Topology in the Geodatabase: An Introduction

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ESRI Super Secret Topology Laboratory, May 2017

Agenda

- ArcGIS Topology defined
- Validating a topology
- Editing a topology
- Geoprocessing tools
- Ephemeral topologies
- Data model design and performance
- Topology at 10.1 and 10.3

- Various cheesy demos

ArcGIS Topology Defined

ArcGIS Topology

- Fundamentally, topology is used to manage how a set of simple feature classes share geometry

What Happens to the Features?

- Nothing

- No change to storage of features
- No change to behavior of features

- So, what changes?

What Changes with a Topology?

- Topology tracks edits you make to the features
- Flags areas that have been modified
- Validate Topology command analyzes the edited areas and evaluates the rules
- If a rule is violated, a topology error feature is created
- You correct the errors or mark them as exceptions to the rule (or you may ignore the errors altogether)

Topology Rules

- Define integrity rules and constraints for the feature classes
- Can include point, line and polygon features
- Evaluated when the topology is validated
- Violations are expressed as topology errors
- 31 different rule types
  - 14 ArcGIS Topology rules can emulate coverage model
  - More may follow
- It is not possible to create custom rules

Rules to Model Coverage Topology

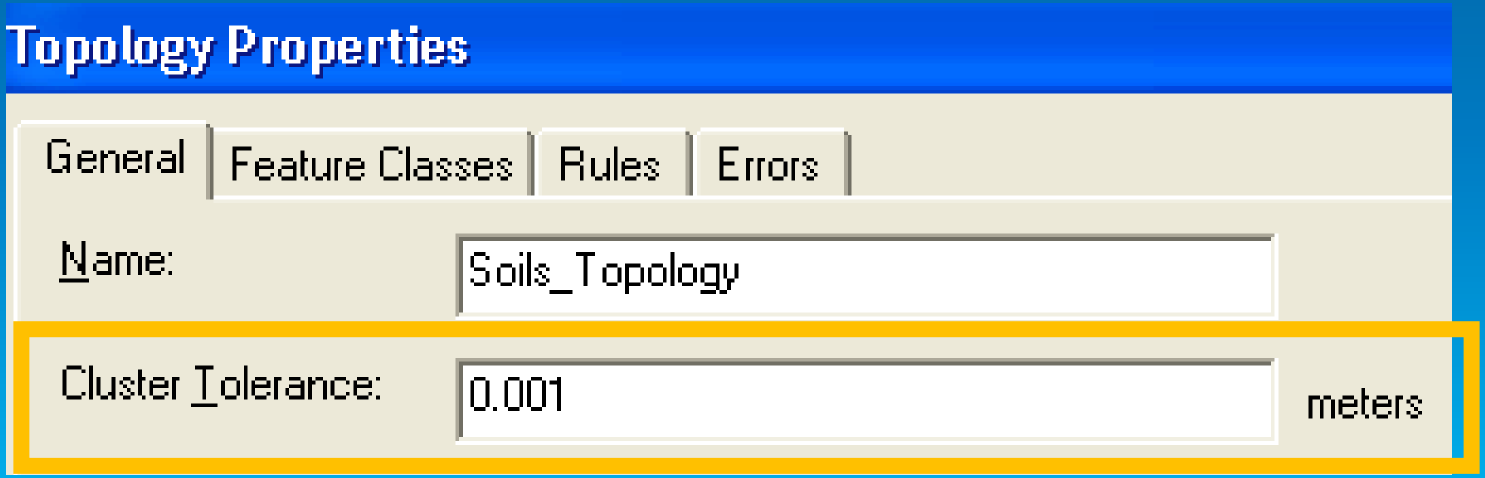
- Arc rules
  - Line must not have dangles
  - Line must not intersect or touch interior
  - Line must not have pseudos
  - Line must be single part
  - Line must not self-intersect
- Arc-Node rules
  - Line endpoint must be covered by point
  - Point must be covered by line endpoint
- Polygon rules
  - Polygon must not have gaps
  - Polygon must not have overlaps
  - Polygon must be covered by line
  - Line must be covered by boundary of polygon
- Region rules
  - Polygon must be covered by boundary of polygon
- Route rules
  - Line must be covered by feature class of line
- Label Rules
  - Point must be properly inside polygon

Dirty Areas

- Define locations where the spatial integrity of the topology is unknown
  - I.e., validate has not been run following edits
  - Used to optimize the validate process
- May contain existing or *undiscovered* topology errors
  - A clean area does not contain any undiscovered errors
- Stored in the geodatabase
- Created as a byproduct of editing features
- Created when shape or subtype changes

Cluster Tolerances

- Cluster tolerance is a property of the topology
  - Cannot be set on a per feature class basis
- Minimum cluster tolerance is the default
- Support separate cluster tolerances for XY and Z



