ANSI X9.82, Part 3 Deterministic Random Bit Generators (DRBGs)

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Elaine Barker (NIST)

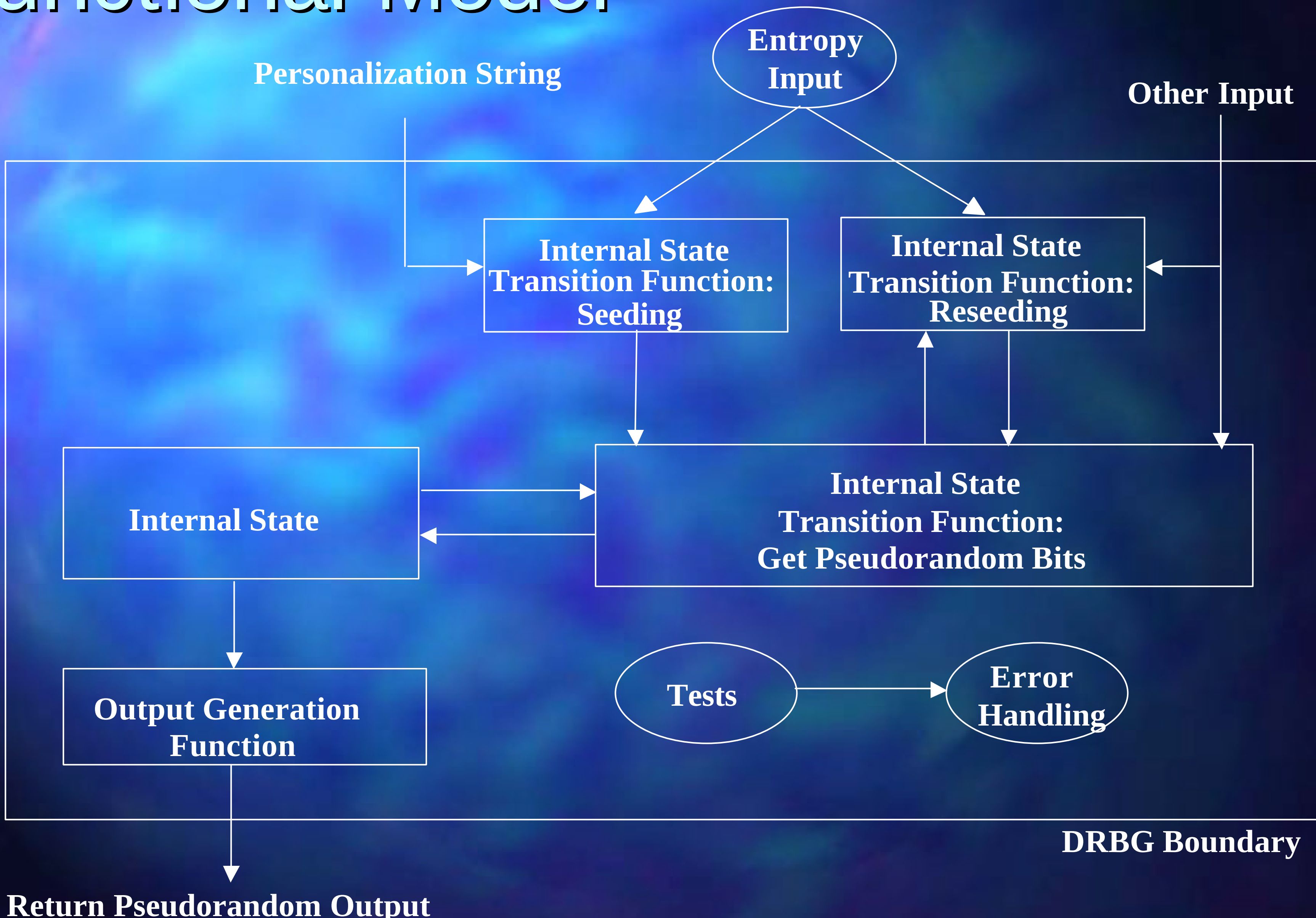
ebarker@nist.gov

301-975-2911

The Plan:

- Stroll through the document
- Hash-based and block-cipher based DRBGs (John Kelsey)
- Number theoretic DRBGs (Don Johnson)
- Address additional questions/issues

