



# Media Engineering Programming Tools

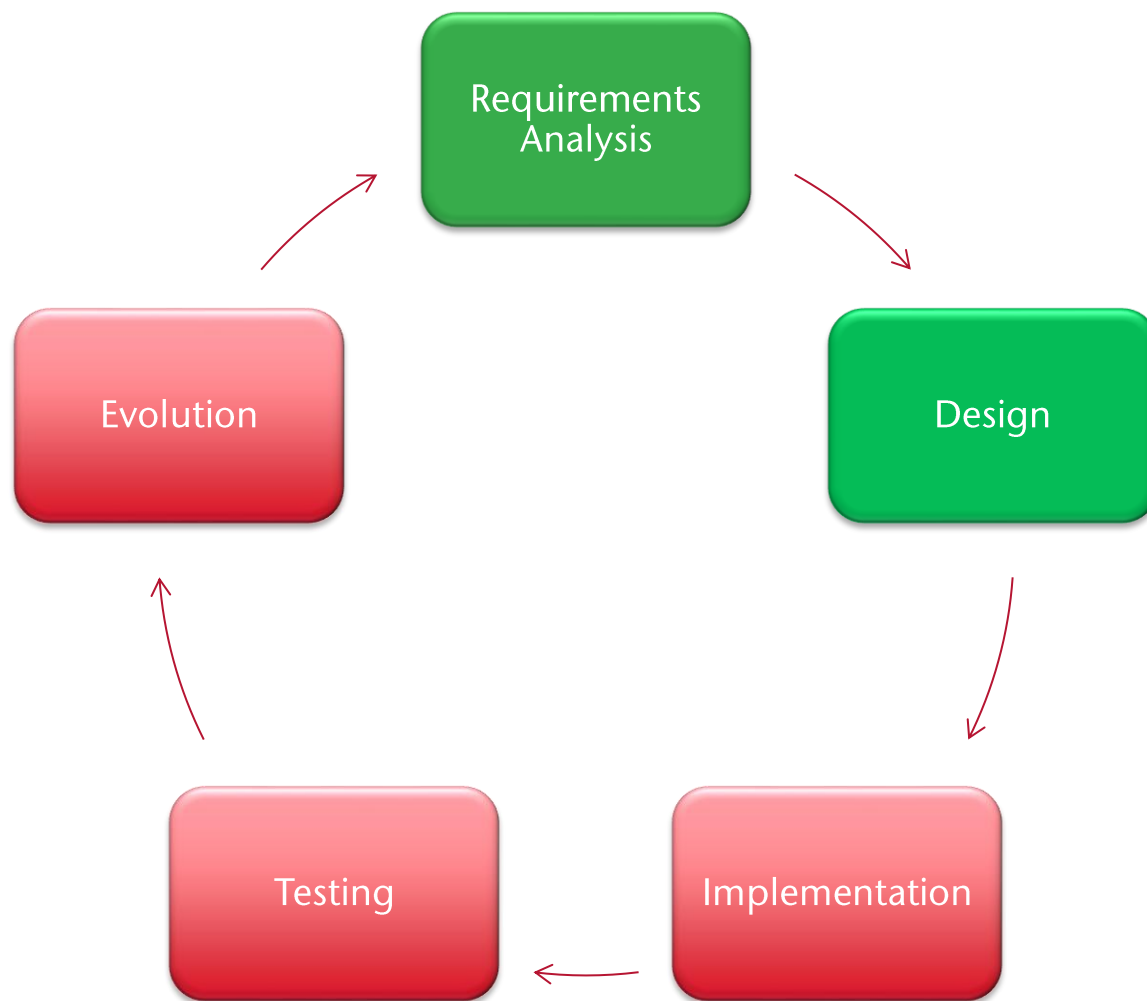


R. Weller

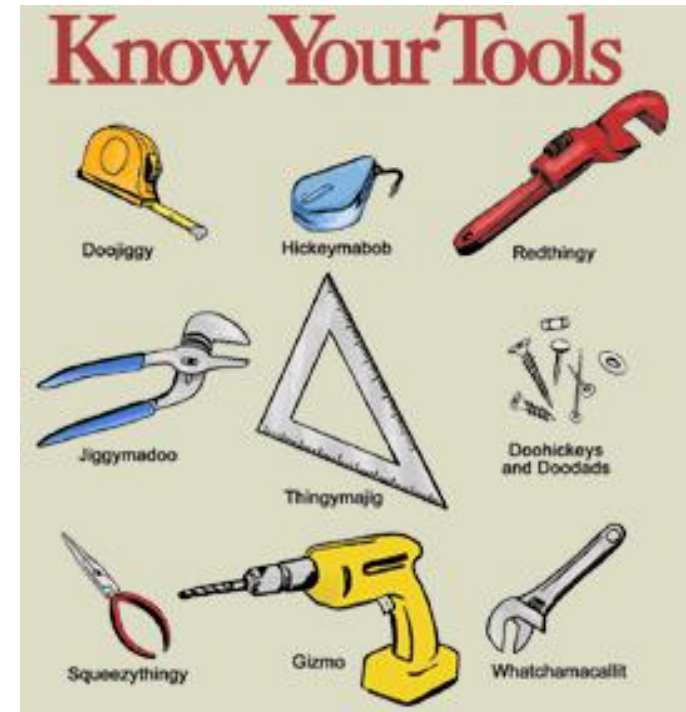
University of Bremen, Germany

[cgvr.cs.uni-bremen.de](http://cgvr.cs.uni-bremen.de)

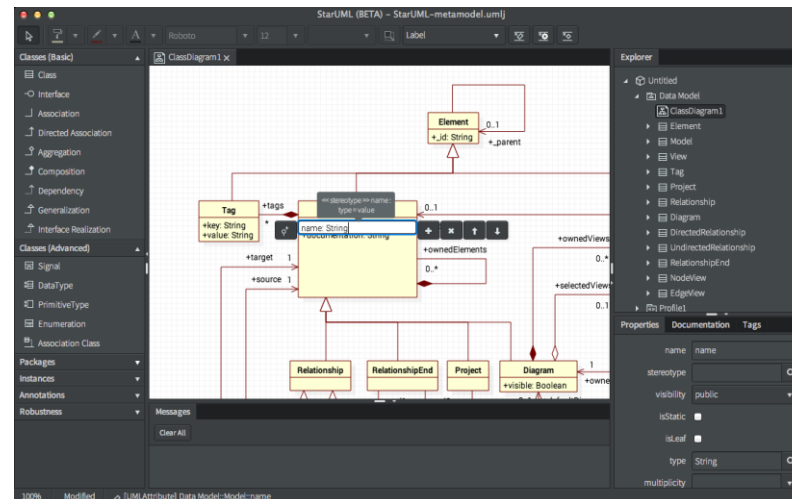
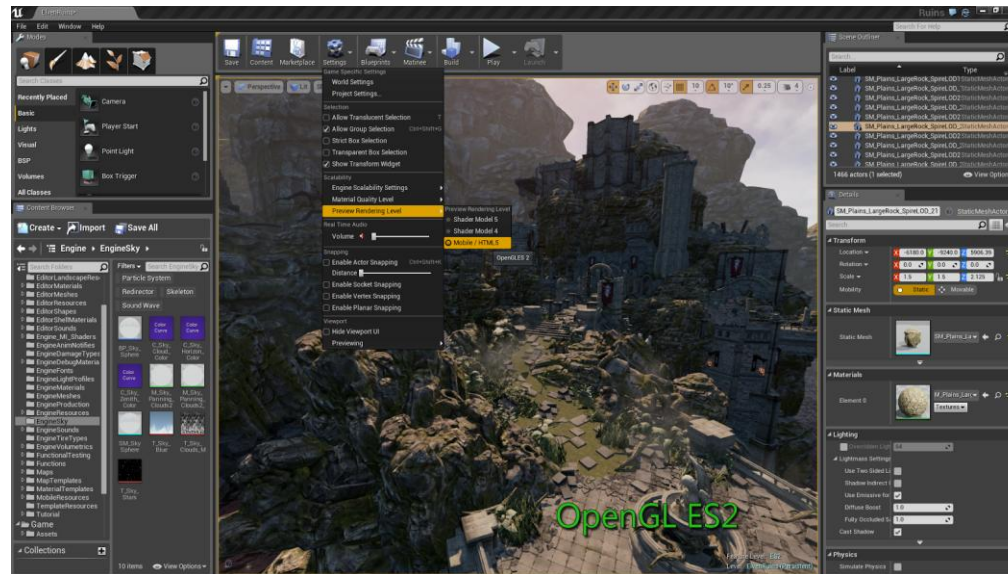
# Der Software Development-Lifecycle



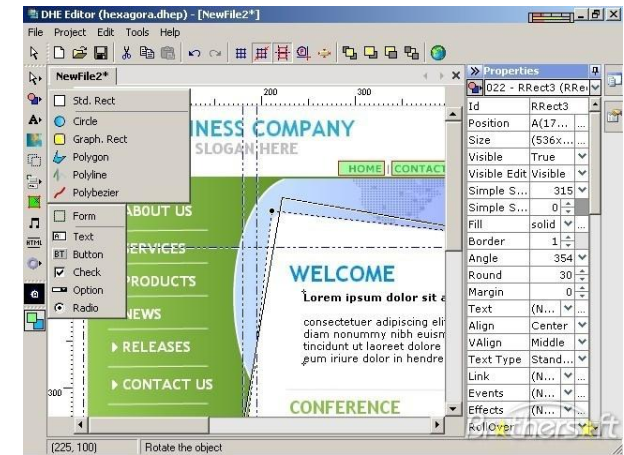
# Also endlich?



# Einige Tools kennen wir schon



# Viele Werkzeuge für digitale Medien



- In dieser Vorlesung beschränken wir uns auf **Programmierwerkzeuge**

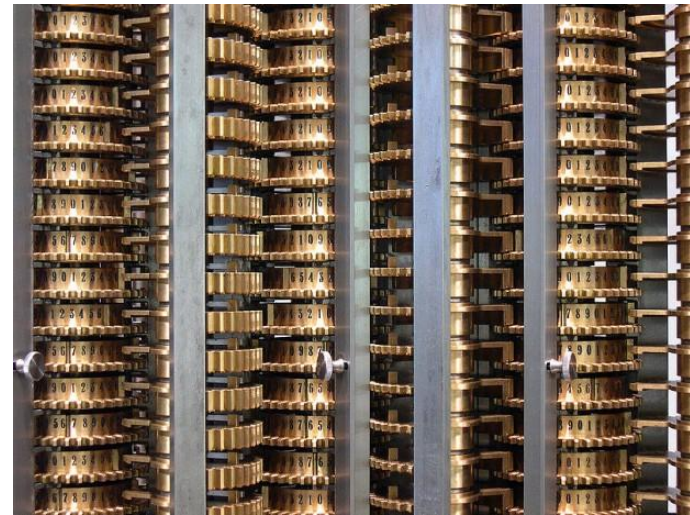
# Programmierung – Die Anfänge

Diagram for the comparison by the Engines of the Numbers of Bernoulli. See Note G. (page 279 of sup.)