Name: Soils_Topology

Cluster Tolerance: 0.001 meters

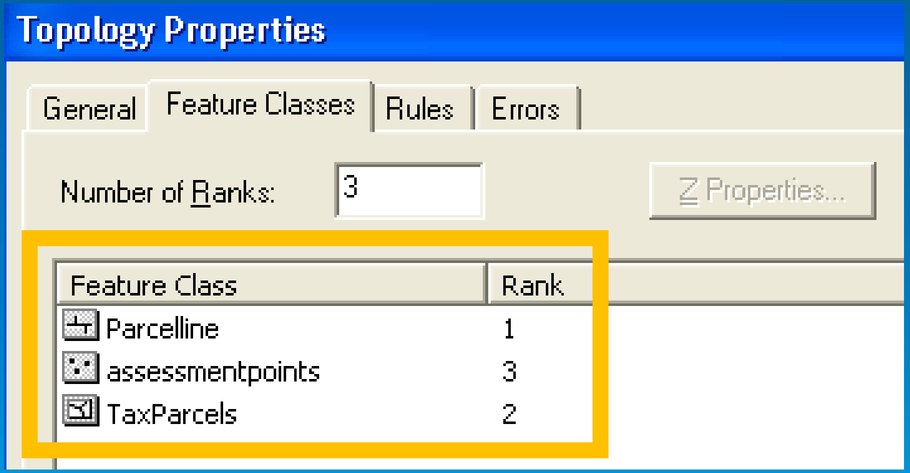
Cluster Tolerances

- NOT an upper bound for point movement
- Instead, a lower bound for line to line and point to line separation

- Used during validation to ensure:
  - No two points are closer than the cluster tolerance
  - No point is closer than the cluster tolerance to a line of which it is not an endpoint
  - No two lines intersect except at their endpoints

Topology Ranks

- Each feature class has a rank
- Ranks are used to establish a priority ordering
- Vertex with the highest rank determines the cluster location
- Nothing is sacred
- Ranks supported for
  - XY
  - Z



Number of Ranks: 3

Feature Class	Rank
Parcelline	1
assessmentpoints	3
TaxParcels	2

Validating a Topology

Validation

- Integrates the geometries:
  - Segmentize the geometries
  - Cracking and clustering

    (this may update the geometries of the features)
- Evaluates topology rules
- Generates topology errors
- Deletes errors if rules are no longer violated
- Removes validated portions of dirty area

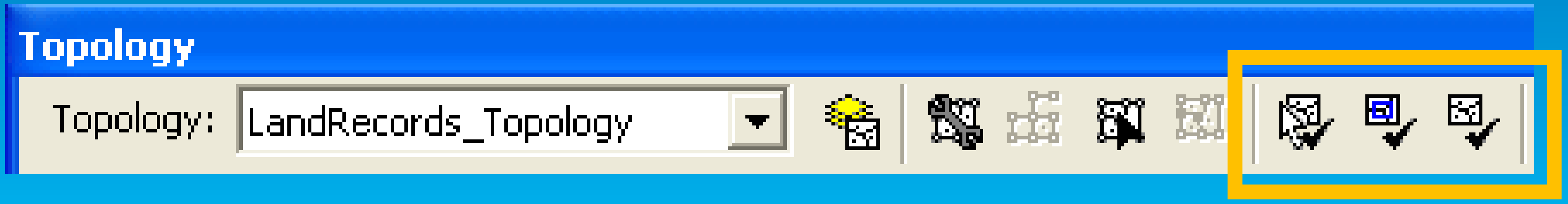
Cracking and Clustering

- Can go through a number of iterations
  - Maximum of six iterations

- In each iteration, a point may move no further than the cluster tolerance times the square root of two
  - Maximum movement is 6 * tolerance * sqrt(2)
  - The probability of this occurring is completely negligible
  - Point movement should be considered a statistical parameter, much like the standard deviation for a normal distribution

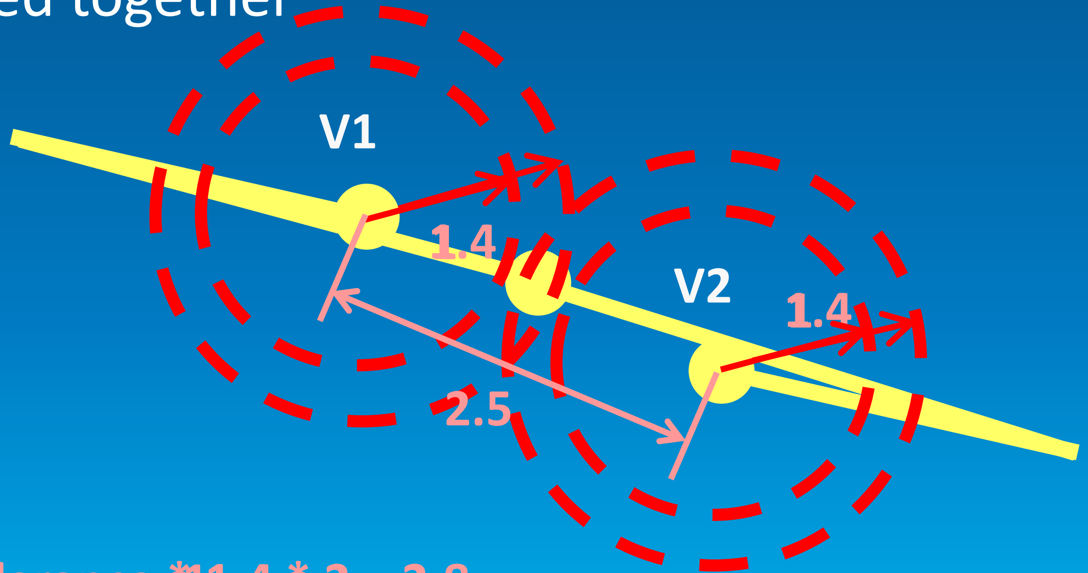
Validation

- Any part of the dirty area can be validated
- Not required to validate before saving changes or reconciling
- Users can define their own workflow
  - Validate after every edit operation
  - Validate once prior to saving
  - Validate once a week