Functional Model



Functional Components (1)

- Entropy Input
  - Approved NRBG
  - Approved DRBG (or DRBG chain)
  - Other entropy source
    - Conditioned (translate to bits & remove bias)
    - Entropy assessed
    - Opt. derivation function

Functional Components (2)

- Other Inputs
  - Personalization string
  - Additional input
  - Counters, etc.
- Internal State
  - All the working parameters and other stored values
  - Some portion changes during each request

Functional Components (3)

- Internal State Transition Function
  - Instantiate
  - Generate bits
  - Reseed
  - Uninstantiate

Fundamental

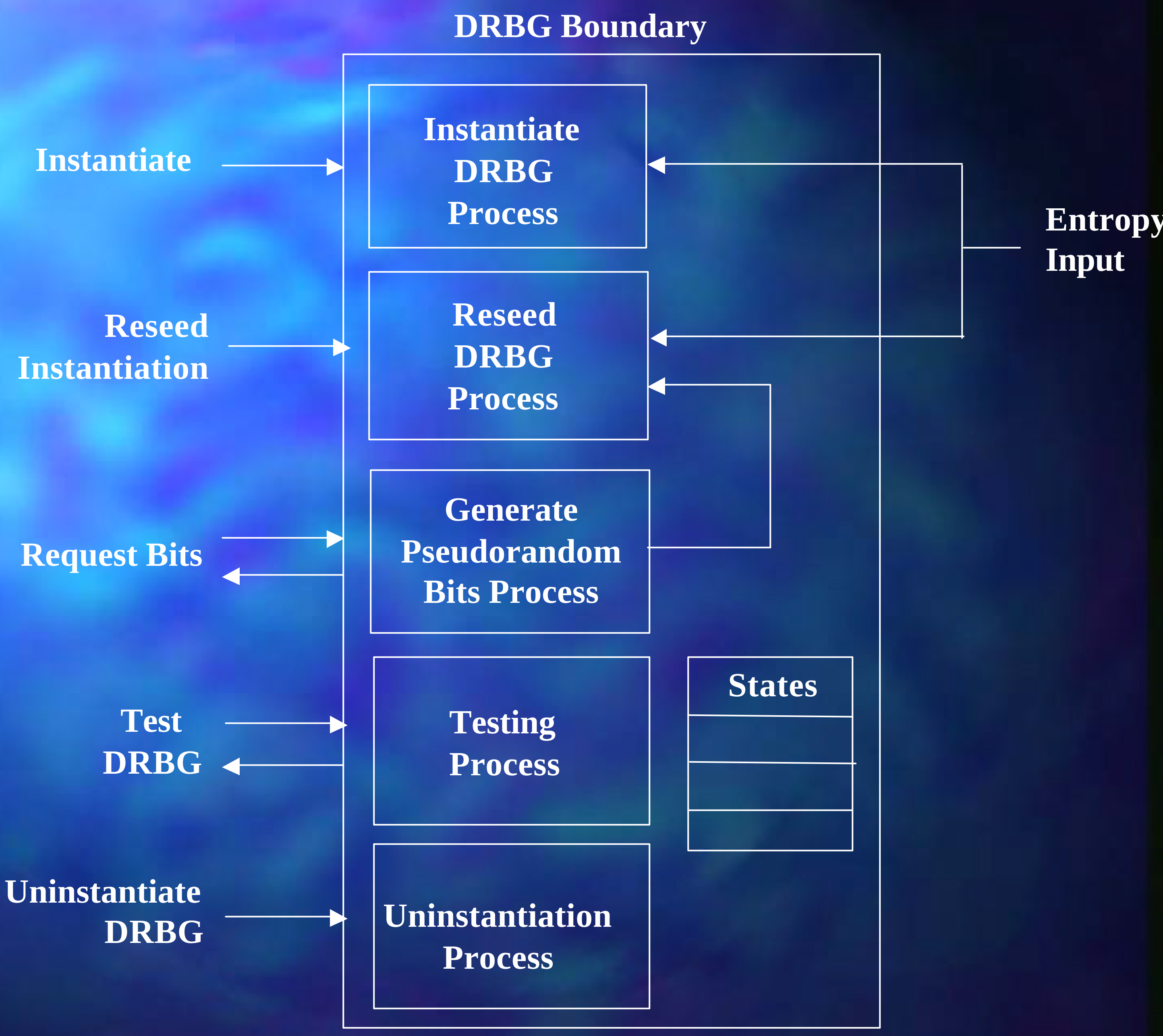
Functional Components (4)