| Number of Operations. | Variables and signs.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Variables and signs, results. | Indication of change in the value as any Variable varies. | Statement of Results. | Data                                    |                                         |                                         |                                         |                                         |                                         |                                         |                                         |                                         |                                           | Working Variables                         |                                           |                                           |                                           | Result Variables                          |                                           |                                           |  |
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                               |                                                           |                       | $\frac{1}{1} + \frac{1}{1} \frac{1}{2}$ | $\frac{1}{2} + \frac{1}{2} \frac{1}{2}$ | $\frac{1}{3} + \frac{1}{3} \frac{1}{2}$ | $\frac{1}{4} + \frac{1}{4} \frac{1}{2}$ | $\frac{1}{5} + \frac{1}{5} \frac{1}{2}$ | $\frac{1}{6} + \frac{1}{6} \frac{1}{2}$ | $\frac{1}{7} + \frac{1}{7} \frac{1}{2}$ | $\frac{1}{8} + \frac{1}{8} \frac{1}{2}$ | $\frac{1}{9} + \frac{1}{9} \frac{1}{2}$ | $\frac{1}{10} + \frac{1}{10} \frac{1}{2}$ | $\frac{1}{11} + \frac{1}{11} \frac{1}{2}$ | $\frac{1}{12} + \frac{1}{12} \frac{1}{2}$ | $\frac{1}{13} + \frac{1}{13} \frac{1}{2}$ | $\frac{1}{14} + \frac{1}{14} \frac{1}{2}$ | $\frac{1}{15} + \frac{1}{15} \frac{1}{2}$ | $\frac{1}{16} + \frac{1}{16} \frac{1}{2}$ | $\frac{1}{17} + \frac{1}{17} \frac{1}{2}$ |  |
| 1                     | $x = V_1, V_2, V_3, V_4, V_5, V_6, V_7, V_8, V_9, V_{10}, V_{11}, V_{12}, V_{13}, V_{14}, V_{15}, V_{16}, V_{17}, V_{18}, V_{19}, V_{20}, V_{21}, V_{22}, V_{23}, V_{24}, V_{25}, V_{26}, V_{27}, V_{28}, V_{29}, V_{30}, V_{31}, V_{32}, V_{33}, V_{34}, V_{35}, V_{36}, V_{37}, V_{38}, V_{39}, V_{40}, V_{41}, V_{42}, V_{43}, V_{44}, V_{45}, V_{46}, V_{47}, V_{48}, V_{49}, V_{50}, V_{51}, V_{52}, V_{53}, V_{54}, V_{55}, V_{56}, V_{57}, V_{58}, V_{59}, V_{60}, V_{61}, V_{62}, V_{63}, V_{64}, V_{65}, V_{66}, V_{67}, V_{68}, V_{69}, V_{70}, V_{71}, V_{72}, V_{73}, V_{74}, V_{75}, V_{76}, V_{77}, V_{78}, V_{79}, V_{80}, V_{81}, V_{82}, V_{83}, V_{84}, V_{85}, V_{86}, V_{87}, V_{88}, V_{89}, V_{90}, V_{91}, V_{92}, V_{93}, V_{94}, V_{95}, V_{96}, V_{97}, V_{98}, V_{99}, V_{100}, V_{101}, V_{102}, V_{103}, V_{104}, V_{105}, V_{106}, V_{107}, V_{108}, V_{109}, V_{110}, V_{111}, V_{112}, V_{113}, V_{114}, V_{115}, V_{116}, V_{117}, V_{118}, V_{119}, V_{120}, V_{121}, V_{122}, V_{123}, V_{124}, V_{125}, V_{126}, V_{127}, V_{128}, V_{129}, V_{130}, V_{131}, V_{132}, V_{133}, V_{134}, V_{135}, V_{136}, V_{137}, V_{138}, V_{139}, V_{140}, V_{141}, V_{142}, V_{143}, V_{144}, V_{145}, V_{146}, V_{147}, V_{148}, V_{149}, V_{150}, V_{151}, V_{152}, V_{153}, V_{154}, V_{155}, V_{156}, V_{157}, V_{158}, V_{159}, V_{160}, V_{161}, V_{162}, V_{163}, V_{164}, V_{165}, V_{166}, V_{167}, V_{168}, V_{169}, V_{170}, V_{171}, V_{172}, V_{173}, V_{174}, V_{175}, V_{176}, V_{177}, V_{178}, V_{179}, V_{180}, V_{181}, V_{182}, V_{183}, V_{184}, V_{185}, V_{186}, V_{187}, V_{188}, V_{189}, V_{190}, V_{191}, V_{192}, V_{193}, V_{194}, V_{195}, V_{196}, V_{197}, V_{198}, V_{199}, V_{200}, V_{201}, V_{202}, V_{203}, V_{204}, V_{205}, V_{206}, V_{207}, V_{208}, V_{209}, V_{210}, V_{211}, V_{212}, V_{213}, V_{214}, V_{215}, V_{216}, V_{217}, V_{218}, V_{219}, V_{220}, V_{221}, V_{222}, V_{223}, V_{224}, V_{225}, V_{226}, V_{227}, V_{228}, V_{229}, V_{230}, V_{231}, V_{232}, 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V_{788}, V_{789}, V_{790}, V_{791}, V_{792}, V_{793}, V_{794}, V_{795}, V_{796}, V_{797}, V_{798}, V_{799}, V_{800}, V_{801}, V_{802}, V_{803}, V_{804}, V_{805}, V_{806}, V_{807}, V_{808}, V_{809}, V_{810}, V_{811}, V_{812}, V_{813}, V_{814}, V_{815}, V_{816}, V_{817}, V_{818}, V_{819}, V_{820}, V_{821}, V_{822}, V_{823}, V_{824}, V_{825}, V_{826}, V_{827}, V_{828}, V_{829}, V_{830}, V_{831}, V_{832}, V_{833}, V_{834}, V_{835}, V_{836}, V_{837}, V_{838}, V_{839}, V_{840}, V_{841}, V_{842}, V_{843}, V_{844}, V_{845}, V_{846}, V_{847}, V_{848}, V_{849}, V_{850}, V_{851}, V_{852}, V_{853}, V_{854}, V_{855}, V_{856}, V_{857}, V_{858}, V_{859}, V_{860}, V_{861}, V_{862}, V_{863}, V_{864}, V_{865}, V_{866}, V_{867}, V_{868}, V_{869}, V_{870}, V_{871}, V_{872}, V_{873}, V_{874}, V_{875}, V_{876}, V_{877}, V_{878}, V_{879}, V_{880}, V_{881}, V_{882}, V_{883}, V_{884}, V_{885}, V_{886}, V_{887}, V_{888}, V_{889}, V_{890}, V_{891}, V_{892}, V_{893}, V_{894}, V_{895}, V_{896}, V_{897}, V_{898}, V_{899}, V_{900}, V_{901}, V_{902}, V_{903}, V_{904}, V_{905}, V_{906}, V_{907}, V_{908}, V_{909}, V_{910}, V_{911}, V_{912}, V_{913}, V_{914}, V_{915}, V_{916}, V_{917}, V_{918}, V_{919}, V_{920}, V_{921}, V_{922}, V_{923}, V_{924}, V_{925}, V_{926}, V_{927}, V_{928}, V_{929}, V_{930}, V_{931}, V_{932}, V_{933}, V_{934}, V_{935}, V_{936}, V_{937}, V_{938}, V_{939}, V_{940}, V_{941}, V_{942}, V_{943}, V_{944}, V_{945}, V_{946}, V_{947}, V_{948}, V_{949}, V_{950}, V_{951}, V_{952}, V_{953}, V_{954}, V_{955}, V_{956}, V_{957}, V_{958}, V_{959}, V_{960}, V_{961}, V_{962}, V_{963}, V_{964}, V_{965}, V_{966}, V_{967}, V_{968}, V_{969}, V_{970}, V_{971}, V_{972}, V_{973}, V_{974}, V_{975}, V_{976}, V_{977}, V_{978}, V_{979}, V_{980}, V_{981}, V_{982}, V_{983}, V_{984}, V_{985}, V_{986}, V_{987}, V_{988}, V_{989}, V_{990}, V_{991}, V_{992}, V_{993}, V_{994}, V_{995}, V_{996}, V_{997}, V_{998}, V_{999}, V_{1000}, V_{1001}, V_{1002}, V_{1003}, V_{1004}, V_{1005}, V_{1006}, V_{1007}, V_{1008}, V_{1009}, V_{1010}, V_{1011}, V_{1012}, V_{1013}, V_{1014}, V_{1015}, V_{1016}, V_{1017}, V_{1018}, V_{1019}, V_{1020}, V_{1021}, V_{1022}, V_{1023}, V_{1024}, V_{1025}, V_{1026}, V_{1027}, V_{1028}, V_{1029}, V_{1030}, V_{1031}, V_{1032}, V_{1033}, V_{1034}, V_{1035}, V_{1036}, V_{1037}, V_{1038}, V_{1039}, V_{1040}, V_{1041}, V_{1042}, V_{1043}, V_{1044}, V_{1045}, V_{1046}, V_{1047}, V_{1048}, V_{1049}, V_{1050}, V_{1051}, V_{1052}, V_{1053}, V_{1054}, V_{1055}, V_{1056}, V_{1057}, V_{1058}, V_{1059}, V_{1060}, V_{1061}, V_{1062}, V_{1063}, V_{1064}, V_{1065}, V_{1066}, V_{1067}, V_{1068}, V_{1069}, V_{1070}, V_{1071}, V_{1072}, V_{1073}, V_{1074}, V_{1075}, V_{1076}, V_{1077}, V_{1078}, V_{1079}, V_{1080}, V_{1081}, V_{1082}, V_{1083}, V_{1084}, V_{1085}, V_{1086}, V_{1087}, V_{1088}, V_{1089}, V_{1090}, V_{1091}, V_{1092}, V_{1093}, V_{1094}, V_{1095}, V_{1096}, V_{1097}, V_{1098}, V_{1099}, V_{1100}, V_{1101}, V_{1102}, V_{1103}, V_{1104}, V_{1105}, V_{1106}, V_{1107}, V_{1108}, V_{1109}, V_{1110}, V_{1111}, V_{1112}, V_{1113}, V_{1114}, V_{1115}, V_{1116}, V_{1117}, V_{1118}, V_{1119}, V_{1120}, V_{1121}, V_{1122}, V_{1123}, V_{1124}, V_{1125}, V_{1126}, V_{1127}, V_{1128}, V_{1129}, V_{1130}, V_{1131}, V_{1132}, V_{1133}, V_{1134}, V_{1135}, V_{1136}, V_{1137}, V_{1138}, V_{1139}, V_{1140}, V_{1141}, V_{1142}, V_{1143}, V_{1144}, V_{1145}, V_{1146}, V_{1147}, V_{1148}, V_{1149}, V_{1150}, V_{1151}, V_{1152}, V_{1153}, V_{1154}, V_{1155}, V_{1156}, V_{1157}, V_{1158}, V_{1159}, V_{1160}, V_{1161}, V_{1162}, V_{1163}, V_{1164}, V_{1165}, V_{1166}, V_{1167}, V_{1168}, V_{1169}, V_{1170}, V_{1171}, V_{1172}, V_{1173}, V_{1174}, V_{1175}, V_{1176}, V_{1177}, V_{1178}, V_{1179}, V_{1180}, V_{1181}, V_{1182}, V_{1183}, V_{1184}, V_{1185}, V_{1186}, V_{1187}, V_{1188}, V_{1189}, V_{1190}, V_{1191}, V_{1192}, V_{1193}, V_{1194}, V_{1195}, V_{1196}, V_{1197}, V_{1198}, V_{1199}, V_{1200}, V_{1201}, V_{1202}, V_{1203}, V_{1204}, V_{1205}, V_{1206}, V_{1207}, V_{1208}, V_{1209}, V_{1210}, V_{1211}, V_{1212}, V_{1213}, V_{1214}, V_{1215}, V_{1216}, V_{1217}, V_{1218}, V_{1219}, V_{1220}, V_{1221}, V_{1222}, V_{1223}, V_{1224}, V_{1225}, V_{1226}, V_{1227}, V_{1228}, V_{1229}, V_{1230}, V_{1231}, V_{1232}, V_{1233}, V_{1234}, V_{1235}, V_{1236}, V_{1237}, V_{1238}, V_{1239}, V_{1240}, V_{1241}, V_{1242}, V_{1243}, V_{1244}, V_{1245}, V_{1246}, V_{1247}, V_{1248}, V_{1249}, V_{1250}, V_{1251}, V_{1252}, V_{1253}, V_{1254}, V_{1255}, V_{1256}, V_{1257}, V_{1258}, V_{1259}, V_{1260}, V_{1261}, V_{1262}, V_{1263}, V_{1264}, V_{1265}, V_{1266}, V_{1267}, V_{1268}, V_{1269}, V_{1270}, V_{1271}, V_{1272}, V_{1273}, V_{1274}, V_{1275}, V_{1276}, V_{1277}, V_{1278}, V_{1279}, V_{1280}, V_{1281}, V_{1282}, V_{1283}, V_{1284}, V_{1285}, V_{1286}, V_{1287}, V_{1288}, V_{1289}, V_{1290}, V_{1291}, V_{1292}, V_{1293}, V_{1294}, V_{1295}, V_{1296}, V_{1297}, V_{1298}, V_{1299}, V_{1300}, V_{1301}, V_{1302}, V_{1303}, V_{1304}, V_{1305}, V_{1306}, V_{1307}, V_{1308}, V_{1309}, V_{1310}, V_{1311}, V_{1312}, V_{1313}, V_{1314}, V_{1315}, V_{1316}, V_{1317}, V_{1318}, V_{1319}, V_{1320}, V_{1321}, V_{1322}, V_{1323}, V_{1324}, V_{1325}, V_{1326}, V_{1327}, V_{1328}, V_{1329}, V_{1330}, V_{1331}, V_{1332}, V_{1333}, V_{1334}, V_{1335}, V_{1336}, V_{1337}, V_{1338}, V_{1339}, V_{1340}, V_{1341}, V_{1342}, V_{1343}, V_{1344}, V_{1345}, V_{1346}, V_{1347}, V_{1348}, V_{1349}, V_{1350}, V_{1351}, V_{1352}, V_{1353}, V_{1354}, V_{1355}, V_{1356}, V_{1357}, V_{1358}, V_{1359}, V_{1360}, V_{1361}, V_{1362}, V_{1363}, V_{1364}, V_{1365}, V_{1366}, V_{1367}, V_{1368}, V_{1369}, V_{1370}, V_{1371}, V_{1372}, V_{1373}, V_{1374}, V_{1375}, V_{1376}, V_{1377}, V_{1378}, V_{1379}, V_{1380}, V_{1381}, V_{1382}, V_{1383}, V_{1384}, V_{1385}, V_{1386}, V_{1387}, V_{1388}, V_{1389}, V_{1390}, V_{1391}, V_{1392}, V_{1393}, V_{1394}, V_{1395}, V_{1396}, V_{1397}, V_{1398}, V_{1399}, V_{1400}, V_{1401}, V_{1402}, V_{1403}, V_{1404}, V_{1405}, V_{1406}, V_{1407}, V_{1408}, V_{1409}, V_{1410}, V_{1411}, V_{1412}, V_{1413}, V_{1414}, V_{1415}, V_{1416}, V_{1417}, V_{1418}, V_{1419}, V_{1420}, V_{1421}, V_{1422}, V_{1423}, V_{1424}, V_{1425}, V_{1426}, V_{1427}, V_{1428}, V_{1429}, V_{1430}, V_{1431}, V_{1432}, V_{1433}, V_{1434}, V_{1435}, V_{1436}, V_{1437}, V_{1438}, V_{1439}, V_{1440}, V_{1441}, V_{1442}, V_{1443}, V_{1444}, V_{1445}, V_{1446}, V_{1447}, V_{1448}, V_{1449}, V_{1450}, V_{1451}, V_{1452}, V_{1453}, V_{1454}, V_{1455}, V_{1456}, V_{1457}, V_{1458}, V_{1459}, V_{1460}, V_{1461}, V_{1462}, V_{1463}, V_{1464}, V_{1465}, V_{1466}, V_{1467}, V_{1468}, V_{1469}, V_{1470}, V_{1471}, V_{1472}, V_{1473}, V_{1474}, V_{1475}, V_{1476}, V_{1477}, V_{1478}, V_{1479}, V_{1480}, V_{1481}, V_{1482}, V_{1483}, V_{1484}, V_{1485}, V_{1486}, V_{1487}, V_{1488}, V_{1489}, V_{1490}, V_{1491}, V_{1492}, V_{1493}, V_{1494}, V_{1495}, V_{1496}, V_{1497}, V_{1498}, V_{1499}, V_{1500}, V_{1501}, V_{1502}, V_{1503}, V_{1504}, V_{1505}, V_{1506}, V_{1507}, V_{1508}, V_{1509}, V_{1510}, V_{1511}, V_{1512}, V_{1513}, V_{1514}, V_{1515}, V_{1516}, V_{1517}, V_{1518}, V_{1519}, V_{1520}, V_{1521}, V_{1522}, V_{1523}, V_{1524}, V_{1525}, V_{1526}, V_{1527}, V_{1528}, V_{1529}, V_{1530}, V_{1531}, V_{1532}, V_{1533}, V_{1534}, V_{1535}, V_{1536}, V_{1537}, V_{1538}, V_{1539}, V_{1540}, V_{1541}, V_{1542}, V_{1543}, V_{1544}, V_{1545}, V_{1546}, V_{1547}, V_{1548}, V_{1549}, V_{1550}, V_{1551}, V_{1552}, V_{1553}, V_{1554}, V_{1555}, V_{1556}, V_{1557}, V_{1558}, V_{1559}, V_{1560}, V_{1561}, V_{1562}, V_{1563}, V_{1564}, V_{1565}, V_{1566}, V_{1567}, V_{1568}, V_{1569}, V_{1570}, V_{1571}, V_{1572}, V_{1573}, V_{1574}, V_{1575}, V_{1576}, V_{1577}, V_{1578}, V_{1579}, V_{1580}, V_{1581}, V_{1582}, V_{1583}, V_{1584}, V_{1585}, V_{1586}, V_{1587}, V_{1588}, V_{1589}, V_{1590}, V_{1591}, V_{1592}, V_{1593}, V_{1594}, V_{1595}, V_{1596}, V_{1597}, V_{1598}, V_{1599}, V_{1600}, V_{1601}, V_{1602}, V_{1603}, V_{1604}, V_{1605}, V_{1606}, V_{1607}, V_{1608}, V_{1609}, V_{1610}, V_{1611}, V_{1612}, V_{1613}, V_{1614}, V_{1615}, V_{1616}, V_{1617}, V_{1618}, V_{1619}, V_{1620}, V_{1621}, V_{1622}, V_{1623}, V_{1624}, V_{1625}, V_{1626}, V_{1627}, V_{1628}, V_{1629}, V_{1630}, V_{1631}, V_{1632}, V_{1633}, V_{1634}, V_{1635}, V_{1636}, V_{1637}, V_{1638}, V_{1639}, V_{1640}, V_{1641}, V_{1642}, V_{1643}, V_{1644}, V_{1645}, V_{1646}, V_{1647}, V_{1648}, V_{1649}, V_{1650}, V_{1651}, V_{1652}, V_{1653}, V_{1654}, V_{1655}, V_{1656}, V_{1657}, V_{1658}, V_{1659}, V_{1660}, V_{1661}, V_{1662}, V_{1663}, V_{1664}, V_{1665}, V_{1666}, V_{1667}, V_{1668}, V_{1669}, V_{1670}, V_{1671}, V_{1672}, V_{1673}, V_{1674}, V_{1675}, V_{1676}, V_{1677}, V_{1678}, V_{1679}, V_{1680}, V_{1681}, V_{1682}, V_{1683}, V_{1684}, V_{1685}, V_{1686}, V_{1687}, V_{1688}, V_{1689}, V_{1690}, V_{1691}, V_{1692}, V_{1693}, V_{1694}, V_{1695}, V_{1696}, V_{1697}, V_{1698}, V_{1699}, V_{1700}, V_{1701}, V_{1702}, V_{1703}, V_{1704}, V_{1705}, V_{1706}, V_{1707}, V_{1708}, V_{1709}, V_{1710}, V_{1711}, V_{1712}, V_{1713}, V_{1714}, V_{1715}, V_{1716}, V_{1717}, V_{1718}, V_{1719}, V_{1720}, V_{1721}, V_{1722}, V_{1723}, V_{1724}, V_{1725}, V_{1726}, V_{1727}, V_{1728}, V_{1729}, V_{1730}, V_{1731}, V_{1732}, V_{1733}, V_{1734}, V_{1735}, V_{1736}, V_{1737}, V_{1738}, V_{1739}, V_{1740}, V_{1741}, V_{1742}, V_{1743}, V_{1744}, V_{1745}, V_{1746}, V_{1747}, V_{1748}, V_{1749}, V_{1750}, V_{1751}, V_{1752}, V_{1753}, V_{1754}, V_{1755}, V_{1756}, V_{1757}, V_{1758}, V_{1759}, V_{1760}, V_{1761}, V_{1762}, V_{1763}, V_{1764}, V_{1765}, V_{1766}, V_{1767}, V_{1768}, V_{1769}, V_{1770}, V_{1771}, V_{1772}, V_{1773}, V_{1774}, V_{1775}, V_{1776}, V_{1777}, V_{1778}, V_{1779}, V_{1780}, V_{1781}, V_{1782}, V_{1783}, V_{1784}, V_{1785}, V_{1786}, V_{1787}, V_{1788}, V_{1789}, V_{1790}, V_{1791}, V_{1792}, V_{1793}, V_{1794}, V_{1795}, V_{1796}, V_{1797}, V_{1798}, V_{1799}, V_{1800}, V_{1801}, V_{1802}, V_{1803}, V_{1804}, V_{1805}, V_{1806}, V_{1807}, V_{1808}, V_{1809}, V_{1810}, V_{1811}, V_{1812}, V_{1813}, V_{1814}, V_{1815}, V_{1816}, V_{1817}, V_{1818}, V_{1819}, V_{1820}, V_{1821}, V_{1822}, V_{1823}, V_{1824}, V_{1825}, V_{$ |                               |                                                           |                       |                                         |                                         |                                         |                                         |                                         |                                         |                                         |                                         |                                         |                                           |                                           |                                           |                                           |                                           |                                           |                                           |                                           |  |