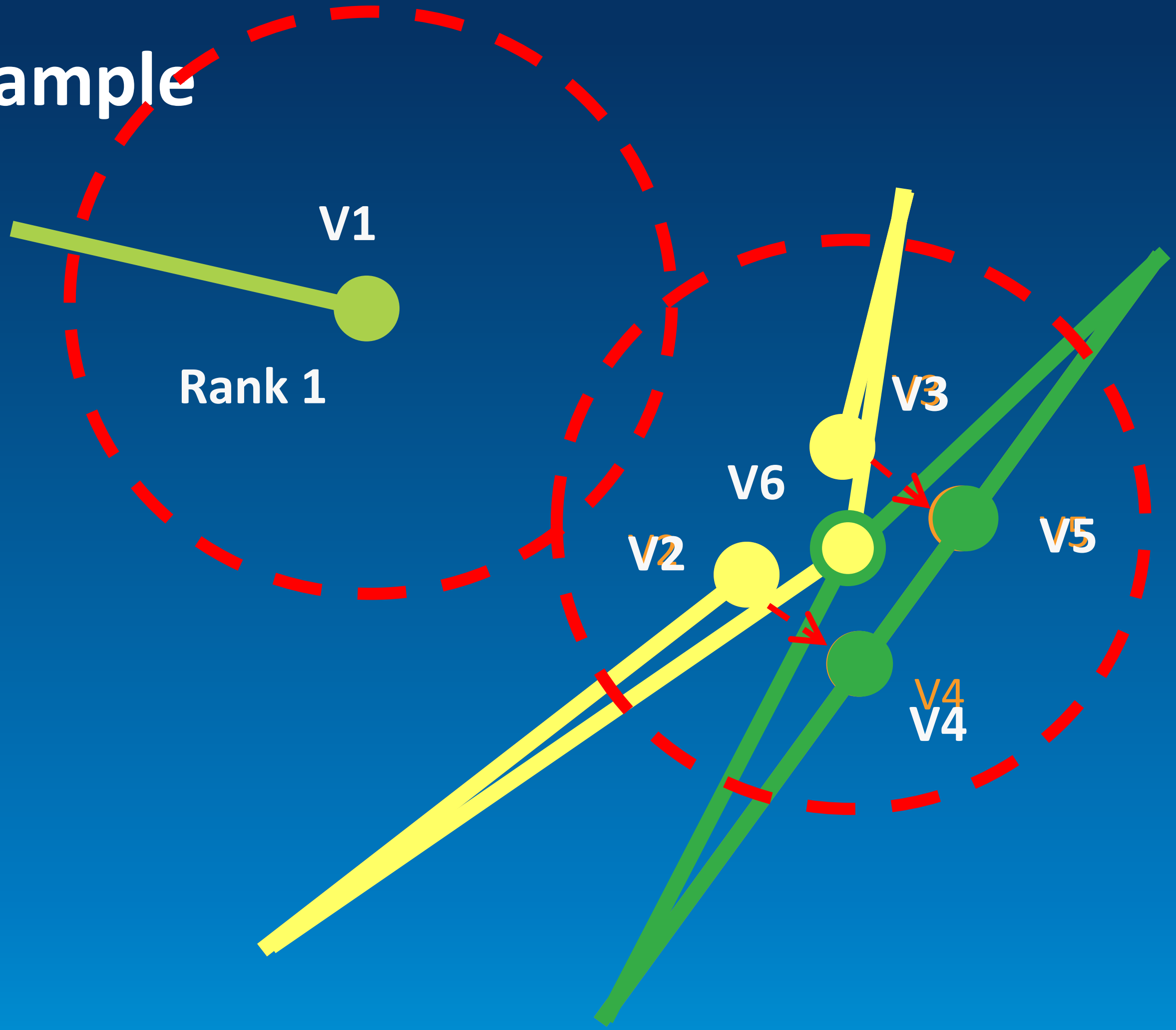
Validation

- A vertex may move up to the square root of 2 (~1.4) times the cluster tolerance during each iteration of cracking and clustering
  - Thus, two vertices that are separated by ~2.8 times the cluster tolerance may be clustered together



Cluster tolerance:*11.4 * 2 = 2.8

Validation Example



V1 and new point V6 are not clustered (V1 is in feature class with higher rank)