- Output Generation Function
  - Selects bits from the internal state
  - Varies by DRBG
- Support Functions: Testing and Error Handling
  - Performs health checks
  - Aborts for catastrophic errors

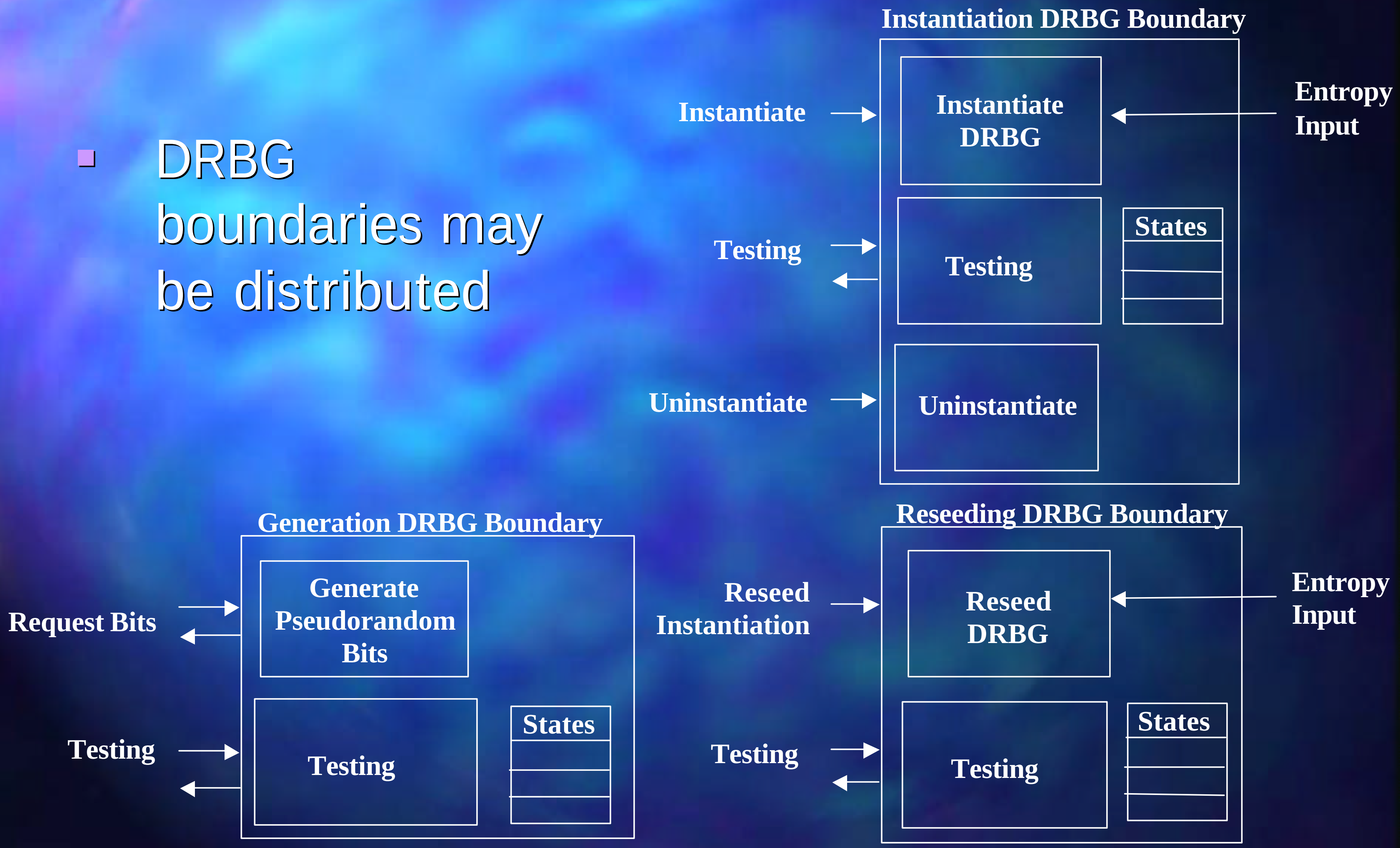
DRBG Boundary

- Physical or logical boundary
- Protects the DRBG internal state
  - Exists only within the boundary
  - Only affected per the DRBG spec.
  - State values remain within the boundary
- Other crypto functions
  - May reside within the boundary
  - May access the DRBG’s crypto primitive(s), but not the state