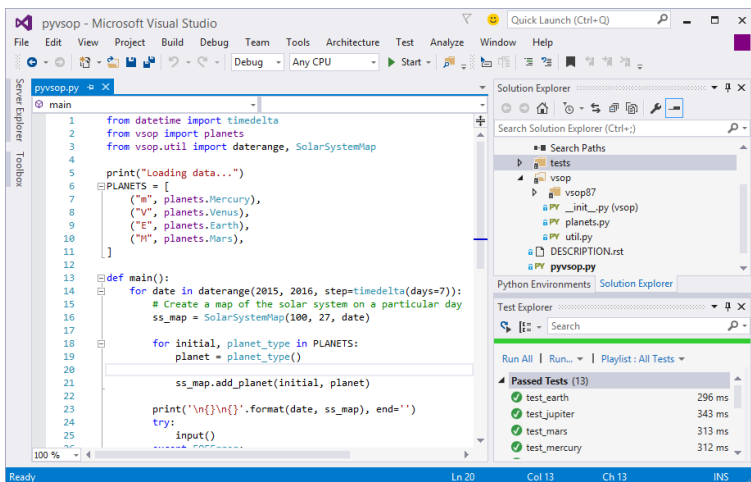
Ada Lovelace  
(1815 – 1852)



# Programmierung im Wandel der Zeit



1969



Heute



1980



2154?

# Weg zum Ausführbaren Programm

## ■ Quellcode

- In C++:
  - Header als \*.h
  - Implementation als \*.cpp – Dateien speichern

```
void CHyfc30bView::OnLButtonDown(UINT nFlags, CPoint point)
{
    // TODO: Add your message handler code here and/or call default
    CHyfc30bDoc* pDoc = GetDocument();
    if (a_tracker.HitTest(point) == CRectTracker::hitMiddle) {
        CObjectSource* pSource = SaveDib();
        if (pSource) {
            // DoDragDrop returns only after drop is complete
            CClientDC dc(this);
            OnPrepareDC(&dc);
            CPoint topLeft = a_rectTracker.TopLeft();
            dc.MoveTo(&topLeft);
            // 'point' here is not the same as the point parameter in
            // OnDragEnter, so we use this one to compute the offset
            a_dragOffset = point - topLeft; // device coordinates
            pDoc->a_bDragHere = TRUE;
            DROPEFFECT dropEffect = pSource->DoDragDrop(
                DROPEFFECT_MOVE | DROPEFFECT_COPY, CRect(0, 0, 0, 0));
            TRACE("after DoDragDrop -- dropEffect = %ld\n", dropEffect);
            if (dropEffect == DROPEFFECT_MOVE && pDoc->a_bDragHere) {
                pDoc->OnEditClearAll();
                pDoc->a_bDragHere = FALSE;
                delete pSource;
            }
        }
        else {
            if (a_tracker.Track(this, point, FALSE, NULL)) {
                CClientDC dc(this);
                OnPrepareDC(&dc);
                // should have some way to prevent it going out of bounds
                a_rectTracker = a_tracker; a_rect;
                dc.DPtoLP(a_rectTracker); // Update logical coords
            }
        }
        Invalidate();
    }
}
```

## ■ Compiler

- Übersetzt Quellcode in maschinenlesbare Sprache



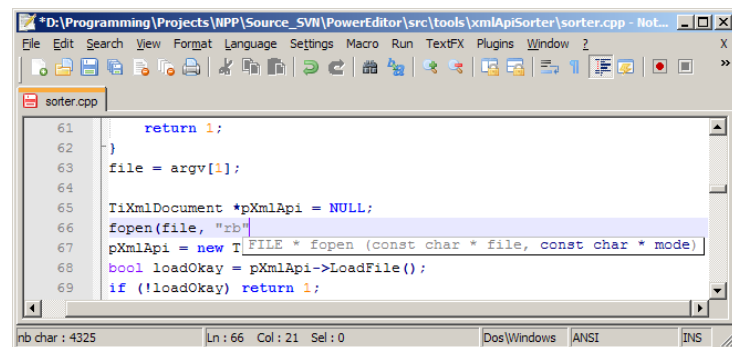
## ■ Linker

- Fasst mehrere kompilierte Module zu Gesamtprogramm zusammen
- Symbolische Adressen von Funktionen oder Variablen werden in Speicheradressen umgewandelt



## ■ Features

- Syntax-Highlighting
- Suchen und Ersetzen
- Code-Faltung
- Codevervollständigung
- Calltips
- Automatische Einrückung
- Symbolbrowser
- Makros



```

=====
idSmokeParticles::init
=====
void idSmokeParticles::init( void ) {
    if ( !initialized ) {
        Shutdown();
    }

    // set up the free list
    for ( int i = 0; i < MAX_SMOKE_PARTICLES-1; i++ ) {
        smokes[i].next = &smokes[i+1];
    }
    smokes[MAX_SMOKE_PARTICLES-1].next = NULL;
    freeSmokes = &smokes[0];
    numActiveSmokes = 0;

    activeStages.Clear();

    memset( &renderEntity, 0, sizeof( renderEntity ) );

    renderEntity.bounds.Clear();
    renderEntity.axis = Mat3_Identity;
    renderEntity.shaderParams[ SHADERPARAM_RED ] = 1;
    renderEntity.shaderParams[ SHADERPARAM_GREEN ] = 1;
    renderEntity.shaderParams[ SHADERPARAM_BLUE ] = 1;
    renderEntity.shaderParams[3] = 1;

    renderEntity.Model = renderModelManager->allocModel();
    renderEntity.Model->InitEmpty( smokeParticle_SnapshotName );

    // we certainly don't want particle shadows
    renderEntity.noShadow = 1;

    // huge bounds, so it will be present in every world area
    renderEntity.bounds.AddPoint( idVec3( -100000, -100000, -100000 ) );
    renderEntity.bounds.AddPoint( idVec3( 100000, 100000, 100000 ) );

    renderEntity.callback = idSmokeParticles::ModelCallback;
    // add to render list
    renderEntity.Handle = gameRenderWorld->AddEntityDef( &renderEntity );

    currentParticleTime = -1;

    initialized = true;
}
    
```

```

=====
idSmokeParticles::init
=====
void idSmokeParticles::init( void ) {
    if ( !initialized ) {
        Shutdown();
    }

    // set up the free list
    for ( int i = 0; i < MAX_SMOKE_PARTICLES-1; i++ ) {
        smokes[i].next = &smokes[i+1];
    }
    smokes[MAX_SMOKE_PARTICLES-1].next = NULL;
    freeSmokes = &smokes[0];
    numActiveSmokes = 0;

    activeStages.Clear();

    memset( &renderEntity, 0, sizeof( renderEntity ) );

    renderEntity.bounds.Clear();
    renderEntity.axis = Mat3_Identity;
    renderEntity.shaderParams[ SHADERPARAM_RED ] = 1;
    renderEntity.shaderParams[ SHADERPARAM_GREEN ] = 1;
    renderEntity.shaderParams[ SHADERPARAM_BLUE ] = 1;
    renderEntity.shaderParams[3] = 1;

    renderEntity.Model = renderModelManager->allocModel();
    renderEntity.Model->InitEmpty( smokeParticle_SnapshotName );

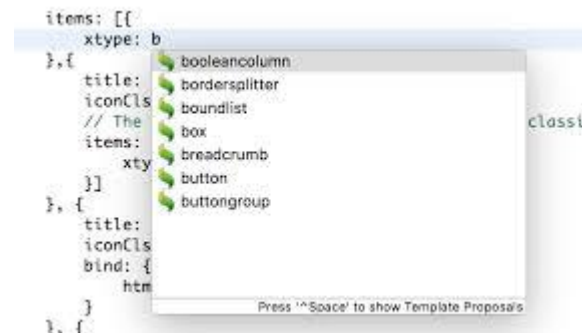
    // we certainly don't want particle shadows
    renderEntity.noShadow = 1;

    // huge bounds, so it will be present in every world area
    renderEntity.bounds.AddPoint( idVec3( -100000, -100000, -100000 ) );
    renderEntity.bounds.AddPoint( idVec3( 100000, 100000, 100000 ) );

    renderEntity.callback = idSmokeParticles::ModelCallback;
    // add to render list
    renderEntity.Handle = gameRenderWorld->AddEntityDef( &renderEntity );

    currentParticleTime = -1;

    initialized = true;
}
    
```





# Warum braucht man schönen Code?

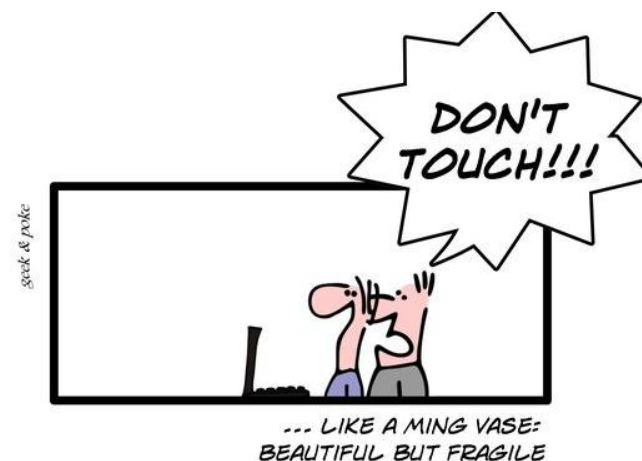
- „Schönen“ Code schreibt man nicht (nur) für sich selbst
  - Programmieren heute meist Teamarbeit
    - Kollegen müssen den Code auch lesen
  - Wiederverwendbarkeit
    - Eventuell will man Codeteile in Zukunft in anderen Projekten wieder verwenden
  - Wartung
    - 80% der Lebenszeit entfallen auf Wartung
    - Programmierer warten selten selbst