Three endpoint vertices and one line with specified priorities

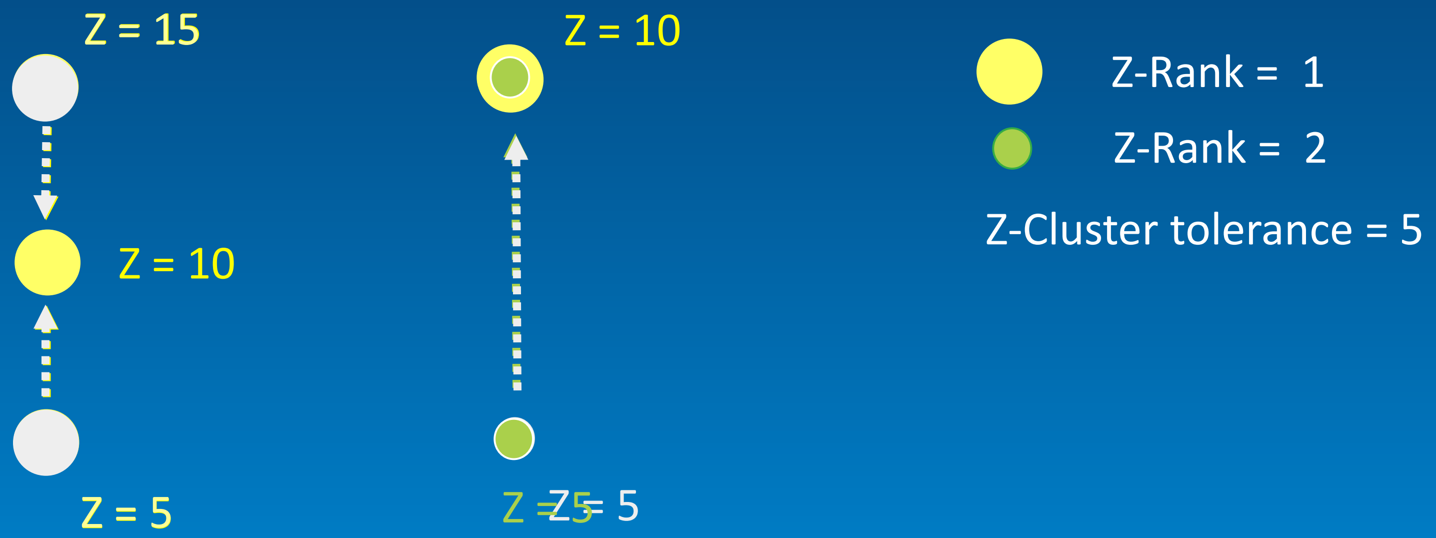
Z-Aware Data

- Two different models based on Z-cluster tolerance

- “Terrain” model
  - All coincident vertices share a single elevation
  - Use a large Z-cluster tolerance

- “Building” model
  - Coincident vertices may or may not have common elevation value
  - Use a smaller Z-cluster tolerance

Clustering Z-Aware Features

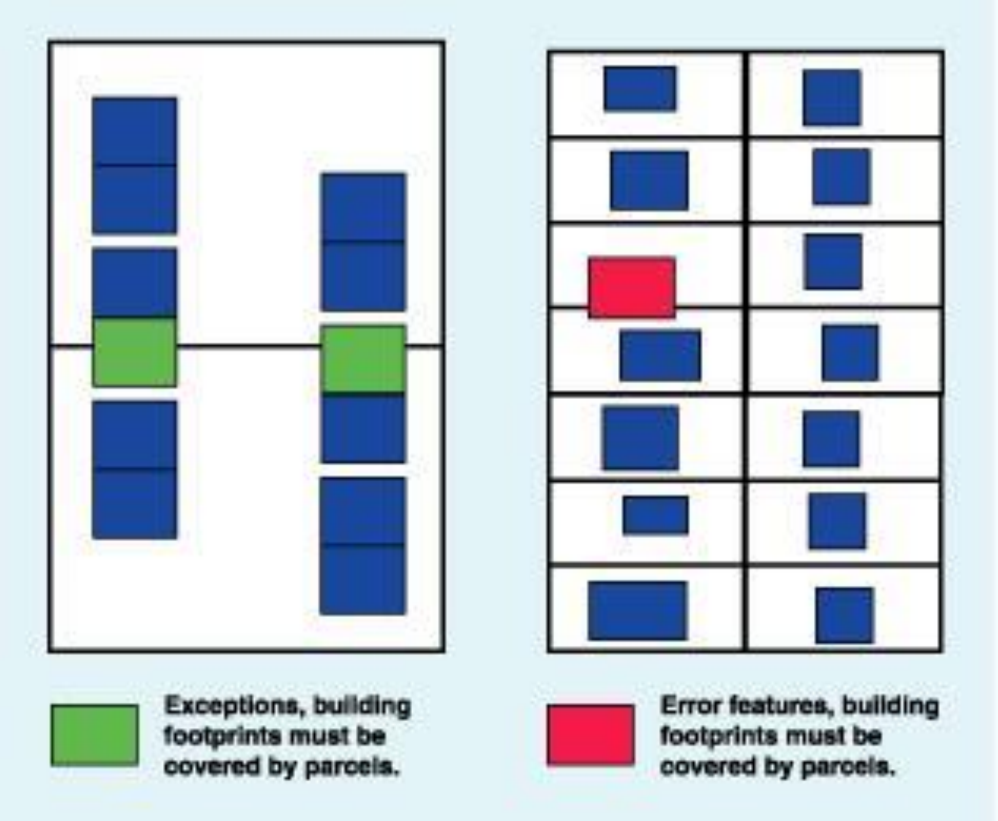


Be[illegible]es, more than th[illegible] it inherits the Z of the higher vertex

(note: sqrt(2) factor does not apply to z clustering process)