- All DRBG processes may be in the same boundary



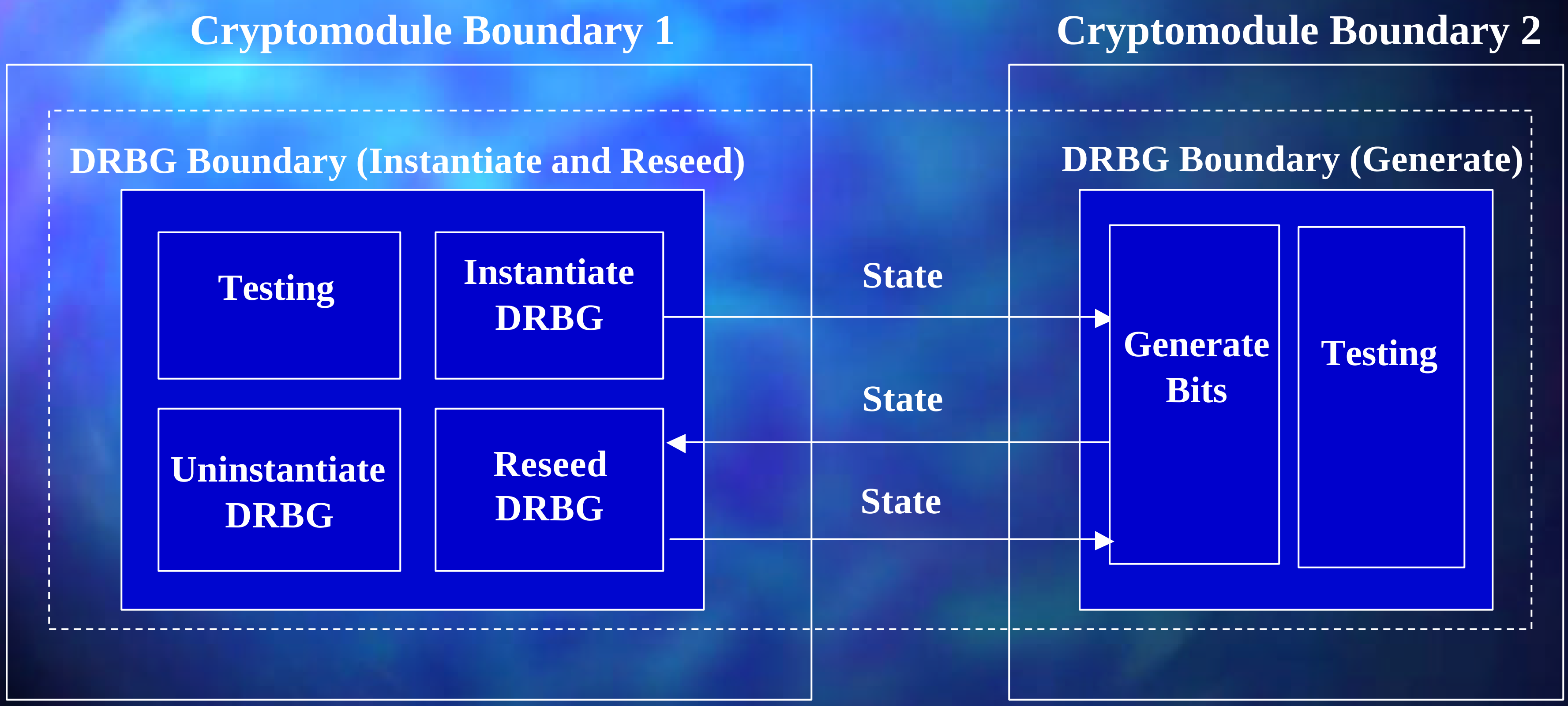
- DRBG boundaries may be distributed



DRBG Boundaries and Cryptographic Modules

- DRBG processes used by applications shall be in FIPS 140-2 cryptomodule boundaries
- A DRBG may be distributed across multiple cryptographic modules
- All DRBG processes for a given DRBG in a cryptomodule shall be in the same DRBG boundary
- Multiple DRBGs may be in the same or in different DRBG boundaries within the same cryptomodule