# Wann ist Code schön?

- Ziel: Der perfekte Code ist
  - Lesbar
  - Verständlich
  - Wartbar
- Elemente guten **Programmierstils**
  - Festlegung von Namenskonventionen
    - Benennung von Klassen, Variablen, Funktionen
  - Code-Strukturierung
    - Einrückungen
    - Leerzeichen
    - Zeilenanzahl
  - Dokumentation
    - Kommentare

*GOOD CODE IS...*



# Standards?

- Einige Qualitätsnormen im Softwarebereich fordern die explizite Anwendung von Regelwerken
  - Beispiel: MISRA-C (1998)
- Tatsächlich hängen die Regeln von vielen Faktoren ab
  - Programmiersprache
  - Projektgröße
  - Historische Entwicklung
  - ...
- Beispiele
  - Google Java Style (19 Seiten)
  - GNU Coding Standards (85 Seiten)
  - Linux Kernel Coding Style (3 Seiten)
  - CGVR-Programmierrichtlinien



# Bekannte Namenskonventionen



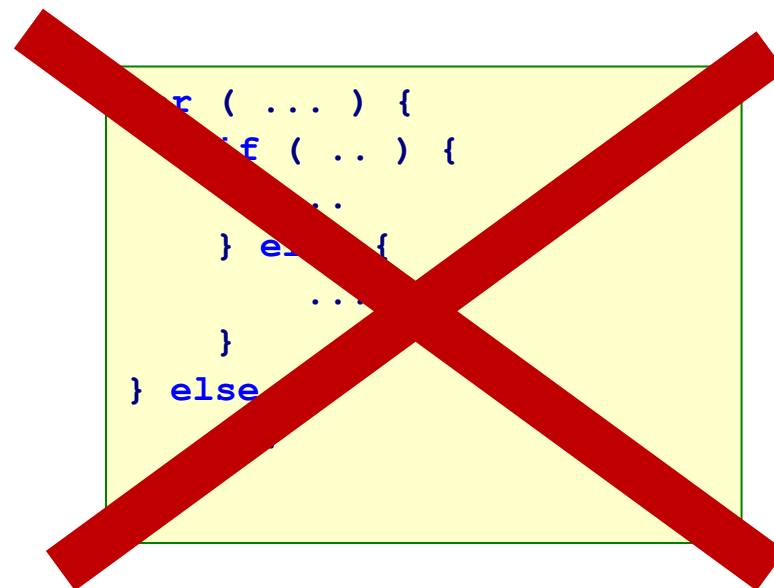
- Ungarische Notation
  - Entwickelt von Charles Simonyi
  - Lange Zeit von Microsoft verwendet
  - Beispiele:
    - Variablennamen setzen sich aus (Präfix) (Datentyp) (Bezeichner) zusammen
    - ichArray, uuluwchArray
  - Namen wegen Herkunft des Erfinders und des exotischen Aussehens
  - Linus Torwalds Meinung: „Encoding the type of a function into the name (so-called Hungarian notation) is brain damaged—the compiler knows the types anyway and can check those, and it only confuses the programmer”
- Ähnliche Konventionen
  - Reddick-Namenskonvention (Microsoft .NET)
  - Leszynski-Namenskonvention (Microsoft Access)

| Art                | Beispiel                   | Erläuterung                       |
|--------------------|----------------------------|-----------------------------------|
| Lokale Variablen   | mylocalvar<br>my_local_var | Alles klein                       |
| Instanzvariablen   | m_var                      | m für „member“                    |
| Klassennamen       | MyCoolClass                | Anfang Groß (ohne „C“ für Klasse) |
| Methoden           | calcSomeCoolValue()        | inCaps, klein anfangen            |
| Konstanten         | const int MaxNum = 10;     | Anfang groß                       |
| Defines            | #define MY_DEFINE          | all-caps mit Underscores          |
| Typedef            | SomethingT                 | Wie Klassen mit Suffix „T“        |
| Enum-Typen         | myEnumTypeE                | Wie Variablen, Suffix E           |
| Enum-Member        | COL_TRUE, COL_FALSE        | Wie Defines                       |
| Template-Parameter | <MyTypeT>                  | Wie Klassennamen, Suffix T        |

# CGVR-Konventionen für Einrückungen

- Allman/“East Coast“-Style
- Einrückung: 4 Leerzeichen
  - Keine Tabulatoren verwenden
- Klammern beginnen in eigener Zeile
  - Leichtere Zuordnung
- Nicht K&R-Style verwenden
  - Vorteil: Code kompakter
    - Aber bei heutiger Monitorauflösung kein Argument mehr
  - Nachteil: Öffnende Klammern werden leicht übersehen

```
for( ... )
{
    if( ... )
    {
        ...
    }
    else
    {
        ...
    }
}
```



```
for( ... ) {
    if ( .. ) {
        ...
    } else {
        ...
    }
} else {
    ...
}
```

# Weitere CGVR-Konventionen

- Nicht mit Leerzeichen sparen

```
for( i = obj->begin(); i < obj->l() && obj->f(i) != -1; i++ )
    obj->M(i) = -1;
}
```

```
for( i = obj->begin(); i < obj->l() && obj->f(i) != -1; i++ )
{
    obj->f(i) = -1;
}
```

- Maximale Zeilenlänge: 80 Zeichen
  - Kürzere Zeilen leichter lesbar
    - Vergleiche mehrspaltigen Satz in Zeitungen
  - Formatierung bleibt beim Ausdrucken vorhanden
  - Bei zu großer Schachtelungstiefe eher in Funktionen auslagern
  - Verhindert zu lange Namen
    - Namenswahl extrem wichtig, lang Klassennamen deuten oft auf Designfehler hin

# CGVR-Konventionen für Klassen

## ■ Klassenlayout

```
class MyClass
{
    public:
        1. Konstanten
        2. Typen
        3. Variablen
        4. Methoden

    protected:
        ...

    private:
        ...

}
```

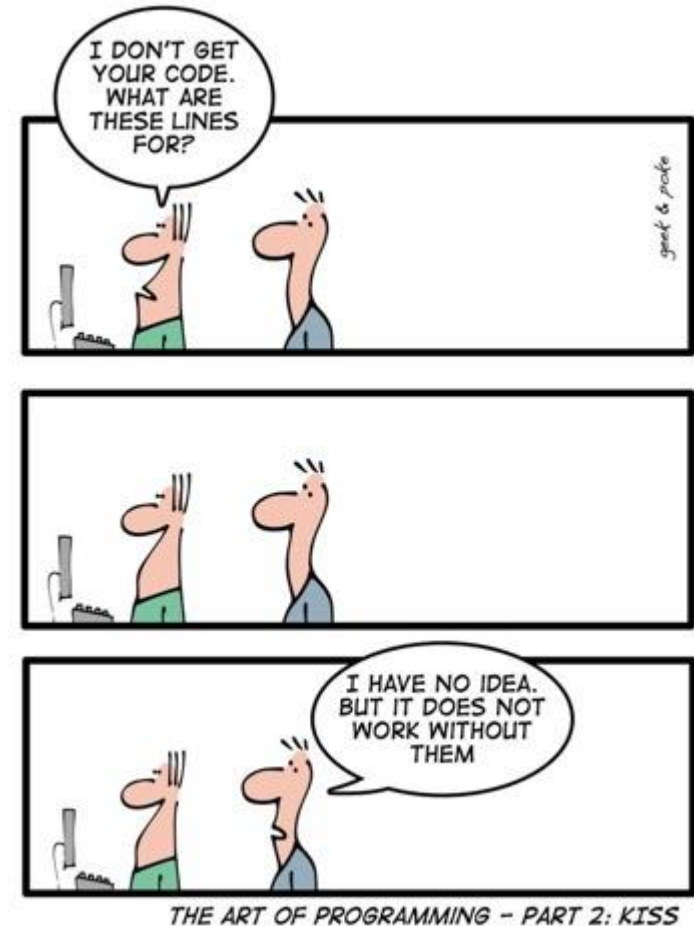
## ■ Tabulieren von Variablen

```
int          x, y;           // dominant coord planes of polygon
int          xturns, yturns; // # turns of xslope, yslope
objPolyhedronP  p1, p2;
int          i;
```

```
int x, y;           // dominant coord planes of polygon
int xturns, yturns; // # turns of xslope, yslope
objPolyhedronP  p1, p2;
int i;
```

# Kommentare

- Mehrere Funktionen
  - Hilft eigene Gedanken zu ordnen (und damit sauberer zu programmieren)
  - Hilft anderen zu verstehen, was passiert
  - Code ist nicht selbsterklärend!
- Wie man es macht und wie nicht
  - „Später“ kommt nie!
  - Optimalerweise dann kommentieren, wenn Funktion „halb“-fertig ist
    - Gedanken noch frisch
    - Anschließend nochmal überprüfen



# Arten von Kommentare

- Grundsätzlich 4 Arten von Kommentaren
  - Am Anfange von Klassen
    - Adressat: Verwender der Klasse
    - Big Picture
    - Besonderheiten (z.B. Compiler-Flags)
  - Vor Funktionen
    - Beschreibung
    - Parameter (besonders Ausgabeparameter kennzeichnen)
    - Pre-/Postconditions
    - Seiteneffekte
  - Vor Variablen
    - Immer vor globalen Variablen
  - Zwischen Code-Abschnitten
    - Beschreiben **was** gemacht wird, nicht **wie**

# Beispiel: Kommentierung einer Funktion

- Diesen Header vor jede Funktion kopieren und ausfüllen!

```
/**  Do something (Einzeiler)
 *
 * @param param1      blubber (in)
 * @param param2      bla (out)
 *
 * @return
 *   Beschreibung der Rückgabe-Werte, z.B.
 *   -1 falls fehlgeschlagen, 0 wenn alles ok.
 *
 * Ausführliche, mehrzeilige Beschreibung, z.B.
 * Diese Funktion berechnet ...
 * Basiert auf dem Algorithmus von ...
 *
 * @throw Exception
 *   Genaue Beschreibung der Exceptions und deren Bedingungen, z.B.
 *   XOutOfMemory, falls kein Speicher mehr verfügbar.
 *   XCoffee, falls kein Kaffee mehr da.
 *
 * @warning
 *   Beschreibung von Eingabe-Parameter-Werten oder Zuständen,
 *   die zu Fehlern oder Abstürzen führen, die aber nicht abgefangen werden.
 *   (sollte nur sehr selten vorkommen!)
```

# Beispiel: Kommentierung einer Funktion (cont)

```
* @pre
*   Genaue Beschreibung der Vorbedingungen, z.B.
*   Erwartet, dass die Funktion init() schon aufgerufen wurde.
*   Param1 muss von der Funktion blub() berechnet worden sein.
*
* @sideeffects
*   Nebenwirkungen, globale Variablen, die verändert werden, ..., z.B.
*   @arg The global variable @c M_Interest will be modified.
*
* @todo
*   Schneller machen.
*
* @bug
*   Produziert einen core dump, wenn @a param1 = 0.0 ist.
*
* @internal
*
* @see
*   Querverweise auf andere Funktionen, z.B., weil sie etwas ähnliches berechnen,
*   oder weil es irgend eine Abhängigkeit zwischen beiden gibt. Beispiel:
*   eineAndereFunktion()
*
**/
```

# Software-Dokumentationswerkzeuge

- Automatische Generierung von Dokumenten aus verschiedenen Quellen
  - Quelltext
  - UML-Diagrammen
- Export als browsbare HTML-, PDF- oder Epub-Dateien
- Beispiele:
  - Doxygen (C++)
  - Javadoc (Java)



# Live-Demo Doxygen

Doxygen GUI frontend +

File Settings Help

Step 1: Specify the working directory from which doxygen will run

C:\Program Files\doxygen\bin Select...

Step 2: Configure doxygen using the Wizard and/or Expert tab, then switch to the Run tab to generate the documentation

Wizard **Expert** Run

Topics

- Project
- Mode
- Output
- Diagrams

Provide some information about the project you are documenting

Project name: CollDet

Project synopsis:

Project version or id:

Project logo: Select... No Project logo selected.

Specify the directory to scan for source code

Source code directory: ktop\CollDetGit - Kopie\CollDet\src Select...

☒ Scan recursively

Specify the directory where doxygen should put the generated documentation

Destination directory: etGit - Kopie\CollDet\Documentation Select...

Previous Next

# Tools für schönen Code?

- Beautifier (auch Quelltext-Formatierer)
  - Formatieren vorhandenen Quelltext gemäß voreingestellter Regeln
  - Beispiel: Prettyprint
- Style Checker
  - Überprüft die Einhaltung eines vorher definierten Programmierstils
  - Führt im Gegensatz zum Beautifier aber meist keine Umformatierung durch
  - Unterstützen oft auch eine (sehr eingeschränkte) semantische Analyse

```
int
foo (int k)
{
    if (k < 1 || k > 2)
    {
        printf ("out of range\n");
        printf ("this function requires of 1 or 2\ ");
    }
    else
    {
        printf ("Switching\n");
        switch (k)
        {
            case 1:
                printf ("1\n");
                break;
            case 2:
                printf ("2\n");
                break;
        }
    }
}
```

```
int foo(int k){if(k<1||k>2){printf("out of range\n");
printf("this function requires a value of 1 or 2\n");}else{
printf("Switching\n");switch(k){case 1:printf("1\n");break;case 2:printf("2\n");break;}}}
```

# Das Gegenteil – Code Obfuscators

- Macht das Gegenteil vom Beautifier
- Ziel: Soll Reverse-Engineering verhindern
  - Security-by-Obscurity
- Beispiel

```
void _ (int __,int ____,int _____,int _____){((
____/____)<=_____)? _ (____,____+_____,_____,_____) : !
(_____%____)? _ (____,____+_____,_____%____,_____) : (
(_____%____)==(_____/____) && !_____)?(printf("%d "
, (_____/____)), _ (____,____+_____,_____,_____)) : ((____
%____)>_____%____&&(_____%____)<(_____/____))?(
____,____+_____,_____+!((_____/____)%(_____%____)),
_____) : (_____  
_____*____)? _ (____,____+_____,
_____,_____) : 0;} int main(void){ _ (50,0,0,1 ) ;}
```

