release,*** for Outlook and Thunderbird

  https://kurer.daneportal.net/install

WATERSHED MOMENT: MAKING INTERNET PROTECTIONS BEFIT SETTING

- This technology will secure digital objects throughout cyberspace:
  - Mobile Healthcare (**mHealth**), Smart and Connected Communities (**SCC**), **5G** Internet of Things (**IoT**) security, Vehicle-to-Everything (**V2X**) communications, and much more.
- Just like email, those disciplines will *also* need
  - Inter-organizational foundations
  - Per-user E2E crypto, Internet-scale
  - Human-usable tools
- Securing email with DANE paves the way to evolve protections from the Internet's core
  - This work will *evaluate* in order to *evolve* protections that fit
  - Deployable *immediately*
- Next: Entity-Security… Developing a tool for Security, Privacy and Trust Enrollment (SPaTE)

THANK YOU!

EOSTER@GMU.EDU

BACKUP

SECURE/PRIVATE COMMUNICATIONS ON THE INTERNET, TODAY

- Are our communications and data private on the Internet?
- Well, maybe you've heard, no:

And so are your EMAILS!

TAKE AWAY FROM THAT…

- What did we see there (besides a mixed metaphor of mail vs. messaging)?
  - Privacy: People expect that even snail-mail, in meat-space, is private
- What did we ***not*** we see there?
  - Authenticity: no one expected to verify the of ***sources*** of mail
- Cybersecurity and privacy on the Internet should be ***more*** advanced and automated than in meat-space
  - Drones & automobiles should be able to transact with each other
  - Doctors should be able to send health records to patients
  - …
- The Internet should enable this, but fundamental requirements have ***not*** been met

ARCHITECTURE FOR INTERNET OBJECT-SECURITY

- Examples like IoT, mHealth, V2X, etc. show increasingly repeated requirements:
  - Inter-organizational (e.g., entity at University A to entity at company B)
  - Per-entity (e.g., device, user, etc.) E2E crypto at Internet-scale
  - Usable tools
  - Automation

- The foundations we need already operational in Internet's core
- The Domain Name System's Security Extensions (DNSSEC)
  - 16+ years, ~10^7 global zones, inter-org loosely-federated, etc.
- DNS-based Authentication of Named Entities (DANE)
  - General object-security, ~10 years, per-entity crypto, etc.

DISCUSSION

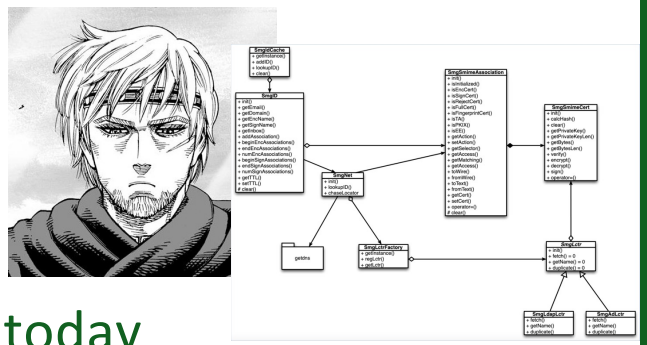
- Why not build cybersecurity / privacy protections from the top down?
  - Secure messaging works, right?
  - Why not build on blockchain?
  - Why not something else that fills a need?
- Internet needs an architecture for ***cross-app*** object-security
- Internet continuously proves things that "work" may not work ***at scale***
- Internet's needs ***evolve***, and protections need to be **(re)*evaluated***
- Building on Internet's scalable core (protections) inherits versatility
  - DNSSEC has embodied scalable/usable protections for 16+ years
  - Email is inter-org, has been scalable/evolvable core protocol for decades, etc.
- S/MIME + DANE → scalable messaging and object security

PLAY WITH DANE AND ITS TOOLS

- DANE has been used in CTF at M3AAWG
  - https://www.m3aawg.org/

M3AAWG Messaging Malware Mobile Anti-Abuse Working Group

- libCanute: a reference library for DANE protocols
  - https://github.com/gmu-msl/canute



- DANEportal.net and Kurer will let you get started today

kurer

FOR EXAMPLE: SENDING MESSAGE OBJECTS

If Alice, from Example U., can get Bob's key, from Company B, she can transact with him at will!

If Alice, Bob, and Chuck can securely find each others' crypto keys, they can all communicate securely/privately!