Example of A DRBG in Two Cryptomodules



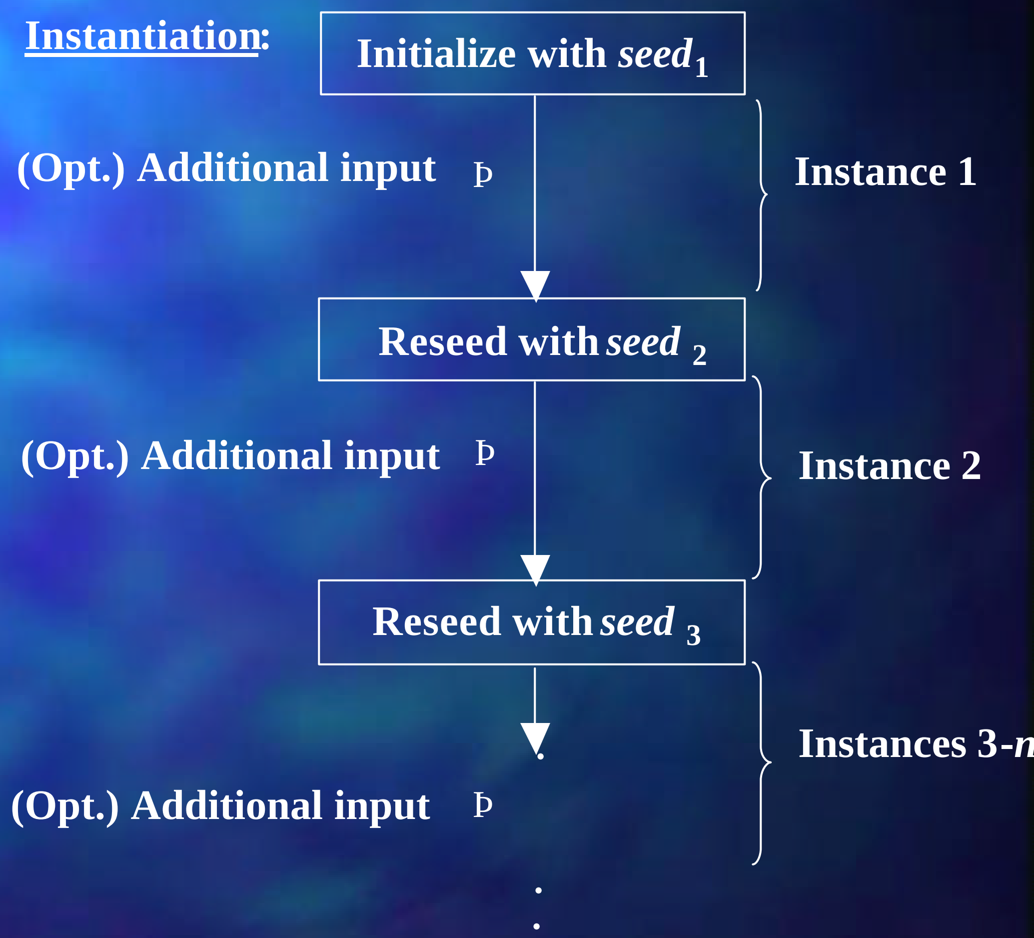
- - - Logical DRBG Boundary

DRBG Boundaries and Cryptographic Modules (contd.)