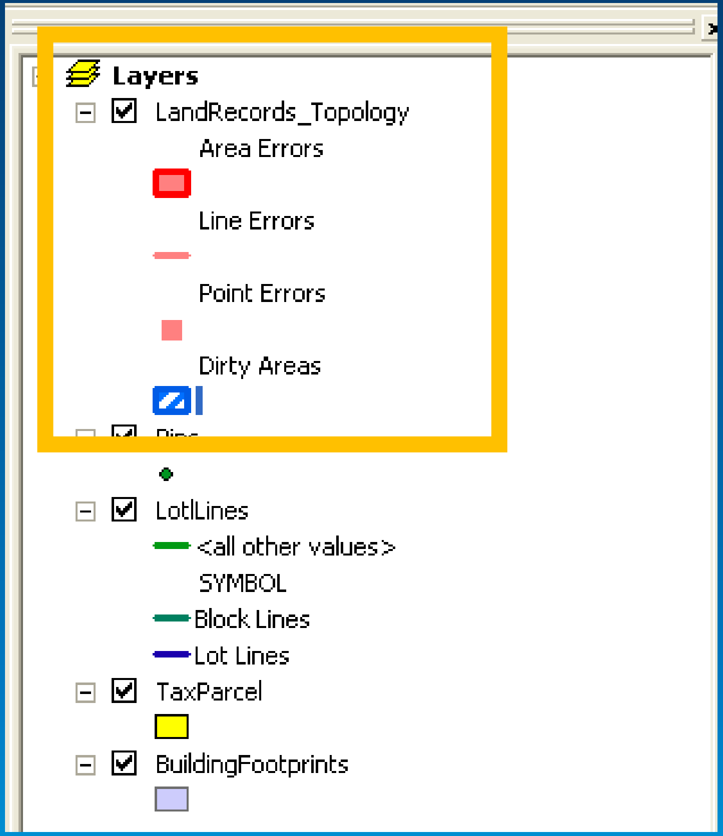
Topology Errors

- Created during validate when a topology rule is violated
- Contain information necessary to:
  - Understand the rule violation
  - Draw the rule violation
- Have geometry based on violated rule type


🟩 Exceptions, building footprints must be covered by parcels.
🟥 Error features, building footprints must be covered by parcels.

Topology Errors

- Visible through the topology layer
- Cannot be deleted by the user
- User has three options:
  - Leave the error
  - Fix the error
  - Elevate the error to exception status
    - E.g., rule applies everywhere except 'here'

