NXConnect: Multi-User CAX on a Commercial Engineering Software Application

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Presentation Outline

• Motivation
• Background
• NX Multi-user Prototype
• NX Multi-user Demo
• NX Skype Demo
• NX Design Rational Capture/Reuse Demo
• Summary
The multi-user CAx problem

One user, one app, one cursor!
The multi-user CAx problem

Serial process architectures result in poor user collaboration with numerous feedback modifications.

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The multi-user CAXx problem

It doesn't matter how close you sit, if your CAXx apps can't share your ideas and models!

Collaboration occurs when multi-users share CAXx apps, processes, models, ideas, worlds and compute clouds.

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The multi-user CAx problem

- CAx software apps *not designed for multi-users*.
- PLM systems assign *file edit rights to one individual*.
- Windows sharing only supports *one active user per window*.
- **Security** - current global methods expose IP to many groups.
- Industry *dependent on current CAx technologies*.
- CAx developers and distributors *dependent on industry*.
- Competition makes *architectural change almost impossible*.
- Challenge of collaboration among *different cultural groups*.

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Current state-of-the-art

Acknowledgements

To the researchers in multi-input and multi-touch technologies over several decades. Multi-touch is a rather recent addition to our PDA and computer interfaces. (Lee, Buxton, Smith, Wellner, Boie, …)
Current state-of-the-art
Acknowledgements

To the many researchers over the last 15 years in multi-user CAx and network gaming. Their advances proved that multi-user collaboration is feasible and effective.

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Current state-of-the-art
Collaborative architectures

- GoogleDocs (CS)
- Sun et al. (CS) – CoWord, TA/OT
- Zheng et al. – CoAutoCAD (TA methods, early research)
- Ramani et al. (CS) – CADDAC (ACIS at server)
- Cera et al. (CS) – MUG (Java3D, OpenGL)
- Jing et al. (P2P) – RCCS (ACIS)
- Li et al. – review paper, CS dominant, security weakness, network latencies
- Liu et al. (CS) – Co-CAD, software agents

CS = Client Server
P2P = Peer-to-Peer
TA/OT = Transparent Adaptation/Operational Transformation

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Current state-of-the-art
Collaborative infrastructure

- Chen et al. (CS) – DCCAD, adaptable modules for common functionalities
- Barbosa et al. (CS) – design objects, ACIS
- Bonneau et al. - model decomposition
- Fan et al. (CS/P2P) – grid sharing of resources

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Current state-of-the-art
Collaborative interfaces & tools

- Liu et al. (CS) – agent software at each user site (earlier ref.)
- Shen et al. (CS) – Augmented Reality models at each site
- Wallace et al. – X windows multi-cursors, multi-apps, time share cursors
- Xu et al. - broadcast user GUI events rather than CAD API events
- Multi-touch – TeamPlayer, etc.
Current state-of-the-art
Model sharing & security

- Wang et al. – selective information sharing
- Cera et al. – role based viewing, model partitioning, information
- General observation – less work in collaborative security than might be expected.
Current state-of-the-art

Constraints & conflict resolution

- Jing (earlier ref.) – local locking
- Bu et al. - semantic locking, user negotiation
- Chen et al. (CS) – e-Assembly, assembly constraints
- Dempski et al. – large touch screen displays, one input
- Lin et al. – multi-user constraint management difficult
- Lu et al. – socio-perspectives
- Panchal et al. – multi-designers gradually reduce design space
- Ram et al. – ODBS to propagate design constraints
- Sun et al. – add feature constraints
Current state-of-the-art

Gaming

- Network speed and strategies
- Reduced network communication latencies between players
- Maintaining data consistency and security for hundreds or thousands of players.
- Data compression and grid prediction algorithms to reduce dynamic data.
- CS - make money and provide security
- P2P - improve network responsiveness
- CS/P2P clustering

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NX Connect prototype
Based on Siemens NX – written in C#

CS architecture

Server (thin)
- Information Storage Module
- Data Capture Module
- Data Sync Module
- NX Controller
- CAx Tool

Client (strong)

Server Tables
- Parts
  - Part Name
  - Part ID
- Features
  - Part ID
  - Feature Name
  - Feature ID
- Extrude Feature
  - Feature ID
  - Extrude Name
  - Extrude ID