# Kompilieren und Linken

- Speichern aller \*.cpp und \*.h-Dateien
- Aufruf des Compilers
  - Dieser erzeugt \*.obj-Dateien als Zwischenergebnis
- Aufruf des Linkers
  - Zusammenfassen der \*.obj-Dateien (und eventueller externer Abhängigkeiten) zu ausführbarem Programm

```
E:\Zhenya\Program\menuet\article_h11\examples\uc\hello>cl /c /O2 /nologo /GS- /GR- hello.cpp kosFile.cpp kosSyst.cpp mcsmemm.cpp
hello.cpp
kosFile.cpp
kosSyst.cpp
mcsmemm.cpp
Generating Code...

E:\Zhenya\Program\menuet\article_h11\examples\uc\hello>link /nologo /manifest:no
 /entry:crtStartup /subsystem:native /base:0 /fixed /align:16 /nodefaultlib hell
o.obj kosFile.obj kosSyst.obj mcsmemm.obj
LINK : warning LNK4108: /ALIGN specified without /DRIVER; image may not run

E:\Zhenya\Program\menuet\article_h11\examples\uc\hello>pe2kos hello.exe hello

E:\Zhenya\Program\menuet\article_h11\examples\uc\hello>
```

# The Good News



# Integrierte Entwicklungsumgebungen (IDEs)

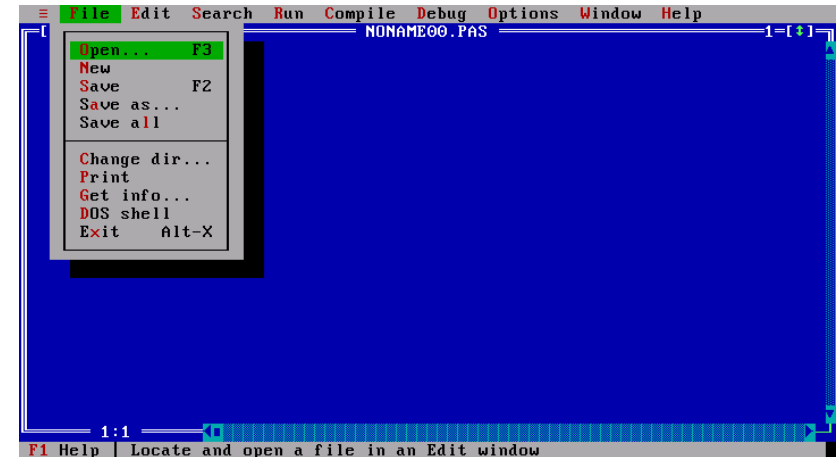
- Quellcode-Editor
- Integrierter (automatisierter) Aufruf von Compiler und Linker
  - Je nach unterstützten Sprachen auch Interpreter
- Oft noch zusätzliche Features:
  - Integrierter Debugger
  - Refactoring
  - Versionsverwaltung
  - Profiling
  - Projektmanagementtools
    - UML-Editoren
  - Werkzeuge für das GUI-Design
  - ...



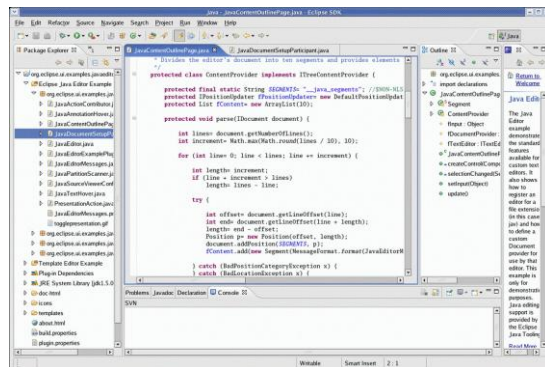
# IDEs - Damals und Heute



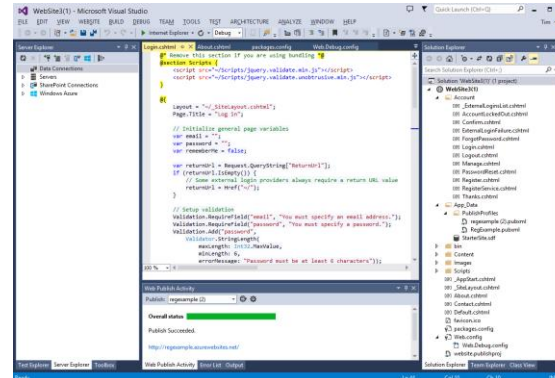
Maestro I (1975)



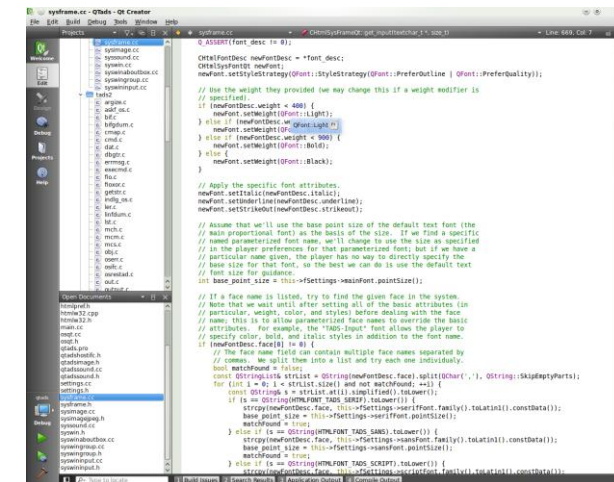
Borland Turbo Pascal (1983)



Eclipse



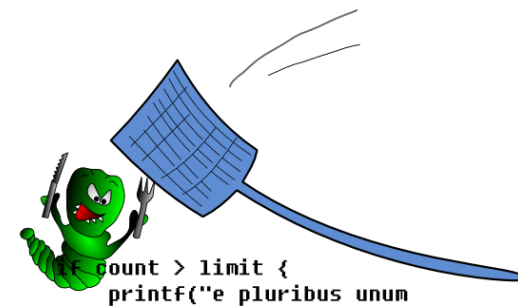
Visual Studio



Qt Creator

# Debugger

- Werkzeug zum Auffinden von Fehlern
  - Vornehmlich in Programmen
  - Gibt es aber auch für Hardware
  - Kann auch zum Reverse-Engineering eingesetzt werden
- Hauptfunktion:
  - Anhalten eines Programms zu beliebigem Zeitpunkt
  - Inspektion des Inhalts des Speichers
- Prinzipiell lässt sich jedes Programm auf Assembler-Ebene debuggen
- Debugger für Hochsprachen bieten aber viele Komfortfunktionen
  - Auflösung von Funktionen
  - Haltepunkte direkt im Quellcode-Editor
  - Ändern von Speicherinhalten



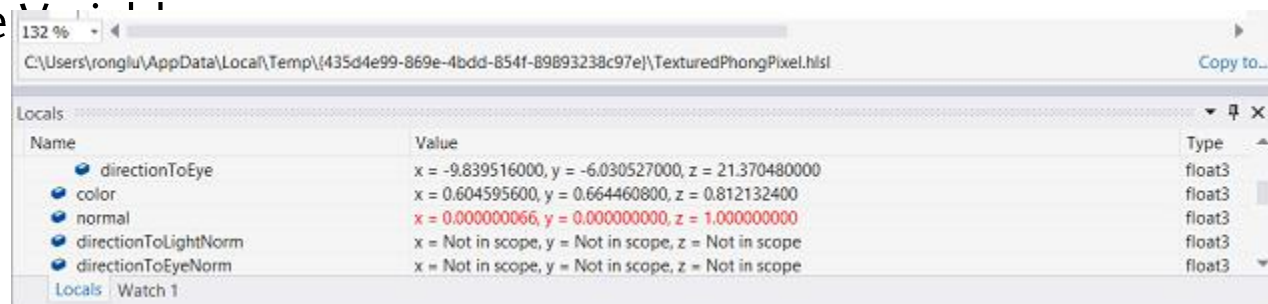
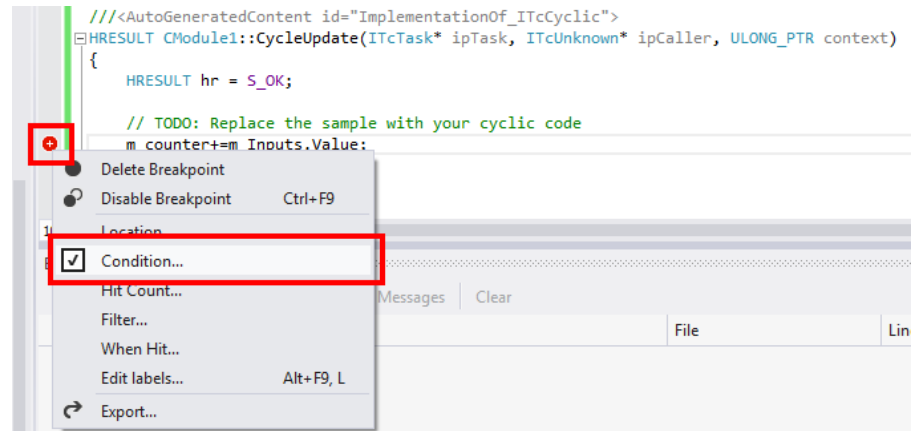
# Debugger-Bestandteile

## ■ Haltepunkte

- Definition von Haltebedingungen

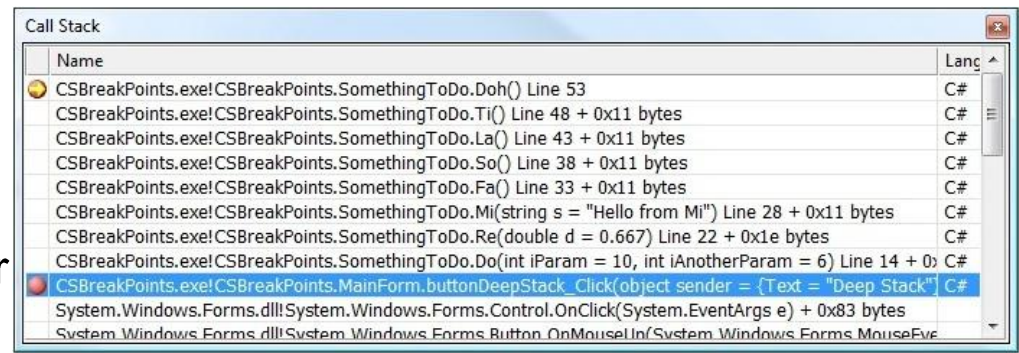
## ■ Darstellung des Speicherinhalts

- Globale und lokale



## ■ Aufrufliste (Call-Stack)

- Zeigt, welche Funktionen vor dem Haltepunkt aufgerufen wurden



**FirefoxDebugging (Debugging) - Microsoft Visual Studio**

File Edit View Project Debug Tools Window Community Help

nsWindow.cpp nsDOMMouseEvent.cpp nsEventListenerManager.h nsBaseWidget.h

(Unknown Scope)

```

4341     case WM_MOUSEMOVE:
4342     {
4343         // Suppress dispatch of pending events
4344         // when mouse moves are generated by widget
4345         // creation instead of user input.
4346         LPARAM lParamScreen = lParamToScreen(lParam);
4347         POINT mp;
4348         mp.x = GET_X_LPARAM(lParamScreen);
4349         mp.y = GET_Y_LPARAM(lParamScreen);
4350         PRBool userMovedMouse = PR_FALSE;
4351         if ((gLastMouseMovePoint.x != mp.x) || (gLastMouseMovePoint.y != mp.y))
    
```

**Autos**

| Name           | Value                        | Type     |
|----------------|------------------------------|----------|
| lParamScreen   | 27263500                     | long     |
| mp             | {x=524 y=416}                | tagPOINT |
| x              | 524                          | long     |
| y              | 416                          | long     |
| mp.y           | 416                          | long     |
| this           | 0x011d2e70 {mLastSize={...}} | nsWindow |
| userMovedMouse | 2147348480                   | int      |

**Call Stack**

| Name                                                          | Lang |
|---------------------------------------------------------------|------|
| gkwidget.dll!nsWindow::ProcessMessage(unsigned int msg= C++   | C++  |
| gkwidget.dll!nsWindow::WindowProc(HWND__ * hWnd=0x0           | C++  |
| user32.dll!77d48734()                                         |      |
| [Frames below may be incorrect and/or missing, no symbols     |      |
| user32.dll!77d48816()                                         |      |
| user32.dll!77d489cd()                                         |      |
| gkwidget.dll!nsAppShell::GetNativeEvent(int & aRealEvent= C++ | C++  |
| appshell.dll!nsXULWindow::ShowModal() Line 405                | C++  |
| appshell.dll!nsContentTreeOwner::ShowAsModal() Line 458       | C++  |

Ready

# Debugging in der Unreal-Engine

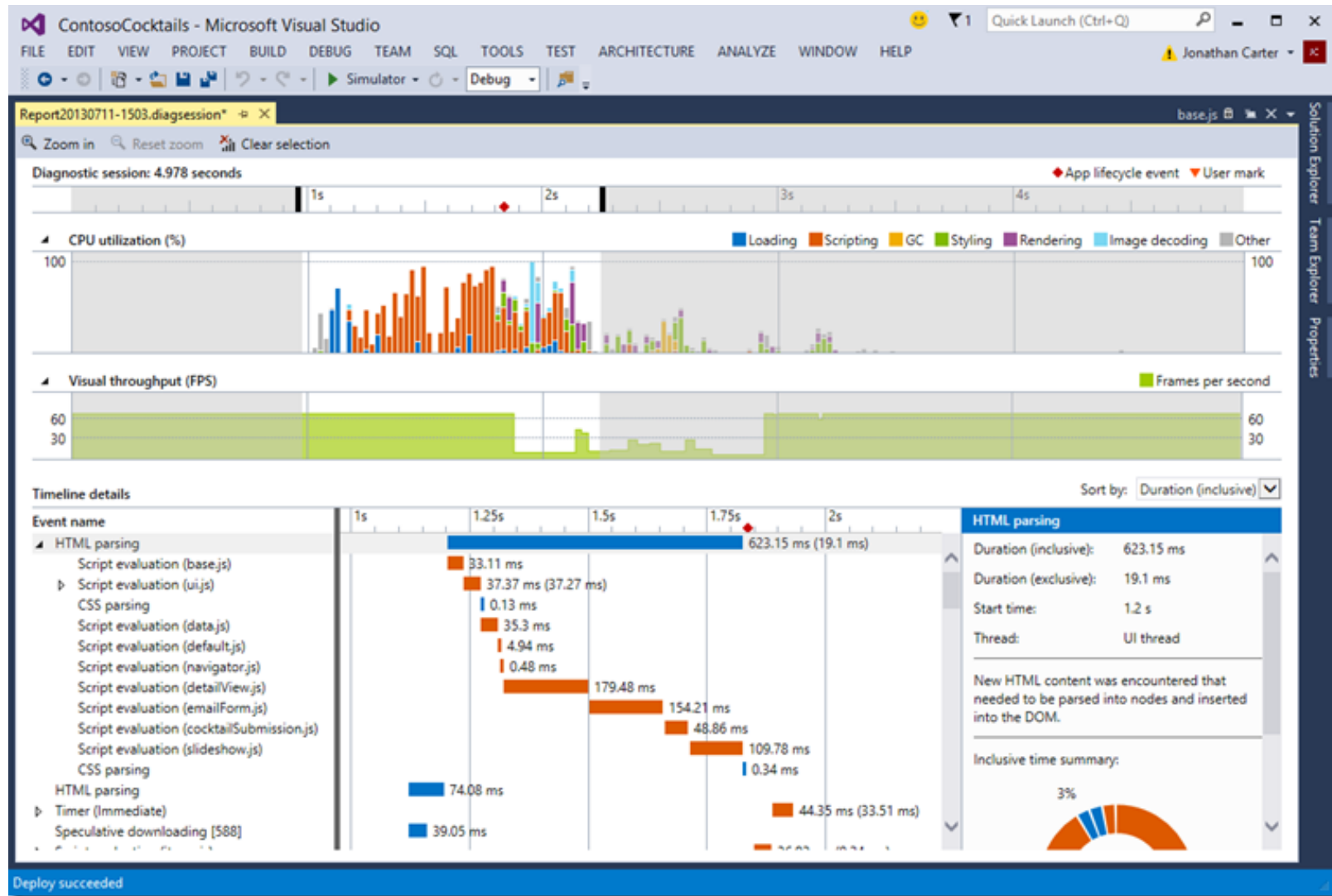
- Die Unreal-Engine bietet neben dem Debugging in der IDE auch Funktionalität für das Debugging von Blueprint