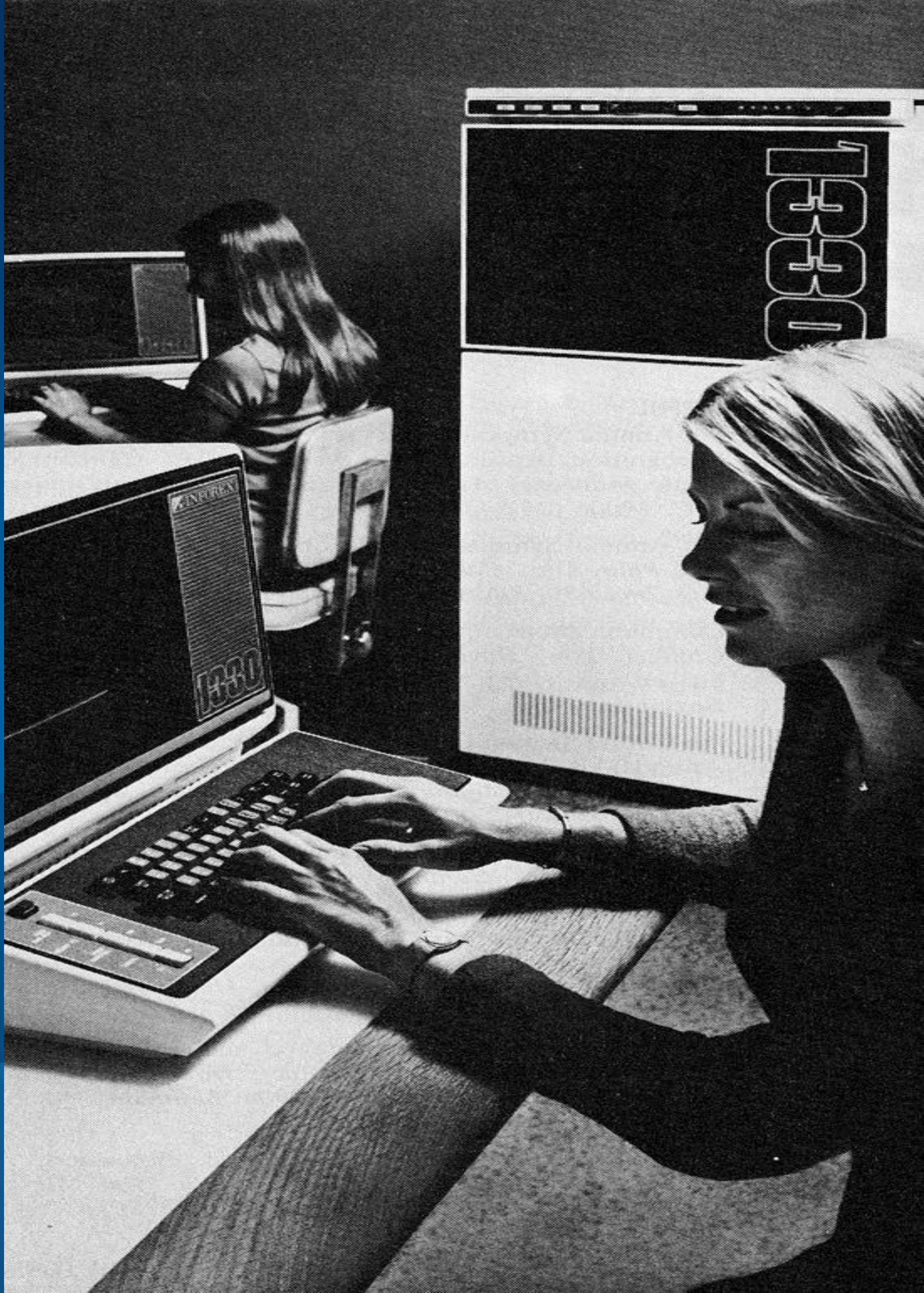


Editing a Topology

DEMO

Hopefully, another decent demo

Colin Zwicker

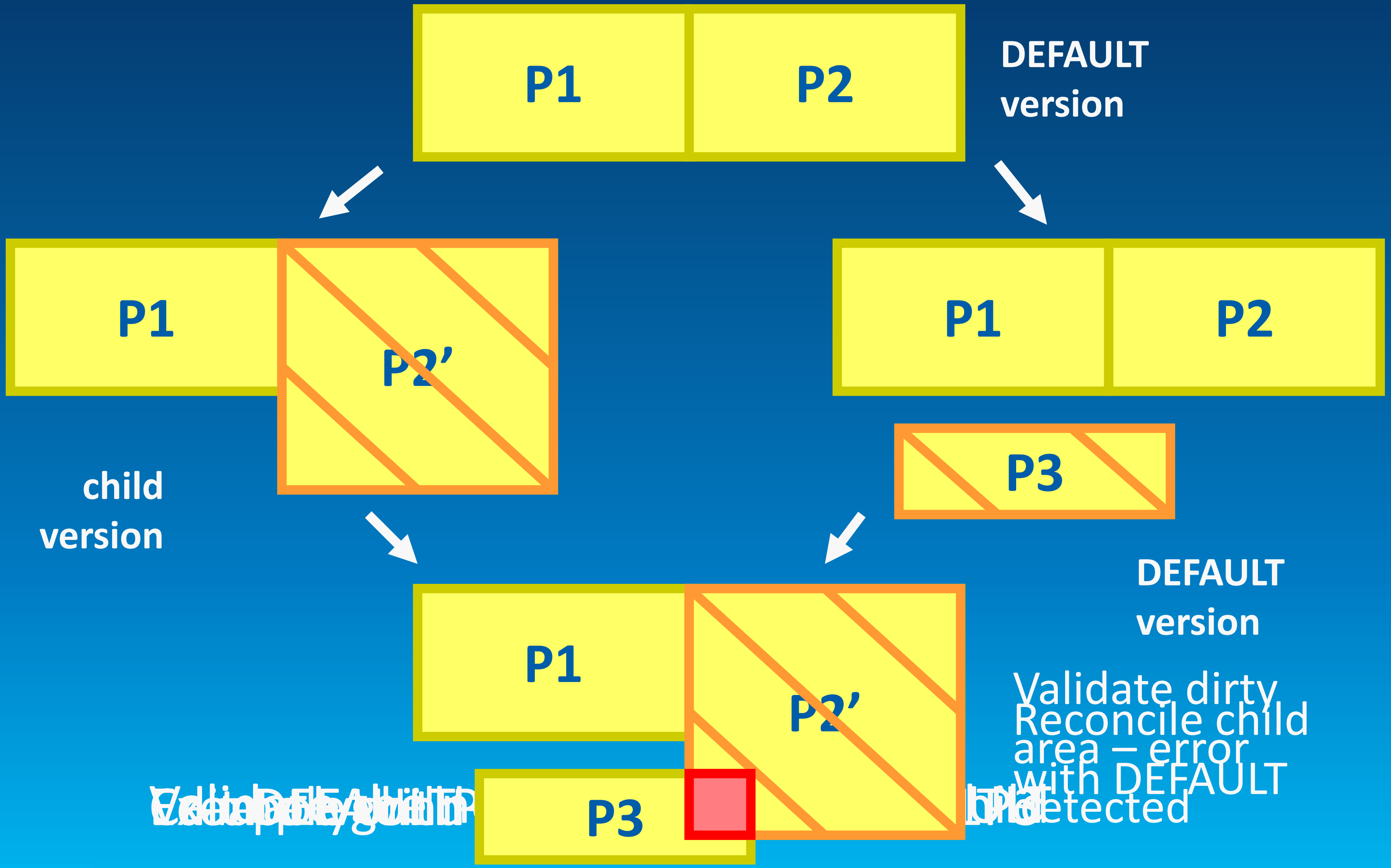


Versioning a Topology

Versioning

- Topology is fully supported in the versioned environment
  - Multiple simultaneous editors of same feature
- No restriction on reconciling and posting only fully validated topologies
  - Dirty areas and errors correctly handled
- Reconcile will result in the areas containing new or updated features becoming dirty
  - Subsequent validation is fast as integrate (cracking and clustering) typically does not need to update the feature geometries

Versioning Example



DEFAULT version

child version

DEFAULT version

Validate dirty area – error detected

Reconcile child with DEFAULT

[illegible]

Versioning Workflow

- Workflow is critical with versioning

- Recommended workflow:

  1. Load all the data
  2. Define the topology
  3. Validate the entire topology
  4. Finally, register the topology as versioned

- Bonus question: Why?