How can we make everyone's keys globally learnable, <u>securely</u>?

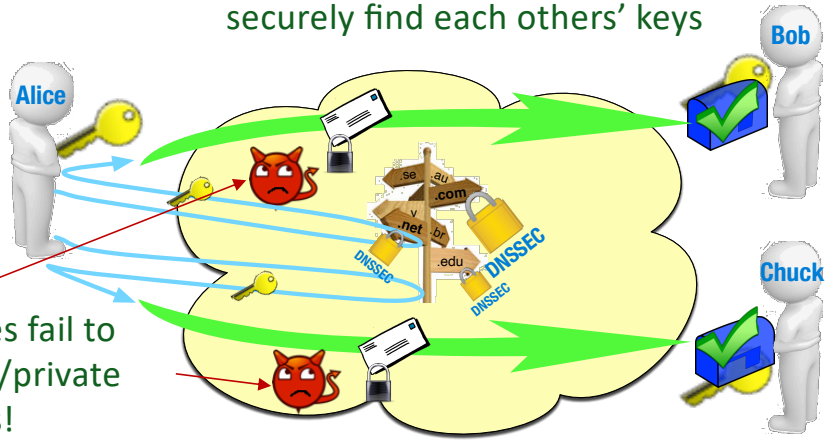
Adversary fails!

But, even if Chuck has a key, Alice **<u>cannot</u>** securely/privately communicate with **him!**

Adversary wins!

Then, adversaries fail to intercept secure/private communications!

Then, with DANE, Alice, Bob, and Chuck can provision their own crypto keys so they can securely find each others' keys



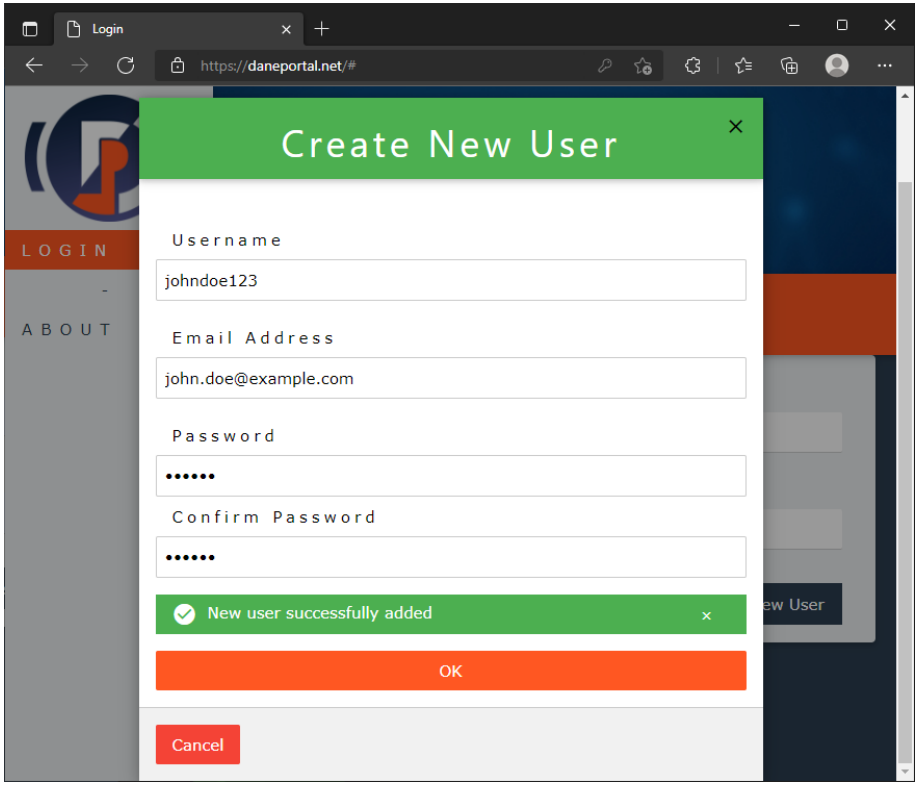
First step: secure DNS with DNSSEC

But, how?!?