NX Connect modules

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For each feature the push and pop functionality must be implemented separately. This code shows the pop function.

```csharp
// Read in variables from Database
ExtrudeFeature extrudeFeatureToPop = (from ef in nxconnectdb.ExtrudeFeatures
where ef.ExtrudeFeatureID == ExtrudeID
select ef).FirstOrDefault();

string nameOfSketch = extrudeFeatureToPop.nameOfSketch;
string EndExtendValueRightHandSide = extrudeFeatureToPop.endExtendValueRightHandSide;
string EndOffsetRightHandSide = extrudeFeatureToPop.endOffsetRightHandSide;
string StartExtendValueRightHandSide = extrudeFeatureToPop.startExtendValueRightHandSide;
double helpPointX = (double)extrudeFeatureToPop.helpPointX;
double helpPointY = (double)extrudeFeatureToPop.helpPointY;
double helpPointZ = (double)extrudeFeatureToPop.helpPointZ;

// Set up Extrude Builder
NXOpen.Features.Feature nullFeatures_Feature = null;
NXOpen.Features.ExtrudeBuilder extrudeBuilder1 = extrudeBuilder1 = workPart.FEATURES.CreateExtrudeBuilder(nullFeatures_Feature);

// Read variables into the Extrude Builder
 Sketch sketch1 = (Sketch)workPart.SketchesFindObject(nameOfSketch);
NXOpen.Direction direction1;
direction1 = workPart.DIRECTIONS.CreateDirection(sketch1, dirSense, withinOrWithoutModeling);
extrudeBuilder1.Direction = direction1;
extrudeBuilder1.Limits.EndExtendValue.RightHandSide = EndExtendValueRightHandSide.ToString();

// Create Extrusion
NXOpen.Features.Feature feature1 = extrudeBuilder1.CommitFeature();
```
Multi-User NX Demo
Single User CAD vs Multi-User CAD
NX Connect limitations

- NX architecture presumes single user (passes object handles among API’s).
- Can’t access NX event handler through API; rather must access undo markers.
- NX sketch session blocks API interruption until geometry complete.
- NX does not consider multiple cursors or multiple viewpoints.
- NX Connect only tested datum planes, sketches, extrusions, Booleans, and revolutions (no surfaces, NURBS, etc.)
NX Connect observation

- *Internet latency* is a challenge to multi-user CAx.
- *CS is dominant* network architecture – better model security.
- *Hybrid and P2P architectures* more responsive, less controllable.
- *User density* challenges gaming, not a problem in CAx.
- *Replication* in all multi-user prototypes (data, application, control).
- *Communication between virtual modelers is essential.*
NX Skype Demo

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NX Skype limitations

- Partial integration
  - Only Skype to Skype
  - No video,
  - Only P2P, no conferencing
- IM cut and paste not implemented
- No method for syncing viewing transforms, i.e. application sharing
NX Skype observation

- *Internet latency* appear to be no worse than regular Skype.
- *Skype conferencing (more than P2P)* is essential.
- *Communicator may provide a better solution.*
- *Capturing the in-process virtual design team collaborations (i.e. design rational)* will be important for model reuse and documentation.
NX Design Rational Capture Demo

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Why was the hole size set to 3mm?
NX Design Rational limitations

- Partial integration
  - Audio
  - IM
  - Screen grabs
- Searches keywords (attributes) and text
- No audio scanning/searching
- Only 1x and 2x speed for replay of screen grabbed frames
NX Design Rational observation

- Need to leverage the previous Design Rational research
- Need a more complete/sophisticated inference engine
- Inference engine needs to be contextually linked to global engineering design standards
- Inference engine needs to be culturally neutral, yet provide appropriate cultural understanding and transforms

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Summary

- Multi-user CAx is **feasible and practical**, with changes/additions to existing API’s and design procedures
  - Modifications are needed to Graphic Kernels
  - Major modifications are needed to the CAx GUIs
- Design processes for complex parts and assemblies can now be done collaboratively and concurrently
- Development of ϱ-CAx applications must be influenced and guided by industry

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e-Design Center: v-CAx Planning Meeting

- August 11th - August 13th, 2010 Snowbird, UT
  (UPRM IAB meeting in Puerto Rico)

http://www.et.byu.edu/~ered/v-CAx/index.html
Login: v-CAx  Password: multiuser

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