The screenshot displays the Unreal Engine IDE with a Blueprint graph in the center. The graph is titled 'Quadtreesetup > GenerateQuads (READ-ONLY)'. It features several nodes including 'Add pin +', 'Watching Float Return Value' (showing 600.000000), 'Branch' (Condition: True), and 'ABC' nodes. The graph is overlaid with a large yellow 'SIMULATING' text and a blue 'BLUEPRINT' text. The left sidebar shows the 'Components' panel with 'Quadtreesetup (self)' selected, and the 'My Blueprint' panel with 'GenerateQuads' selected. The right sidebar shows the 'Details' panel for 'Actor.h' with various settings like 'Map Dimensions', 'Slice Max Tries', 'Slice Try', 'Slice Break', 'Slice Real Room Min', 'Tile Size', 'Slice Hor X', 'Slice Ver Y', 'Chance to Drop Quad', 'Slices', 'Room Wall Border', and 'Main Loop Index'. The bottom right window is the 'Blueprint Debugger', which shows a table of debug info for selected actors.

| Name                         | Value                          |
|------------------------------|--------------------------------|
| DebuggingExample_3           | 0.000000                       |
| Display Timer                |                                |
| CallFunc_AddRelativeLocation |                                |
| CallFunc_SetText             |                                |
| PersistentLevel_LevelScript1 | No debugging info              |
| Execution Trace              |                                |
| Add Relative Location        | DebuggingExample_9 @ 4313.87 s |
| Event ReceiveTick            | DebuggingExample_9 @ 4313.87 s |
| Event ReceiveTick            | DebuggingExample_9 @ 4313.87 s |
| ConstructionScript           | DebuggingExample_9 @ 4313.86 s |
| ConstructionScript           | DebuggingExample_9 @ 4313.86 s |

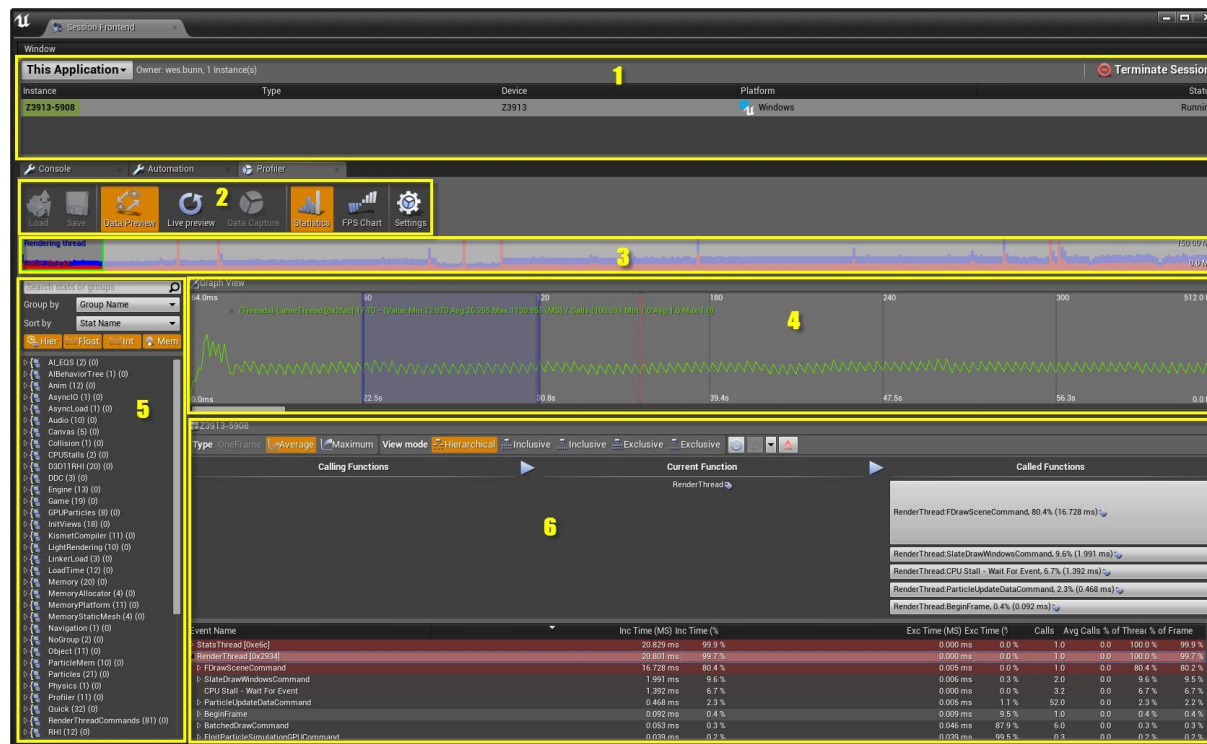
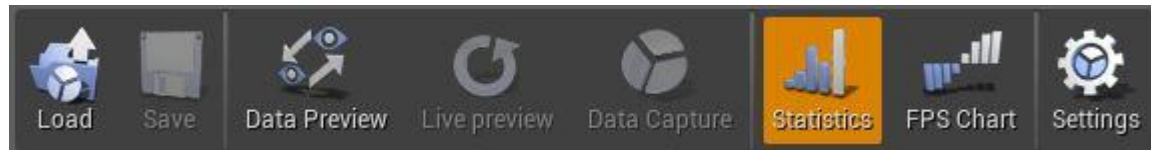
- Werkzeug zur Analyse des Laufzeitverhaltens
  - Helfen Performance-Bottlenecks zu identifizieren
  - Protokollieren während der Laufzeit verschiedene Daten
    - Speicherverbrauch
    - Funktionsaufrufe
    - Berechnungszeiten
    - Nebenläufigkeit
  - Stellen diese Daten meist grafisch dar





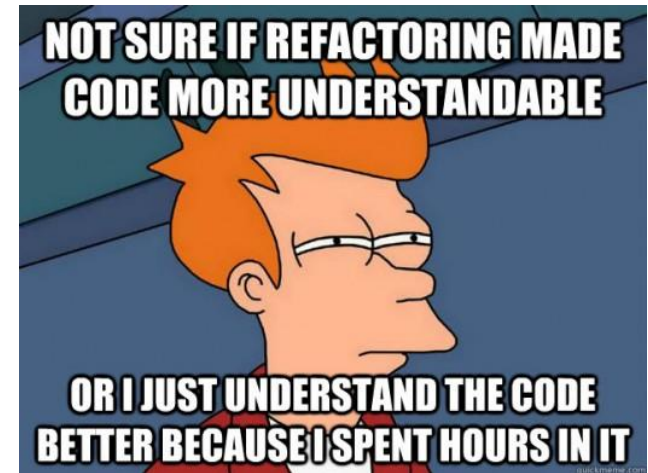
# Profiling in der Unreal-Engine

- Die Unreal-Engine bietet Datensammlung von CPU- und GPU-Daten an um Performance-Bottlenecks zu finden



# Refactoring

- Werkzeug zur **strukturellen Verbesserung** von Quelltexten unter **Beibehaltung des Verhaltens**
- Ziele
  - Lesbarkeit
  - Übersichtlichkeit
  - Verständlichkeit
  - Vermeiden von Redundanzen
- Funktionalitäten
  - Umbenennung von Symbolnamen
  - Aufteilung/Zusammenfassen von Funktionseinheiten (Klassen, Methoden)
  - Verschieben von Symbolen in andere Funktionseinheiten



# Refactoring Beispiel

- Schlecht: Lokale nichtssagende Variable x wird mehrfach verwendet

```
double x = 2 * (breite + hoehe);
cout << "Umfang: " << x << endl;
x = breite * hoehe;
cout << "Fläche: " << x << endl;
```

- Besser: Getrennte Variablen mit aussagekräftigem Namen

```
double umfang = 2 * (breite + hoehe);
cout << "Umfang: " << umfang << endl;
double flaeche = breite * hoehe;
cout << "Fläche: " << flaeche << endl;
```

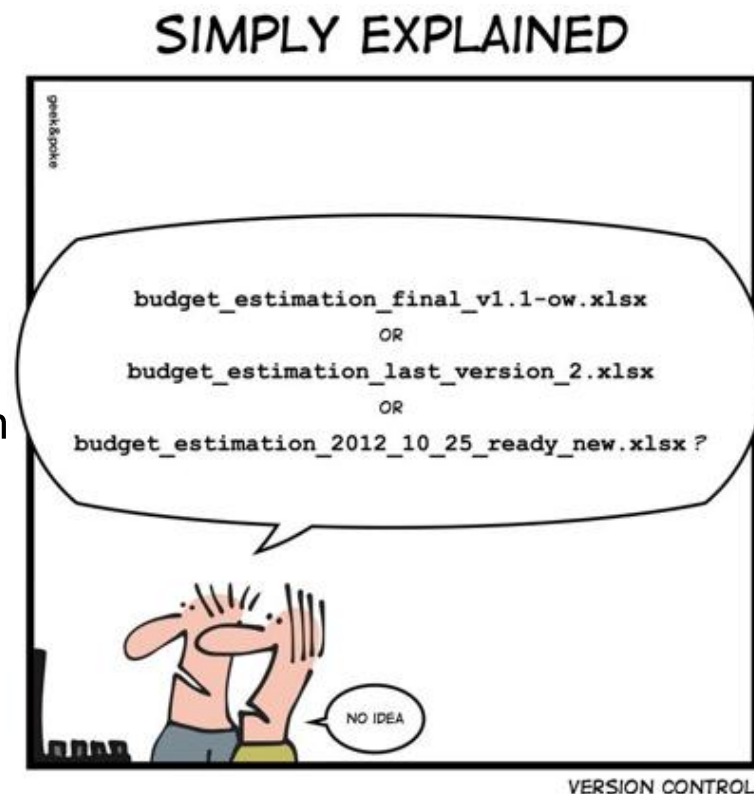
- Andere Variante: Berechnung in Funktionen der Klasse kapseln

```
Rechteck *rect = new Rechteck(breite, hoehe);
cout << "Umfang: " << rect->getUmfang() << endl;
cout << „Flaeche: " << rect->getFlaeche() << endl;
```

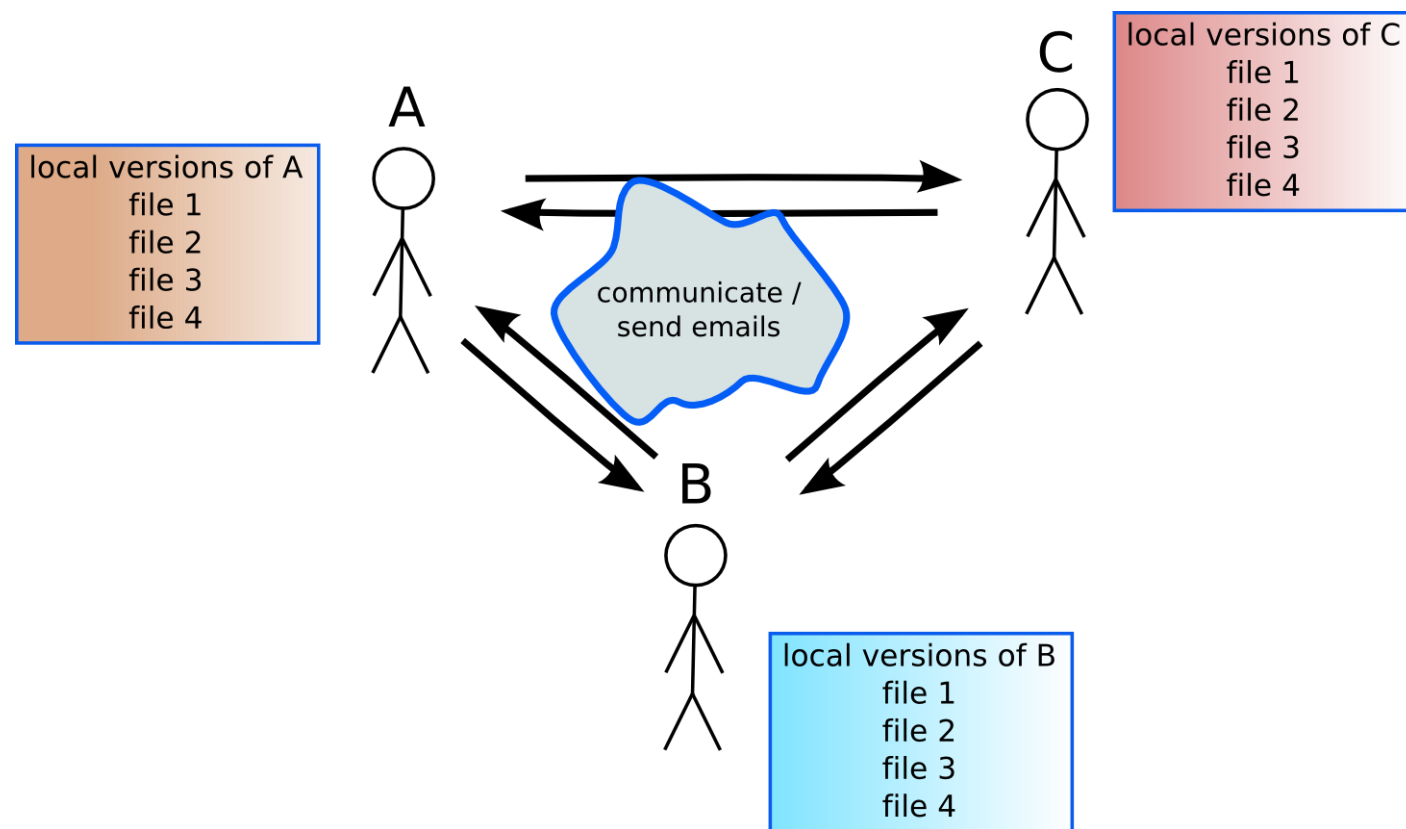
- Wiederverwendbarkeit

# Versionsverwaltung

- Quellcode (aber auch anderen Content, wie Dokumente, Diagramme, ...) zu verwalten ist relativ einfach, wenn nur eine Person am Projekt beteiligt ist
- Bei Teamarbeit treten Probleme auf
  - Die gleiche Datei kann von mehreren Personen gleichzeitig bearbeitet werden
    - Diese können in anderem Raum/Land sitzen
  - Wie garantiert man trotzdem konsistenten Stand des Quellcodes?
    - Jeder muss Änderungen bekommen/sehen
    - Es darf keine Konflikte geben