Geoprocessing Tools

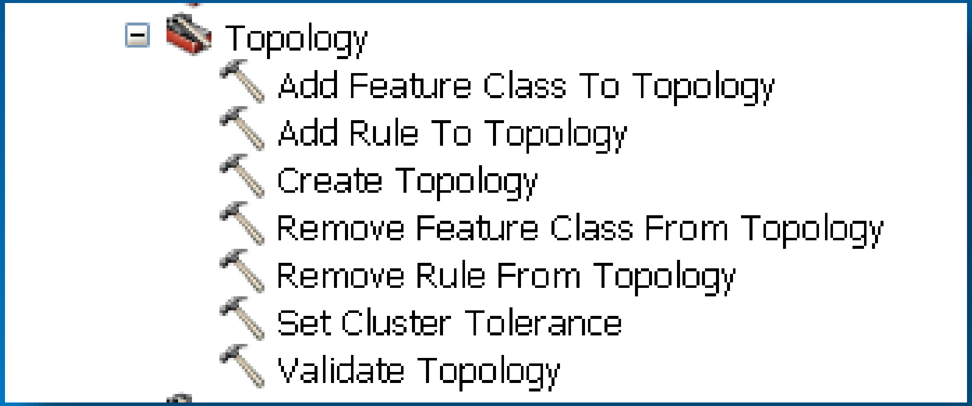
Geoprocessing Tools

- There are a number of GP tools available that can be used to:
  - Manage topologies
  - Validate topologies
  - Perform bulk topological updates
  - Output new feature classes based upon topological operations

- Like all Geoprocessing tools, these are scriptable in Python, and may be used with the GP Service

Managing Topologies

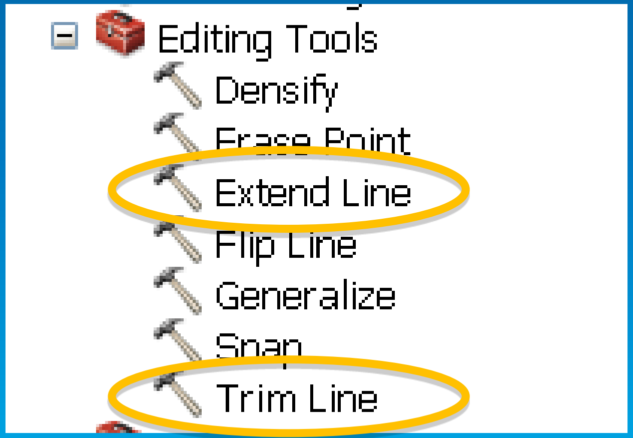
- There are many GP tools that can be used to manage topologies:
  - Add Feature Class
  - Add Rule
  - Create
  - Remove Feature Class
  - Remove Rule
  - Set Cluster Tolerance
  - Validate



Topology
Add Feature Class To Topology
Add Rule To Topology
Create Topology
Remove Feature Class From Topology
Remove Rule From Topology
Set Cluster Tolerance
Validate Topology

Geoprocessing Tools

- There is a variation of the Validate operation called “Integrate”, but only applies the cracking and clustering tolerance to a collection of feature classes
  - It updates the geometry of every feature within each feature class as a result of running all of the features through the Topology Engine
- At 10.0, there are GP tools to perform bulk editing
  - These are basically the ARC/INFO capabilities found within ArcEdit
  - Some of the more interesting are “Extend Line” that extends undershoots, and “Trim Line” that removes overshoots (dangles)