CREATE YOURSELF A USER ACCOUNT

- Click [New User]
- Enter desired credentials
- Click [Create User]
- Click [OK] to close modal

- This will be your portal/management account
- Every email user will need their own login
  - Third-party OAuth logins are a planned feature, as is automated bulk account creation

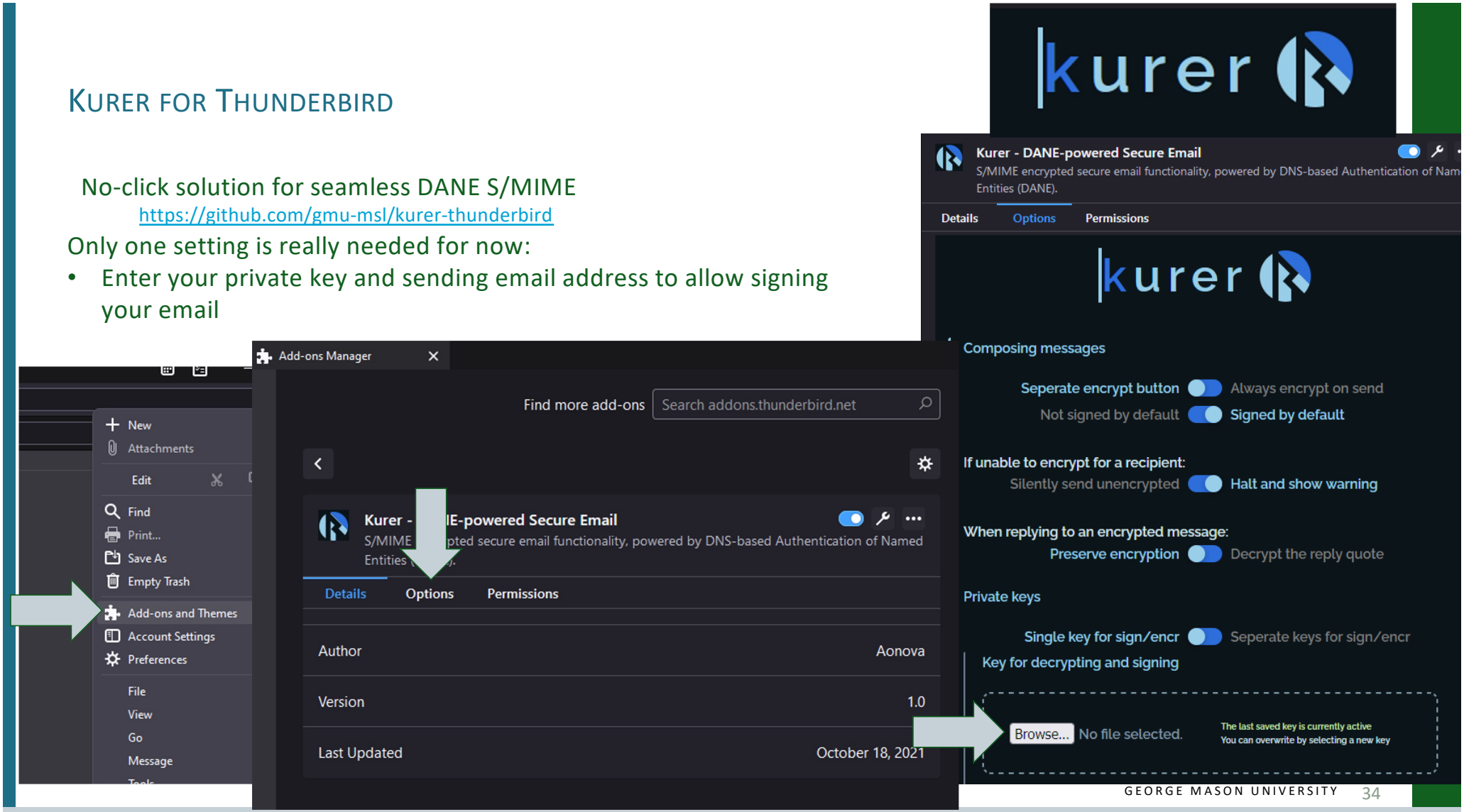


Kurer for Thunderbird

No-click solution for seamless DANE S/MIME
https://github.com/gmu-msl/kurer-thunderbird

Only one setting is really needed for now:

- Enter your private key and sending email address to allow signing your email



JUMP RIGHT IN TO SENDING SECURE EMAIL

- Use the Kurer popup to toggle signing and click send encrypted
  - The SIG tag on the icon means the email will be signed when sending