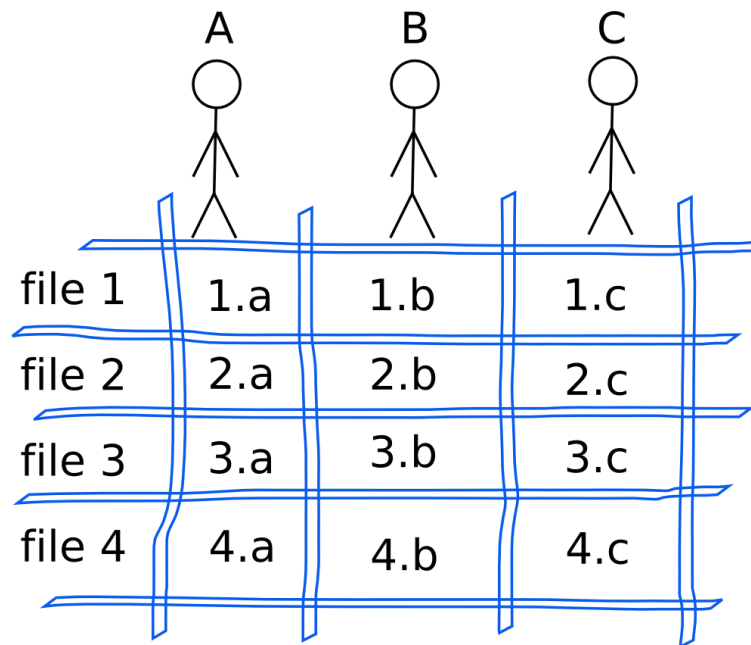


- Versuch 1: Kommunikation via Email
  - Senden der bearbeiteten Dateien an alle anderen Beteiligten
  - Beispiel: 3 Personen in einem Projekt mit 4 Dateien



# Probleme bei Email-Kommunikation

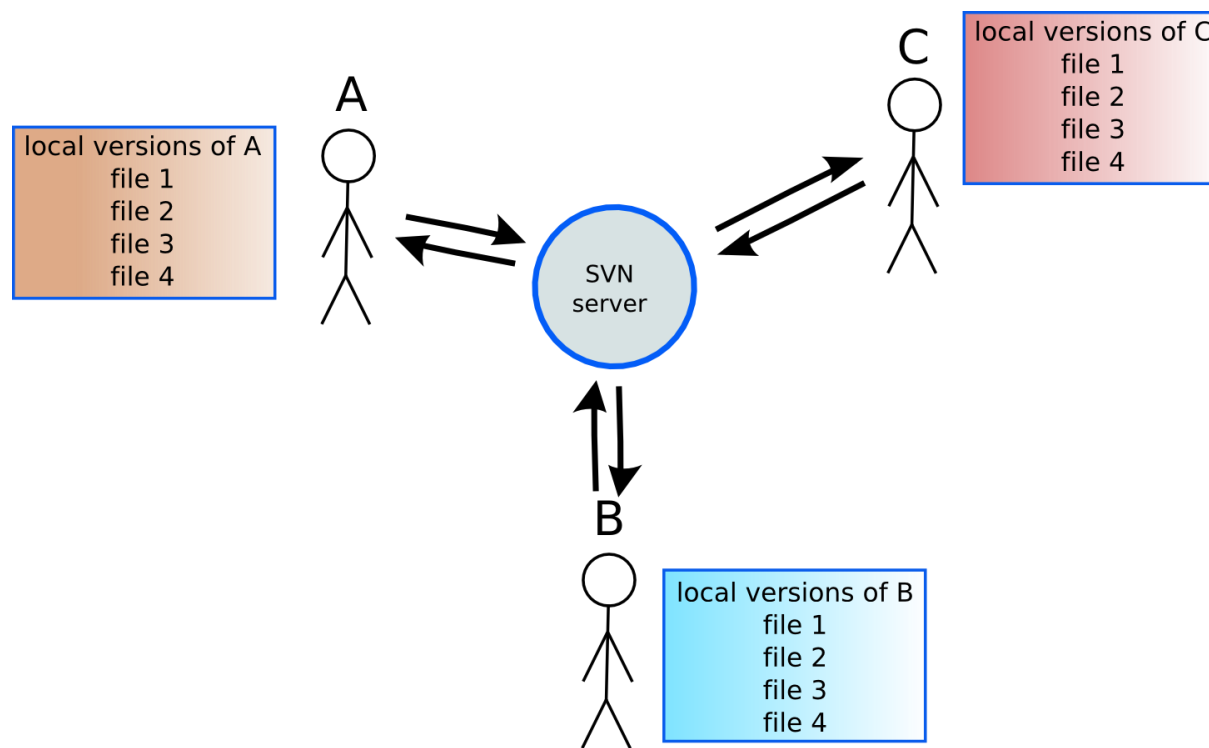
- Problem:
  - 3 unterschiedliche Versionen für je 4 Dateien
  - $4^3=64$  mögliche Kombinationen aus Dateiversion und Person



|        | A   | B   | C   |
|--------|-----|-----|-----|
| file 1 | 1.a | 1.b | 1.c |
| file 2 | 2.a | 2.b | 2.c |
| file 3 | 3.a | 3.b | 3.c |
| file 4 | 4.a | 4.b | 4.c |

# Verteilte Softwareentwicklung - Serveransatz

- Versuch 2: Speichere Dateien auf gemeinsamem lokalem Server
  - Speichere auch ältere Versionen (Historie)
  - Auflösung von Konflikten



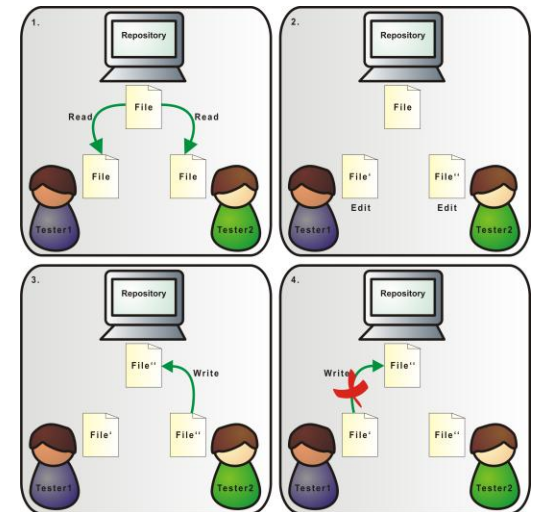
# Versionsverwaltung - Varianten

## ■ Lock-Modify-Unlock

- Wer eine Datei bearbeiten will, sperrt sie für alle anderen Benutzer
- Vorteil: Keine Konflikte
- Nachteil: Eine Datei kann immer nur von einer Person gleichzeitig bearbeitet werden
- Nur für kleine Teams

## ■ Copy-Modify-Merge

- Jeder holt sich eine lokale Version der Dateien
- Alle können simultan an allen Dateien arbeiten
- Im Fall von Konflikten: Auflösung erforderlich
- Geeignet auch für große Projekte und Teams
- Beispiele: CVS, SVN (SubVersion), Mercurial, **Git**



# Beispiel Git

## ■ Basisbefehle

### ■ clone

- Erstellt lokale Kopie eines Git-Repositories

### ■ commit

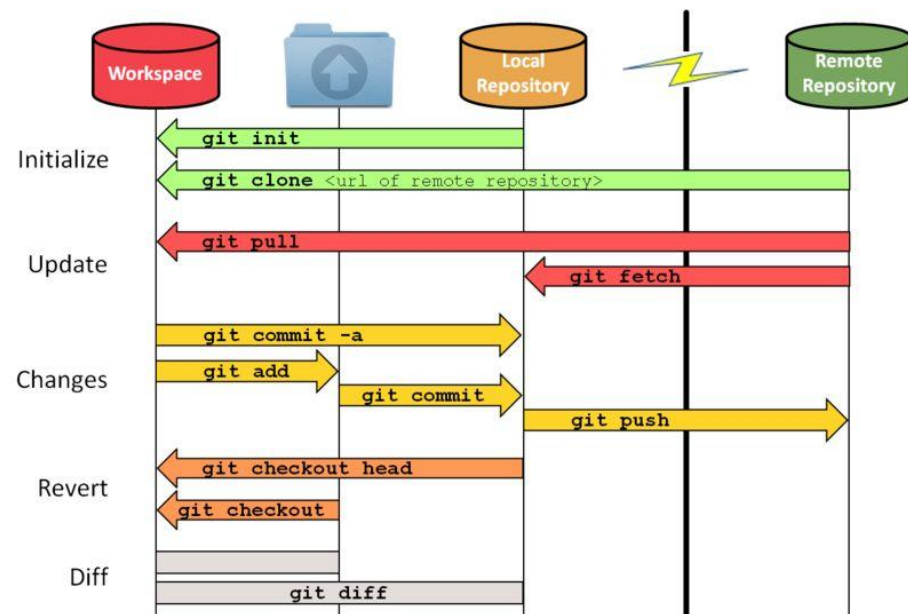
- Übernimmt Änderungen in lokale Kopie

### ■ push

- Überträgt Änderungen an Server

### ■ pull

- Holt Änderungen vom Server



- Wenn Konflikte auftreten, werden sie in einem Diff-Editor angezeigt
- In einem Merge-Schritt werden sie vom Entwickler aufgelöst

PersonaMVC4Example - Microsoft Visual Studio

FILE EDIT VIEW PROJECT BUILD DEBUG TEAM SQL TOOLS TEST ARCHITECTURE DRIVER ANALYZE WINDOW HELP

Google Chrome - Debug

Toolbox Merge - vctmp11076...troller.#60b2125.cs\* Site.css ExternalLoginsListPartial.cshtml HomeController.cs PersonaAuthenticationClient.cs Login.cshtml

1 Conflicts (1 Remaining)

Source: MVC4\PersonaMVC4Example\Controllers\PersonaController.cs;ec8b4958

Target: MVC4\PersonaMVC4Example\Controllers\PersonaController.cs;f60b2125

PersonaMVC4Example\Controllers\PersonaController.cs - Login(string assertion)

32 using (var client = new HttpClient())

33 {

34 var content = new FormUrlEncodedContent(

35 new Dictionary<string, string> {

36 { "assertion", assertion },

37 { "audience", Request.RequestUri.Host },

38 }

39 });

40 var result = await client.PostAsync("https://verifier.login.persona.org/verify", content);

41 var stringresult = await result.Content.ReadAsStringAsync();

42 dynamic jsonresult = JsonConvert.DeserializeObject<dynamic>(stringresult);

43 if (jsonresult.status == "okay")

44 }

83 %

Result: MVC4\PersonaMVC4Example\Controllers\PersonaController.cs

PersonaMVC4Example\Controllers\PersonaController.cs - Login(string assertion)

32 using (var client = new HttpClient())

33 {

34 var content = new FormUrlEncodedContent(

35 new Dictionary<string, string> {

36 { "assertion", assertion },

37 { "audience", Request.Url.Host },

38 }

39 });

40 var result = await client.PostAsync("https://verifier.login.persona.org/verify", content);

41 var stringresult = await result.Content.ReadAsStringAsync();

42 dynamic jsonresult = JsonConvert.DeserializeObject<dynamic>(stringresult);

43 if (jsonresult.status == "okay")

44 }

83 %

Package Manager Console Error List Output Find Results 1 Find Symbol Results

Ready

Team Explorer - Changes

Search Work Items (Ctrl+J)

Changes | Offline

master

Enter a commit message <Required>

Commit Sync View Commits Actions

Included Changes (1)

Exclude Exclude All Undo

Type here to filter the list

C:\Users\Scott\Desktop\Github\AspNetPersonal... PersonaController.cs [Conflict]

Excluded Changes

Include Include All Undo

Drag changes here to exclude from the commit.

Untracked Files

Add Add All Ignore

There are no untracked files.

Solution Explorer Team Explorer Server Explorer

Ln 39 Col 26 Ch 26 INS

# Was gehört ins Repository und was nicht?

- In der Datei **.gitignore** wird definiert, welche Dateien nicht ins Repository gepusht werden
- Es sollten alle Dateien enthalten sein, die man zum Erstellen des Projekts braucht
  - Sourcecode
  - Externe Libraries
    - Entweder als Sourcecode
    - Oder als Binary (\*.lib,\*.dll)
  - Content
  - (eventuell) Dokumentation
- Dateien die automatisch während des Builds erstellt werden gehören nicht ins Git-Repository
  - z.B. das erstellte Executable und Libraries (\*.dll)
  - Debug-Informationen (\*.pdb), Zwischendateien (\*.obj), Logs (\*.log),...