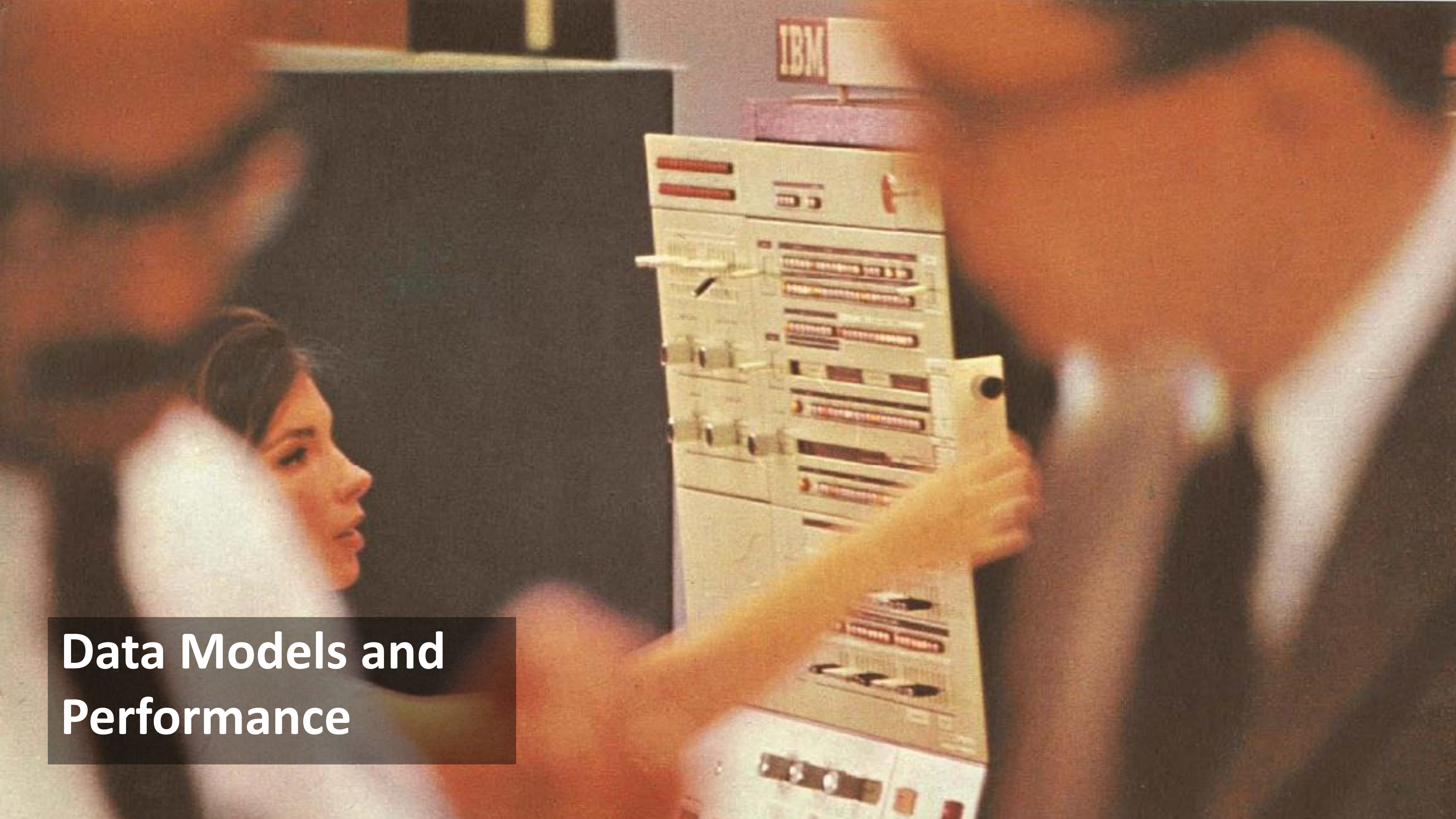
Geoprocessing Tools

- These tools output new feature classes based upon basic topological operations:
  - Feature To Line
    - Generates a planar output of the lines of a collection of input polygons and/or lines (e.g., generating the Arcs)
  - Feature To Polygon
    - Generates a planar output of the polygons of a collection of input polygons and/or lines with a single point feature class providing the attributes (like ARC/INFO CLEAN)
  - Polygon To Line
    - Generates the planar output of lines from a single polygon feature class assigning the left and right of the polygon to the lines (like the Arcs of a Coverage)

Ephemeral Topologies

- Topologies that are short lived and intended to support QA/QC processes on data prior to incorporation into another controller dataset
  - E.g., geometric networks, network datasets, or utility networks (at 10.6/2.1)

- Once data is considered good, the topology is deleted and the participant features are then incorporated into another dataset



Data Models and Performance

Good Ideas

- Choose your spatial domain carefully
  - Resolution should be much smaller than data capture accuracy
- Use the default cluster tolerance
- Couple with network dataset for network routing
- Model only those relationships that are important
- Minimize class count and utilize subtypes
  - Cursors are expensive
  - Pro 2.1 will introduce Subtype Layers that will aid this process

Good Ideas

- Avoid classes containing small number of large features
  - Nation or state polygon
- Consider periodic GP tools for QA/QC
  - Avoidance of large polygons (e.g., nation or state)
- Always prototype the data model

Bad Ideas

- Using a topology with a very large cluster tolerance to clean up bad data
  - Instead, use GP tools (e.g., Integrate)
- Coincident geometrically identical features
  - Stack of polygons representing a multi-story condo with no-overlap rule
- Extremely small features
  - Approximately cluster tolerance size

Topology at 10.1

- Support for schema changes to versioned topologies without having to un-version the feature dataset
  - Add a feature class to or remove one from the topology
  - Add or remove a topology rule
  - Change tolerance or rank
- New GP tool (Export Topology Errors) that allows you to export topology errors as feature classes
- Improved editing tools for maintaining topological data
  - According to Colin, some users are stoked…

Topology today

- Topology was not supported in the early releases of ArcGIS Pro
  - It is supported in ArcGIS Desktop 8.3
- Topology is supported in ArcGIS Pro 1.3

Topology Summary

Summary

- Very flexible
  - You pick the topology rules
  - You decide how to handle errors
  - You control the workflow
  - You can extend the functionality
- Easy to use
  - Wizard for defining
  - Topological editing tools
  - Error correction tools

Summary

- High performance
  - User controlled validation process
  - Incremental validation
- Scalable
  - Nationwide datasets
  - Versioned RDBMS
- Complete geodatabase integration
  - Versioning
  - Copy/paste, XML import/export
  - Replication, distributed geodatabases
  - ArcGIS Server

Understanding our world.