- FIPS 140-2 issues:
  - When a DRBG is distributed, the state needs to be transferred between DRBG boundaries within cryptomodule boundaries.
  - Entropy input source may be outside cryptomodule boundary
  - Manual and electronic entry
  - Different requirements for different FIPS 140-2 levels

Instantiation and the Internal State

- A DRBG is instantiated for one or more purposes
- Reseeding creates a new instance
- Additional input can be provided

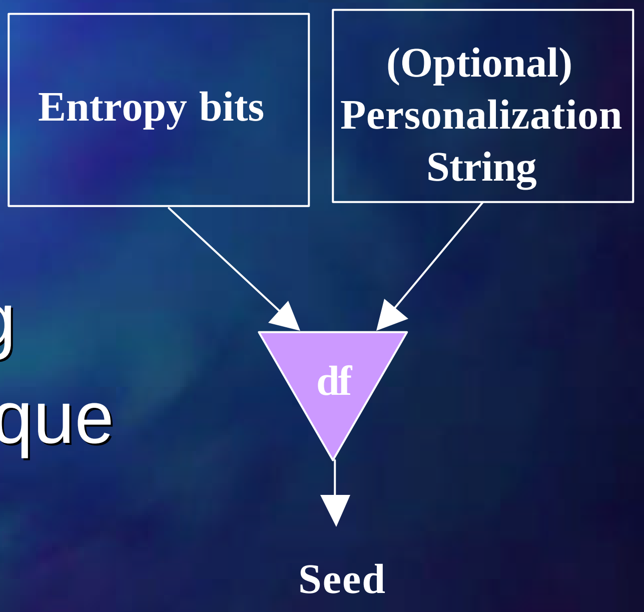


Instantiation and the Internal State (contd.)

- The internal state contains:
  - Values derived from the seed
  - DRBG-specific information
  - Prediction resistance flag
  - Security strength
  - (Opt.) Transformation of entropy input

Seeds (1)

- Acquired prior to the generation of pseudorandom output
- Used to instantiate the DRBG and initialize the state
- Seed construction:
  - Entropy input
  - (Opt.) personalization string
  - Goal: The seed shall be unique



Seeds (2)

- Entropy requirements
  - A seed shall contain sufficient entropy for the desired security level
  - Entropy shall be distributed across the seed
  - *entropy* $\geq$ max (128, *security_level*)
- Seed size: Depends on the DRBG and the security level

Seeds (3)

- Entropy Input Source:
  - Approved NRBG
  - Approved DRBG (or chain of DRBGs) seeded by an NRBG
    - Entropy of higher DRBG ≥ lower DRBG requirement
  - Other source whose characteristics are known
  - Need not be co-located with the instantiation process

Seeds (4)

- Entropy input and seed privacy
- Reseeding
  - Why? Reduce security risks; Recover from compromise
  - Replace seeds periodically
    - As specified
    - Check that entropy input is different
    - Combine new and old entropy to generate new seeds
  - Alternatively, reinstantiate

Seeds (5)

- Seed use
  - DRBGs used to generate secret and public information
  - Should use different instantiations
  - Entropy input and seeds shall remain secret
  - Different instantiations and instances shall use different seeds
  - No output until sufficient entropy is available

Seeds (6)

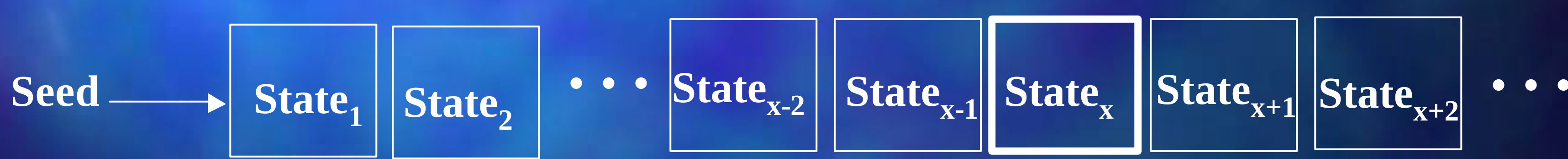
- Seed separation
  - DRBG seeds shall not be used for other purposes
  - Recommend different seeds for different data types
  - DRBG seed separation a cost/benefit decision

Other Input

- During instantiation, generation or reseeding
- Another source of entropy?
- Personalization string
- Additional_input