## ■ Das gehört rein:

- Config (Default-Konfigurationsdateien)
- Content (3D-Objekte, Texturen, Maps,...)
- Source (Quellcode)

## ■ Das nicht:

- DerivedDataCache (temporäre Dateien die während des Spiels erstellt werden)
- Intermediate (temporäre Dateien die beim Kompilieren entstehen)
- Saved (Lokale Konfigurationsdateien, Auto-Saves, Screenshots,...)

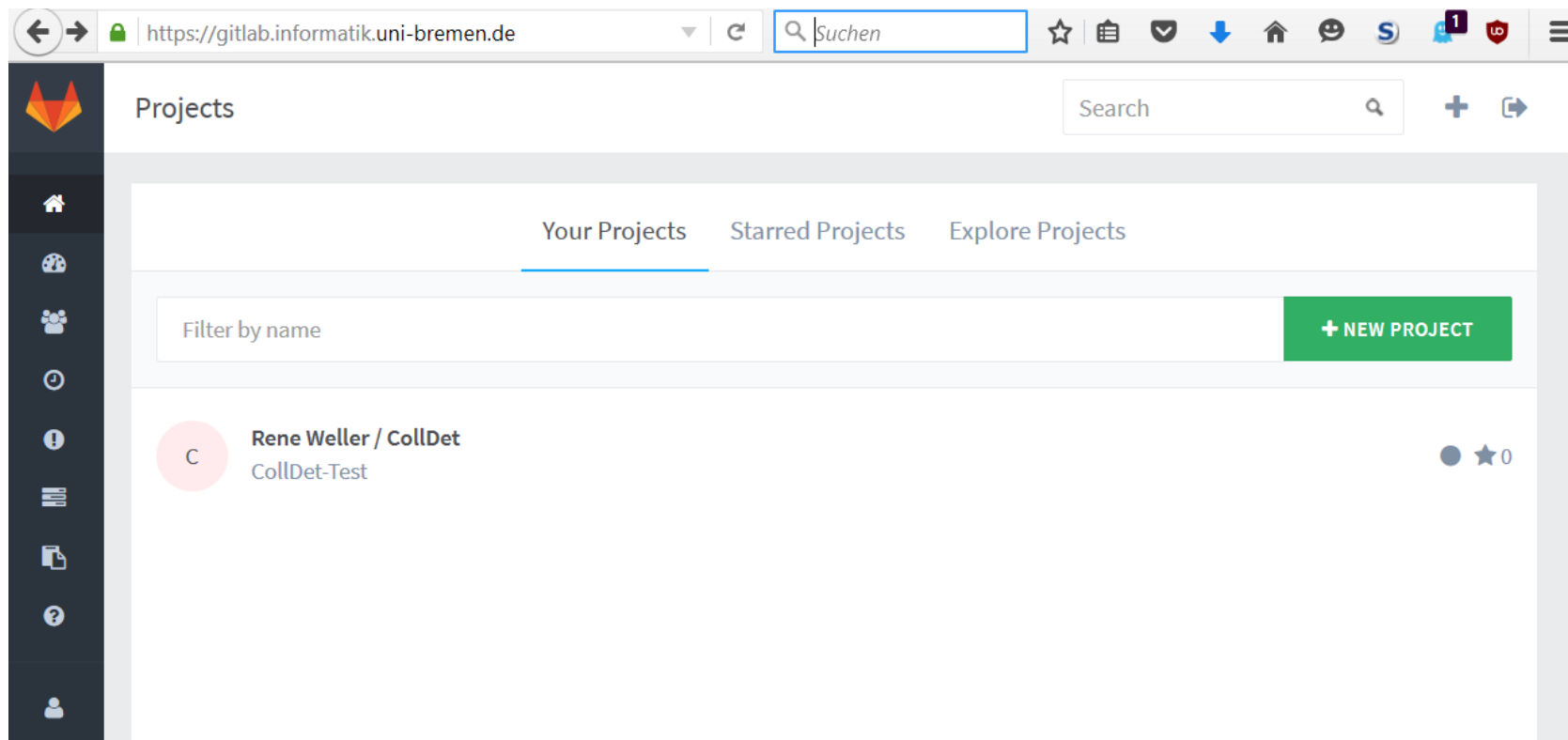
## ■ Kann, muss aber nicht:

- Build (Plattformabhängige Skripte zum Erstellen des Projekts und Abhängigkeiten)

| Name                       | Date modified    | Type                  | Size  |
|----------------------------|------------------|-----------------------|-------|
| Binaries                   | 03/10/2014 09:52 | File folder           |       |
| Build                      | 03/10/2014 09:50 | File folder           |       |
| Config                     | 03/10/2014 09:50 | File folder           |       |
| Content                    | 03/10/2014 09:50 | File folder           |       |
| DerivedDataCache           | 03/10/2014 10:05 | File folder           |       |
| Intermediate               | 03/10/2014 11:10 | File folder           |       |
| Saved                      | 03/10/2014 11:10 | File folder           |       |
| Source                     | 03/10/2014 09:50 | File folder           |       |
| MyProject.uproject         | 03/10/2014 09:50 | Unreal Engine Proj... | 1 KB  |
| TP_FirstPerson_Preview.png | 03/10/2014 09:50 | PNG image             | 97 KB |

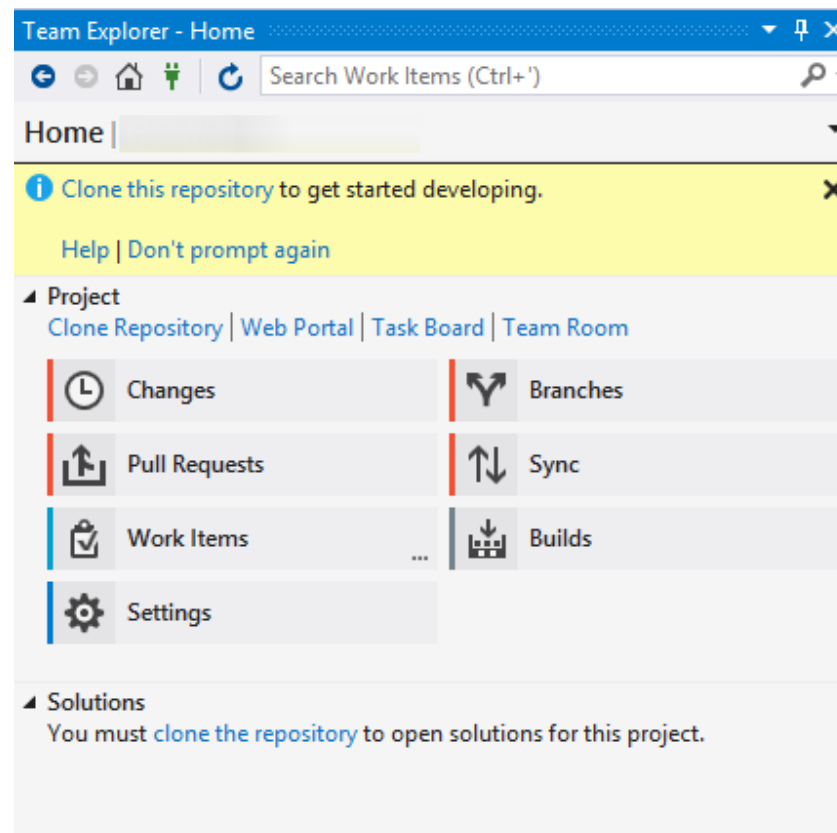
# Git-Repository für die Gruppe aufsetzen

- Der FB3 der Uni Bremen stellt einen Gitlab-Server für die Benutzer der Uni bereit
  - <http://www.informatik.uni-bremen.de/t/Dienste/Gitlab>



# Live-Demo Git in Visual Studio

- Git wird in VS 2015 nicht direkt unterstützt und benötigt ein kostenloses Plugin (direkt von Microsoft)



# Project Hosting-Seiten

- Bieten meist erweiterte Funktionalität im Vergleich zu reinen Versionsverwaltungsservern
  - Webhosting
  - Forum, Mailinglisten
  - Build-Systeme
  - Bug-Tracking
  - Wiki
  - Statistiken
  - Blogs
  - ...
- Beispiele
  - Github, Google Code, Assembla, Bitbucket, SourceForge



# Etwas Off-topic aber sehr praktisch

- Overleaf.com
  - Gemeinsam Latex-Dokumente erstellen
  - Live-Vorschau
  - Arbeiten direkt im Browser

The screenshot displays the Overleaf web editor interface. On the left, a file explorer shows a project named 'writeL<sup>A</sup>T<sub>E</sub>X' with files like 'Compare\_S.pdf', 'Compare\_pulse.pdf', 'Courant\_2.pdf', 'FigureLPancien\_mod.pdf', 'IEEEabrv.bib', 'IEEEtran.bst', 'IEEEtran.cls', 'biblio\_traps\_dynamics.bib', and 'main.tex'. The main editor area shows the LaTeX source code for a document titled 'Modeling of Trap Induced Dispersion of Large Signal Dynamic Characteristics of GaN HEMTs'. The document includes author information (O. Jardel, S. Laurent, T. Reveyrand, R. Quere, P. Nakkala, A. Martin, S. Piotrowicz, M. Campovecchio, S.L. Delage), an abstract, and a figure caption. The abstract discusses a non-linear GaN HEMT model for CAD including trapping effects. The figure caption describes the representation of the mechanism induced by traps on the average drain current. The right side of the interface shows a live preview of the document, including the title, authors, and a graph showing the average drain current versus input power.

# Extern oder in die IDE integriert?

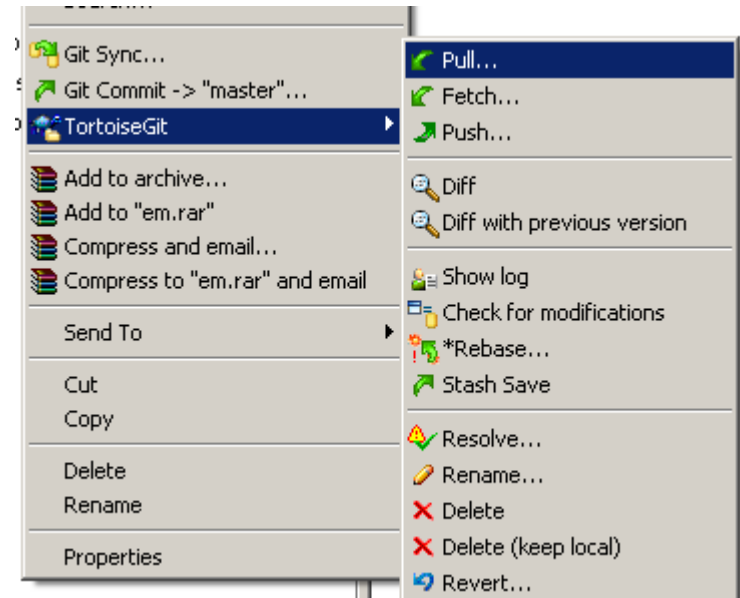
- Für alle hier in die IDE vorgestellten Werkzeuge gibt es auch externe Einzelprogramme
  - Vorteile:
    - oft deutlich erhöhte Funktionalität
    - Unterstützung für Spezialhardware (z.B. die GPU)
  - Nachteile
    - Einarbeitungszeit
    - Kosten
    - Unterbrechung des Workflow



VS



- Beispiele:
  - Editor: Hatten wir schon
    - Emacs, Vim
  - Profiler
    - Intel VTune
    - NVIDIA Nsight (für die GPU)
  - Versionskontrolle
    - TortoiseGit
- Welche man nimmt ist Geschmackssache (oder vom Auftraggeber vorgeschrieben)
- Für unser einfaches Projektchen sollten die integrierten Werkzeuge genügen

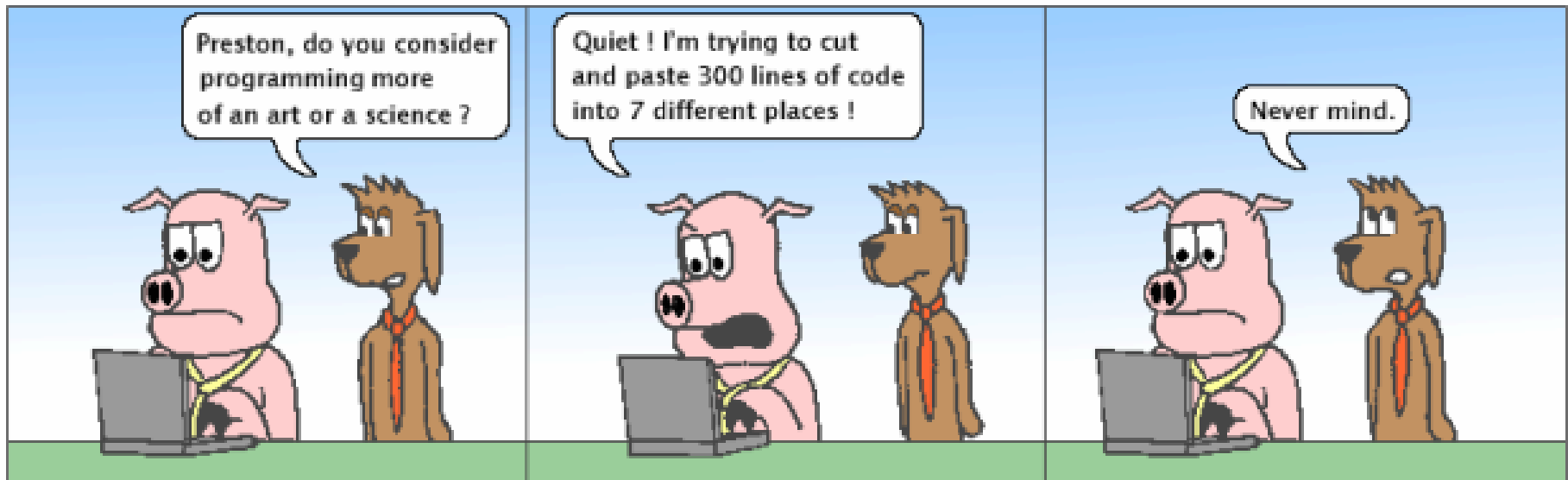


# Für unser Projektchen notwendige Werkzeuge

- IDE (Visual Studio, Xcode)
  - Editor
  - Compiler/Linker
  - Debugger
  - Versionskontrolle (mit Git-Plugin)
  - Profiler
- Dokumentationswerkzeug
  - Doxygen

## Hackles

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<http://hackles.org>

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