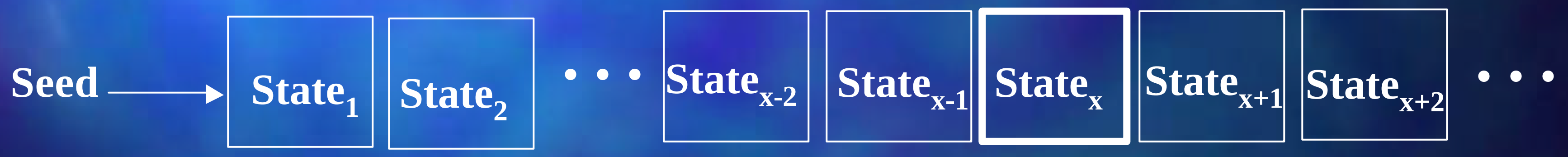
Backtracking Resistance

- Backtracking resistance
  - Compromise of the state has no effect on the security of prior outputs
  - Built into the DRBG design



Prediction Resistance

- Prediction resistance
  - Compromise of the state has no effect on the security of future outputs
  - Obtain sufficient new entropy



Supported Security Strengths

- Support 80, 112, 128, 192 and 256 bits
- Determined during instantiation by the request and the crypto primitive used
- Entropy requirement must support all requests

Security Strength, Entropy and Seed Size

- Seed (i.e., entropy input) must have sufficient entropy
- *min_entropy* = max (128, *requested_strength*)
- Entropy input size: a range of sizes
- Seed size depends on the DRBG and the security level

DRBG Purposes and States

- Recommend different instantiations for different purposes
- One internal state per instantiation
- DRBGs handle multiple states
  - Allow sufficient space for multiple states
  - Allow a state for health testing

State Table

Handle	
1	V_1, C_1, reseed_counter$_1$, strength$_1$, prediction_resistance_flag$_1$, ...
2	V_2, C_2, reseed_counter$_2$, strength$_2$, prediction_resistance_flag$_2$, ...
n	Null, Null, 0, 0, 0, ...

Instantiating a DRBG (1)

- Instantiate process:
  - Input:
    - Requested strength
    - Prediction resistance request
    - (Opt.) Personalization string
    - DRBG-specific parameters
    - Mode
  - Output:
    - Status
    - State_handle

Instantiating a DRBG (2)

- Get_entropy function:
  - Input:
    - Minimum entropy
    - Minimum length
    - Maximum Length
  - Output:
    - Status
    - Entropy_input

Instantiating a DRBG (3)

- Find_state_space function:
  - Input:
    - Mode
  - Output:
    - Status
    - State_handle
- Derivation functions
  - Hash_df
  - Block_Cipher_df (Coming)

Reseeding (1)

- How requested?
  - Explicitly by an application
  - When prediction resistance is requested
  - At the end of the seedlife
  - Triggered by external events

Reseeding (2)

- Reseed process:
  - Input:
    - State_handle
    - (Opt.) Additional_input
    - Mode
  - Output:
    - Status

Generate Pseudorandom Bits (1)

- Generate bits for only one value
- Multiple requests may be used to construct a single value

Generate Pseudorandom Bits (2)

- Generate process:
  - Input:
    - State_handle
    - Number of bits requested
    - Strength to be provided
    - (Opt.) Additional input
    - (Opt.) Prediction resistance request
    - Mode
  - Output:
    - Status
    - Pseudorandom bits

Removing a DRBG Instantiation

- Used to release an instantiation's state space
- Uninstantiate process:
  - Input:
    - State_handle
  - Output:
    - Status

Self-Testing (1)

- To obtain assurance that the implementation continues to operate correctly (health testing)
- Used during validation
- Test the DRBG processes within the DRBG boundary
- Strawman testing process provided

Self Testing (2)

- Test for correct results
- Test error handling
- Abort for failures

DRBGs

- Hash-based:
  - Hash_DRBG
  - HMAC_DRBG
  - KHF_DRBG
- Block cipher-based:
  - CTR_DRBG
  - OFB_DRBG
- Number theoretic
  - Dual_EC_DRBG
  - MS_DRBG

Assurance

- Designs have been evaluated
- Documentation shall be available
- Implementations may be validated
- Operational (health) tests shall be performed

Summary of Part 2 (DRBGs)

- DRBG and Crypomodule Boundaries
- The internal state and the seed must be protected
- Seeds must have sufficient entropy (in accordance with the security level)
- DRBG processes:
  - Required: Instantiate, Generate, Self-test
  - Optional: Reseed
- Assurance